DEVELOPMENT OF SMALL-SCALE LIFT IRRIGATION IN BANGLADESH

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INTRODUCTION

Irrigation in Bangladesh has been developed under a variety of complex and diverse conditions. The physical and social environments of agriculture in this country have resulted in the development of a number of alternative small-scale lift irrigation technologies, such as deep tube wells, shallow tube wells, hand tube wells, and low-lift pumps. In addition, there are also traditional manually operated devices such as *dhones* (conical-shaped containers, usually 3.0 meters x 0.3 meters, used for lifting water for irrigation), swing buckets, and dug-wells. The operation of these irrigation technologies has been accompanied by a variety of administrative control and support services from government and non-government agencies, and as a result a number of farmers' organizational forms have evolved for the operation and maintenance of these installations.

This paper presents an overview of the development of small-scale lift irrigation in Bangladesh, and highlights recent field research on the organization and performance of irrigation systems. The background history of irrigation development in Bangladesh is also discussed, followed by a discussion of the role of irrigation agencies and farmer-agency interactions. The author's own research experiences in irrigation management and performance are discussed in the final section.

BACKGROUND OF IRRIGATION DEVELOPMENT

Physical Context

Bangladesh covers an area of 14.4 million hectares (ha) of which 9.1 million ha are available for cultivation. The remainder falls under forest or is unavailable for cultivation. Almost the entire cultivable land (95%) has already been brought under cultivation, and the proportions of land under single, double, and triple cropping are 54, 39, and 7 percent, respectively. This means that the required increase in agricultural production has to be achieved entirely through crop intensification on the existing land, which can be made possible primarily through the expansion of controlled irrigation and drainage facilities.

Two important climatic factors which have shaped peasant behavior in relation to uncertainty and risk aversion are annual flooding followed by monsoon rains in summer and drought in winter. Rainfall is over 200 centimeters (cm) per year, varying from 550 cm in northeast to 150 cm in the west. About 90 percent of Bangladesh is vulnerable to flooding

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to different depths at one time or another in a typical year, but 70 percent usually experiences deep (1-4 meters) and shallow (0.3-1.0 meters) flooding, affecting crop selection by farmers.

Although the potential for ground water irrigation is not known at present, it is generally reported that about 50 percent of total cultivated area can be irrigated by exploiting both surface and ground water (Bottrall 1983). Small-scale lift devices are suggested for extraction of ground water but the choice of technologies (i.e., whether 2 cusec deep tube wells, 0.75 cusec shallow tube wells, or 0.02 cusec hand tube wells) depends on the groundwater level. For example, smaller devices like shallow or hand tube wells are inappropriate where static water level exceeds 6-7 meters during the dry winter months. In such situations deep tube wells are suggested, but in any area actual discharges from tube wells will depend on the conditions of the aquifer, soil permeability, drawdowns, or tube well-to-tube well spacing.

Social Context

Bangladesh is a densely populated country of 98 million people of whom 80 percent live in rural areas and directly or indirectly depend on agriculture. The density of population in 1984 was 680 per square kilometer. There exists a high inequality in the distribution of land which is the basis of rural wealth and power. Over 56 percent of total households are virtually landless including those possessing less than 0.2 ha of cultivated area with little or no homestead land, and they work mostly as agricultural wage laborers for their livelihood. Small farm owners operating less than one hectare constitute 70 percent of total farm households but possess only 29 percent of the farm land. At the other extreme, large farms operating land above 3 ha constitute less than 5 percent but own 26 percent of total farm land (BBS 1986).

Average farm size has declined from 1.4 ha in 1977 to 0.9 ha in 1983-84 with a high degree of land fragmentation. About 25 percent of farm land is cultivated under tenancy, mostly on 50-50 share-cropping arrangements without any cost-sharing for inputs. The terms for land mortgage are changing from the traditional fixed-term mortgages (*khailkhalashi*) to more stringent unspecified-term mortgages (*daisodhi*), and the extent and incidence of land mortgaging and share-cropping with not only land but also water are increasing with the spread of high yielding varieties (HYV) cultivated under irrigation (Mandal 1985).

Pattern of Irrigation Development

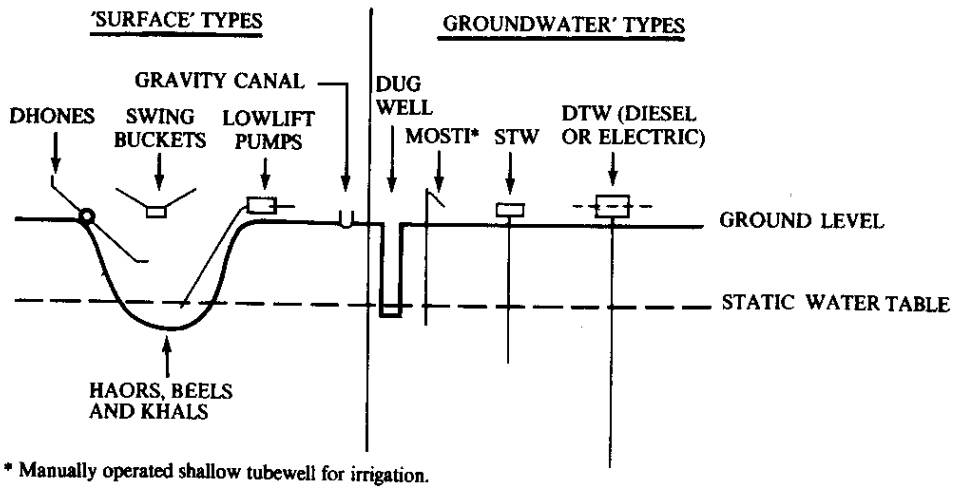
In many parts of the country, particularly in the low lying *haor* areas, farmers have been using surface water for irrigation with the help of the traditional manually operated lift devices, such as swing buckets and dhones. Even open dug-wells have been in use for extracting ground water in many areas for irrigation. Table 1 and Figure 1 present the underlying characteristics of different methods of irrigation currently used in the country.

Table 1. Characteristics of irrigation technologies related to command area ('000 ha, 1983-84).

Criteria	Dhone	Swing bucket	LLP	Gravity canal	Dug well	HTW	STW	DTW
Irrigation coverage	238.50	83.80	666.8	134.0	6.10	22.30	303.6	415.4
Irrigation Percentage	12.70	4.50	35.6	7.2	0.30	1.20	16.2	22.2
Motive power	M	M	D/E	D/E	M	M	D/E	D/E
Average design discharge (cusec)	0.04	0.06	1-2	-	0.01	0.02	0.50-0.75	2
Maximum pumping height from water level/water table (meters)	2.10	0.60	9.1-12.1	-	6.10	6.10	7.6	75.7
Capital cost (1981-82 taka*, '000)	0.06	0.02	50-90	-	0.185	0.80	35	400
Working life (years)	5	2	7	25+	3	7	7	7-15
Potential command area (ha)	0.40	0.10	16.2-32.4	-	0.10	0.20	8.1	32.4
Subsidy as % of capital cost (1981-82)	-	-	70-75	100	-	-	-	75-80

*Taka 21.96 = US$1.00; M = manual; D = diesel; E = electricity; HTW = hand tube wells; STW = shallow tube wells; DTW = deep tube wells. Source: Adapted from Biggs et al. (1978) and Bottrall (1983). Figures for 1983-84 irrigation coverage are taken from BBS (1985)Tables 4.31, 4.32, and 4.33.

Figure 1. Irrigation sources in Bangladesh.



* Manually operated shallow tubewell for irrigation.

The historical background of irrigation development initiated by the government has been a subject of interest or criticism in the country. The first major government attempt to expand irrigation was the creation of the East Pakistan Water and Power Development Board in 1959 (now Bangladesh Water Development Board, BWDB) and the formulation of the first water resources Master Plan in 1964, which emphasized flood control and drainage. This attempt was initiated when widespread floods occurred in the 1950s as a result of earthquakes in Assam. Also, there was a long tradition of gravity flow irrigation systems in the neighboring countries (Bottrall 1983). The immediate outcome of such attempts was the two large systems, the Ganges-Kobadak and Dhaka-Narayangonj-Demra Flood Control and Irrigation Projects, both of which use high-capacity pumps for primary lifting from the river.

Small-scale irrigation was started with the supply of low-lift pumps by the Bangladesh Agricultural Development Corporation (BADC) against fixed rental charges under an initial program called Mechanized Cultivation and Power Pumps Irrigation (MCPPI) in 1962-63, which was limited to low lying *haor* areas of Kishoregonj and Sylhet districts. Low-lift centrifugal pumps have a 1-2 cusec discharge capacity with a pumping head of 9-12 meters from water level and can irrigate 16-32 ha of HYV rice, depending on soils and topography (see Table 1). The number of low-lift pumps in operation increased from about 1,300 in 1960-61 to 39,556 in 1983-84 but the areas covered by pumps have fluctuated with a decreasing trend mainly because of inadequate water supplies in the traditional water sources (e.g., rivers, creeks, *beels*, and canals). Nevertheless, low-lift pumps are still the single largest irrigation source and cover about a third of the total irrigated area of the country.

The exploitation of ground water started in 1961 with the installation of 380 deep tube-wells of 4 cusec capacity in a compact field in the northern district of Thakurgaon as a special project of the BWDB. The subsequent development of tube well irrigation followed a high-cost strategy using sophisticated drilling techniques and imported materials. The well-publicized Thana Irrigation Programme (TIP) was established, and deep tube well pumps were rented to farmers' cooperative societies against payment of fixed annual rental charges. The supervision of cooperative management was given to the well-known Integrated Rural Development Program (IRDP) of Comilla, which has been recently renamed the Bangladesh Rural Development Board (BRDB). The costs of deep tube wells have always been heavily subsidized in the range of 70-80 percent, although the rate of subsidy has been gradually reduced. The number of deep tube wells has more than doubled from 7,407 in 1977-78 to 15,519 in 1983-84, to cover about 22 percent of the total irrigated area (see Table 1).

In the mid-1970s, the government encouraged the development of two more small-scale groundwater devices -- shallow tube wells and hand tube wells, often called MOSTI (manually operated shallow tube wells for irrigation). Government sponsorship promoted the development of MOSTI because these were much cheaper and easier to operate and manage with minimum organizational problems compared to deep tube wells (Planning Commission 1982). But these smaller devices were expected to give better equity results in terms of benefit distribution, a goal which remained unrealized with deep tube well

irrigation under the Comilla cooperative system. Shallow tube wells lift water 7.5 meters and have a 0.50-0.75 cusec discharge, while hand tube wells lift water to the same level but have only a 0.02 cusec discharge.

In recent years, there has been a shallow tube well boom so that their number increased rapidly from 20,931 in 1980-81 to 67,803 in 1983-84. These now cover about 16 percent of the total irrigated area of the country and, if the present trend of credit sale with huge default in loan repayment for deep tube wells continues, shallow tube wells are likely to overtake them. The recent rise in shallow tube well numbers has been accompanied by a government policy of privatizing irrigation equipment and other agricultural inputs.

The commonly used hand tube wells for supplying drinking water were promoted for irrigation following the serious food shortages after the 1974-75 crop failure caused by widespread flooding. UNICEF launched a MOSTI Project in 1975-76 by installing 10,000 pumps, and their number rose to 90,000 by 1979. About 22,000 ha (1.4% of total irrigated area) are currently irrigated by hand tube wells. A hand tube well is a small apparatus with 0.02 cusec discharge and can irrigate 0.1-0.2 ha by lifting water from a maximum depth of 7.5 meters. Although they are cheap, robust, and easily maintained, the expansion of hand tube wells is limited by the extreme drudgery involved in the task of pumping by hand. This is one of the reasons that hand tube wells are being replaced by machine-pumped deep and shallow tube wells.

One may wonder why the decision was not taken to sell irrigation equipment rather than to continue renting it out. The planning documents on the issue of privatization are not easily accessible but the BADC (1981) set out the grounds for selling deep tube wells. Deep tube wells would be sold if: 1) managers of the rented deep tube wells did not follow technical advice for operation and maintenance; 2) low quality fuels and lubricants were frequently used, damaging engines; 3) the engines and pumps were not properly maintained during the off-season; 4) irrigation coverage was low; and 5) farmers' participation in system maintenance was poor.

It is not yet known if there has been any serious evaluation of tube well performance by the agencies concerned following the privatization program, but sales have been promoted by many government and non-government agencies. Although it was initially expected that a certain proportion of equipment (e.g., 10% in the case of shallow tube wells under IDA credit) would be sold on a cash basis, field evidence shows that cash sales have lagged far behind expectation (Hamid et al. 1982; Mandal 1985).

FARMER-AGENCY INTERACTIONS IN IRRIGATION DEVELOPMENT

In recent years, a number of government and non-government agencies have been involved in organizing minor irrigation development in Bangladesh. In view of the physical and social environment of agriculture within which irrigation is promoted (as discussed in the previous section), different agencies pursue different approaches to organize and control irrigation groups. Tables 2 and 3 summarize the main management functions of the major government and non-government agencies involved in irrigation development.

Table 2. Government agencies involved in irrigation development and their management functions.

Government Agencies	Management Functions
Bangladesh Agricultural Development Corporation	
Rental	Supplying, siting, installing equipment; supplying oil, fuel, spare-parts, mechanical services; collecting rental charges,
Private	Selling, siting, and installing deep tube well (DTW) equipment; supplying major spare parts.
Bangladesh Rural Development Board	
KSS (Farmers' Cooperative Society)	Forming and supervising farmers' cooperatives, providing KSS loans, supporting landless irrigation.
KSS-IMP (Farmers' Cooperative Society-Irrigation Management Program)	Integrating back-up services, providing timely loans, and advising on improved water management and production practices.
Bangladesh Water Development Board	Providing irrigation equipment, improving the conveyance system, supporting operation and maintenance of installations, and collecting water charges.
Bangladesh Krishi (Agricultural) Bank	Own shallow tube well (STW) sale program providing loans for equipment and production; no responsibility for operation and maintenance.
Commercial Bank	Providing loans for purchase of equipment and production; no responsibility for operation and maintenance.
Grameen Bank	Supporting landless groups with loans for purchase and operation and maintenance of DTW and STW; negotiating with landowning farmers for command area; collecting weekly installments.

Source: Mandal, unpublished field survey, 1985-86.

Table 3. Non-government agencies involved in irrigation development and their management functions.

Non-government Agencies	Management Functions
Center for Human Development (PROSHIKA)	Providing security to landless groups for bank loans for equipment purchases; providing small operating loans.
Bangladesh Rural Advancement Committee (BRAC)	Providing financial and advisory support to landless groups in acquiring and operating irrigation equipment.
Cooperative for American Relief Everywhere (CARE)	Providing collaborative support for improving irrigation performance;, collaborating with PROSHIKA and Grameen Bank to support landless irrigation (under LOTUS program).
German Agency for Technical Cooperation (GTZ)	Providing loans for irrigation equipment purchases, support services, inputs, and advisory services in collaboration with BRDB.
Danish International Development Agency (DANIDA)	Supporting irrigation development in collaboration with BRDB.
Rangpur-Dinajpur Rehabilitation Service (RDRS)	Supporting mostly small farmers with irrigation equipment, design-improved MOSTI (Treadle pump, bamboo tube well).

Source: Mandal, unpublished field survey, 1985-86.

Management Functions of Irrigation-Related Agencies

The Bangladesh Agricultural Development Corporation (BADC) as the largest government agency has monopolistic control over the procurement and distribution of irrigation equipment. Under the new sales program associated with the privatization policy, BADC sells irrigation equipment to individual farmers or farmers' groups (according to recent regulations these have to be cooperatives for deep tube wells) against payments made in cash or through a bank loan. In the case of the sales program, farmers themselves are responsible for repair and maintenance of machines but BADC should ideally provide spare-parts on payment and mechanic's services free of cost. In reality,

farmers do not receive any mechanical support from BADC which means that they have to depend on private mechanics' services developed on local individual initiatives. Under the rental system, BADC is responsible for delivery, installation, and repair and maintenance of deep tubewells and low lift pumps against fixed annual rental charges to be paid by the farmers. BADC also has greater control over irrigation equipment under this system and hence can ideally influence the formation of irrigation groups and direct the management functions of the schemes. This is one reason why the BADC officials have been generally reluctant about the sales program, especially about the sale of previously rented tube wells to the KSS (farmers' cooperative societies) which are in control of the BRDB.

BRDB is mainly responsible for forming KSS, which are provided with credit to purchase irrigation equipment. The KSS members also get credit from BRDB for the operation and maintenance of equipment as well as for the production of crops with irrigation. Under the BRDB-IMP, the KSS members should ideally receive increased credit and back-up services in terms of timely supply of inputs, ensured repair services for irrigation equipment, and extension advice, all directed towards improving irrigation performance.

The three agencies, BKB, CARE, BADC, are jointly responsible for assisting farmers of different tube well schemes to increase production and income under a program called Deep Tube well Irrigation and Credit Program (DTICP). They provide improved methods of water delivery, arrange necessary credit and complementary inputs, and train farmers to practice improved crop production techniques.

Under its shallow tube well program, the BKB (Bangladesh Agricultural Bank) sells shallow tube wells directly to farmers against loans. The BKB takes responsibility for installing the shallow tube wells through its appointed dealers, but the operation and maintenance of the tube wells become the sole responsibility of the tube well owners.

A very recent and, to some extent, remarkable form of organizational support for irrigation is the introduction of a landless irrigation program with PROSHIKA as the pioneer. In recent years, Grameen Bank also started its landless irrigation program, which is concentrated mostly in Tangail. PROSHIKA provides security for bank loans advanced to the landless groups and also provides small operating loans if there is an emergency. On the other hand, Grameen Bank itself provides credit to landless and near-landless farmer groups to enable them to buy, install, operate, and maintain irrigation equipment (mostly shallow tube wells). The bank also assists the landless groups to negotiate with the land-owning farmers who put their land under the landless groups' command areas and use irrigation water. In this program, the group is entirely responsible for delivering water to farmers' plots and for the construction and maintenance of canals.

Some Areas of Farmer-Agency Interactions

The farmers have to interact with officials in a diverse and complex rural environment. Selected areas of interactions relevant to the acquisition and operation of irrigation equipment are discussed below.

Sanction of tube wells. The sanction of tube wells which are purchased through loans is dependent on the feasibility reports submitted by the representatives of the Upo-Zilla Irrigation Team (UIT). There are frequent reports that the feasibility reports are faulty in that the specified inter-tube well spacing requirements are violated or the installations are incorrectly sited, and that these acts are made possible through bribes. An immediate consequence of such interactions between tube well buyers and approving authorities is the widespread encroachment of deep tube well areas by shallow tube wells resulting in reduced command area per installation. Furthermore, such problems are often used by tube well buyers as excuses for not paying loan installments or tube well rent charges.

Sanction of loans. Credit-purchased deep tube well loans are sanctioned to the KSS which, in most cases, are dominated by a few members who have influence either through their connections with the officials or by virtue of their wealth and power in the community. There are allegations again that loans disbursed by the officials in the name of the KSS are actually allocated to those few who negotiate and keep on good terms with the agencies concerned. These few often divert the loan money to other profitable businesses. One of the serious consequences of this is the huge default in loan repayments, which ultimately affects irrigation performance because lenders are reluctant to make fresh loans for irrigation or crop production. The agencies concerned say that they have neither the authority nor enough incentives to enforce actions against loan defaulters.

Provision of electrical connections. Electrical connections are given to irrigation installations mostly through contractors against payment of exorbitantly high charges: Taka 30,000-40,000 (US$1,366-1,822) for deep tube wells and Taka 10,000-15,000 (US$455-683) for shallow tube wells. There are widespread allegations that most connections are not officially approved, but it is the sole responsibility of the contractors to negotiate with the relevant offices and obtain the connections. Field experiences suggest that because of private negotiation between the contractors and tube well owners, connections are given to installations which cannot be correctly sited according to the spacing specifications of the BADC, which ultimately results in reduced command area of the existing installations.

EXPERIENCE OF FIELD RESEARCH ON IRRIGATION

The irrigation-related agencies mentioned earlier have different approaches toward controlling or managing different lift-irrigation technologies, and therefore provide different incentive structures for the water suppliers, water users, and direct or indirect beneficiaries of irrigation installations. It is hypothesized that the pattern of ownership and control of irrigation equipment and other resources, including land, characterize the form of management in small-scale irrigation schemes and create differential incentive structures for participants in irrigation, which ultimately manifest in the different levels of irrigation performances and efficiencies.[1]

A broad study was conducted in 1985 at the Bangladesh Agricultural University (BAU), Mymensingh, as part of a Ford Foundation supported research project in order to verify the above hypothesis. The major objective of the study was to evaluate the performance of different lift-irrigation technologies which are sponsored and controlled under different management approaches by selected government and non-government agencies involved in irrigation development, and then to explain variations in performance in terms of physical, technical, social, economic, and administrative factors. The two major criteria for evaluating irrigation performance were productivity and equity. The detailed methodology of this study was discussed in Mandal and Dutta (1985, 1986) but the salient features are discussed below.

Research Design

The study was planned to be carried out in two phases, and a multi-disciplinary approach was employed by including engineers, economists, and agronomists on the research team. For the first-phase study, a broad survey was conducted on 100 installations, including deep and shallow tube wells and low-lift pumps under 7 different agency/management approaches in 2 different ecological zones of Tangail and Gazipur. These were: 1) BADC Rental Program, 2) BADC-private (sales program), 3) BRDB-KSS, 4) BRDB-KSS-IMP, 5) BKB Shallow Tubewell Sales Program, 6) Grameen Bank, and 7) BKB-CARE-BADC Deep Tubewell Irrigation and Credit Program (DTICP).

One requirement of this comparative study was the selection of irrigation units which were operated under different main streams with specialized management approaches but in a single area with uniform ecological characteristics. This required the research team to make extensive exploratory trips to the offices of the agencies concerned and to the fields in a number of Tangail and Gazipur district Upo-Zillas immediately before the start of the irrigation season. The initial selection of these two areas was made because of the presence of more specialized programs, such as the landless irrigation program under PROSHIKA and Grameen Bank in Tangail and the BKB-CARE-BADC program in Gazipur.

The irrigation units under study were randomly selected from the relevant lists provided by the respective agencies. Field verifications showed that some of the randomly selected units were either non-existent or not managed by the agency mentioned on the original list. In cases where the desired number of installations was not available (especially under specialized programs), matching combinations of other technologies and institutions had to be found near the infrequently occurring ones to limit the agro-ecological and socio-economic variations. Finally, 44 deep tube wells, 37 shallow tube wells, and 19 low lift pumps were surveyed, including 5 of the first, 10 of the second, and 5 of the third from each of the agency/management approaches selected in the 2 areas.

In this study, two types of survey were conducted simultaneously -- one on technical and the other on socio-economic aspects of irrigation. For the socio-economic survey, apart from managers/owners, one small-scale farmer, one medium-scale farmer, and two large-scale farmers, and two landless laborers working in the vicinity of the selected command areas were also interviewed because they were the individuals first encountered by the investigators.

In the second phase of the study, in-depth case studies were made on four selected irrigation sites: one deep tube well under private management, one deep tube well under KSS management, one shallow tube well under private management, and one shallow tube well under Grameen Bank landless group management. Both technical and socio-economic investigations were conducted at these sites by direct field measurement methods as well as through interviews. In addition, a quick follow-up survey was conducted to record changes in command areas and yields under those installations in Tangail which were studied during the first phase.

Organization of Irrigation Groups

Irrigation groups can be classified into three broad categories: 1) KSS groups; 2) informal non-KSS groups; and 3) landless controlled informal groups. KSS groups are the most formally organized, ideally having a representative management in which a committee adopts and implements decisions on the basis of group participation. These groups are required to maintain separate records of group activities, such as farmers' register, block register, cash book, land register, and receipt book, although in practice these are not adequately maintained. Informal non-KSS groups are formed or at least listed mainly to show the required irrigation command areas while applying to agencies for irrigation sets, loans, and other services. Under landless controlled irrigation, written or unwritten agreements are made between landless groups and the prospective landowning water users. In this case, landless groups are responsible for delivering water to farmers' plots, while the water users are responsible for applying adequate amounts of inputs on time and for paying water charges.

The methods of water distribution are flexible for most irrigation schemes. Empirical information from Tangail and Gazipur (Table 4) reveals that there are usually four different, but not necessarily mutually exclusive, methods for on-farm water distribution: 1) blockwise rotation, 2) canalwise rotation, 3) water delivery on demand, and 4) water delivery on demand against user's fuel.

In most tube well schemes, canalwise rotations are practiced in distributing water, but in actual practice a combination of these methods is followed to meet emergencies or to satisfy specific purposes. The worst form of distribution is the delivery of water against the user's own fuel because it hinders timely delivery of adequate water to fields. This system of water delivery affects irrigation performance seriously because priority is fixed not on the basis of crop-water needs but according to the individual irrigator's ability to manage his fuel. However, in the absence of an electrical power source, for schemes with variations in land topography and distances of individual plots from water sources (as found in some parts of Gazipur), individualistic methods of supplying fuel help to avoid misgivings and distrust and thus contribute to keep the schemes going.

Different systems of payment for water provide different levels of incentives for water suppliers and water users. Evidence from the field revealed four different systems of payment for water (Table 5). The most common practice is cash payments, usually fixed at

a rate per unit of land irrigated. One recent payment system is to pay with a share of rice, the share ranging from 20-25 percent of the harvest. This newly emerged system of share-cropping has accompanied the privatization of irrigation equipment and is expanding rapidly.

Table 4. Methods of on-farm water distribution in Tangail and Gazipur.

Methods	Main features	Remarks
Blockwise rotation	Command area divided into blocks, served water in weekly or daily rotations, supervised by line/drainmen.	Efficient water distribution requires extensive management time and skills, cooperation, and group management.
Canalwise rotation	Distribution by one or two main canals at a time, while other main canals are operated by turns, start irrigation from tail ends, needs supervision by line/drainmen.	Commonly practiced, flexible, problems arise with canals of different capacities and length serving plots at different distances from the turn-out.
Delivery on demand	Water delivered as and when demanded or drainmen report, no fixed preference.	Practicable with abundant water, problematic with low discharge, poor conveyance, or machine breakdowns.
Delivery on demand against user's fuel	Water delivered as fuel supplied, prioritized as "first come with fuel-first served with water."	Inefficient, inadequate irrigation, huge water loss, practiced where topography and plot distance vary widely.

Source: Mandal, unpublished field survey, 1985-86.

Salient Features of the Research Findings

The detailed analyses of the collected data and the preliminary results are presented in the proceedings of the workshop that was held at the Bangladesh Agricultural University in November 1985. Some of the major findings are presented here.

1. BRDB-KSS-managed deep tube wells and shallow tube wells have poor performance as evidenced by low command areas, low yield, and low output in both areas (Tables 6 and 7). This implies that the KSS suffered from internal contradictions and organizational weaknesses.

Table 5. Mode of payment of water charges in Tangail and Gazipur.

Mode	Water charges	Payment procedures
Cash (Fuel by water supplier)	Tk 1112-3758/ha (US$50.64-171.13/ha)	2-3 installments, at least part paid in advance, balance usually after harvest.
Cash (Fuel by water user)	Tk 706-1765/ha (US$32.15-80.37/ha)	2-3 installments, part in advance, balance mid-season and after harvest as in Gazipur.
Cash payment on hourly basis	Tk 30-40/ha (US$1.37-1.82/ha)	Payment usually made immediately after water delivery, common in Gazipur.
Crop-share payment (Fuel by water supplier)	20-25% of crop	Share of crop collected from fields usually by counting bundles of harvested rice as in Tangail.

Source: Adapted from Mandal (1985), Tables 5a and 5b.

Table 6. Indicators of economic productivity of lift-irrigation technologies in Ghatail-Kalihati, Tangail.

Agency/technology/ management/payment	No of units	Command area(ha)	Yield (kg/ha)	Total output ('000 kg)
DTW				
BADC-rental	5	16.48	5536	91
BADC-private	4	23.37	5124	120
BRDB-KSS	4	13.30	4975	66
BRDB-KSS (IMP)	2	26.95	5143	139
Grameen Bank	3	22.30	4700	105
Diesel	11	18.48	5112	94
Electricity	7	20.95	5128	107
All rental	9	19.39	5361	104
All private	9	19.48	4881	95
Cash payment	5	23.66	5344	126
Crop share payment	13	17.81	5006	89

All	18	19.44	5120	99
STW				
BADC-private	11	4.93	5656	27
BRDB-KSS	8	3.13	5227	16
BKB	10	4.98	5514	27
Grameen Bank	8	5.26	5855	31
Diesel	34	4.66	5586	26
Electricity	3	4.33	5787	25
All	37	4.63	5602	26
LLP				
BADC-private	5	8.15	4882	40

Source: Adapted from Mandal (1985), Table 6a.

2. BADC-rented deep tube wells have higher yields but low coverage per unit, while BADC-private deep tube wells showed higher coverage but lower yields because of inadequate water supply to larger command areas. However, when all rented deep tube wells were compared with all private deep tube wells, the rented ones did better in terms of total output, but the difference was not significant (Tables 6 and 7). Furthermore, water users using private deep tube wells had lower returns over water costs than those using rented deep tube wells. This raises serious questions about the efficiency of the privatization policy.

3. Deep tube wells under BRDB-KSS (IMP) show better initial performance compared to deep tube wells under other agencies or management approaches because of integrated back-up services provided by the support agencies. But the success is discounted by the many drop-outs from the program. The drop-outs occur when the promised assistance is not continued; it is also possible that only the better performing schemes are included in the IMP, which abandons those with problems (see Tables 6 and 7).

4. Specialized irrigation programs such as deep tube wells under CARE and shallow tube wells under Grameen Bank show high performance which seems due to strong support services by CARE and better water delivery by the landless groups under Grameen Bank, but these programs are also vulnerable to frequent drop-outs (for evidence on drop-outs, see Biswas 1985).

5. The major factor affecting irrigation performance appears to be the mode of payment for water. The share-cropping payment systems (in Tangail) and the systems where farmers bought their own fuel (in Gazipur) showed lower coverage, yield, output, and returns to farmers than cash payment systems.

Table 7. Indicators of economic productivity of lift-irrigation technologies in Gazipur.

Agency/technology/ management/payment	No of units	Command area(ha)	Yield (kg/ha)	Total output ('000 kg)
DTW				
BADC-rental	7	21.40	4947	106
BADC-private	4	27.73	4574	127
BRDB-KSS	6	18.16	4554	83
BRDB-KSS (IMP)	3	24.90	4962	124
CARE	5	23.60	5162	122
Diesel	22	22.54	4861	110
Electricity	3	22.12	4460	99
All rental	17	21.32	4970	106
All private	8	25.00	4527	113
Cash (managers' fuel)	15	25.33	5012	127
Cash (farmers' fuel)	10	18.24	4402	80
All	25	22.50	4814	108
LLP				
BADC-rental	5	16.49	4767	79
BADC-private	5	6.45	4942	32
BRDB-KSS	4	16.63	5619	93
Diesel	7	8.49	4856	41
Electricity	7	17.40	5222	91
All rental	8	16.74	5041	84
All private	6	7.88	5348	42
All	14	12.94	5112	66

Source: Adapted from Mandal (1985); Table 6b.

6. The distribution of benefits from irrigation is skewed strongly to those having control over water sources and land, and the process is further accelerated by the emerging hard contractual terms for water (e.g., share-cropping with water in Tangail), share-cropping with land, usufructuary land mortgaging, and money lending for usurious interest. These ultimately affect the performance of irrigation.

7. In spite of high profits accruing to equipment owners/managers, especially under share-cropping payment systems, there are many defaults in payment of loans and rents, implying a failure within the state bureaucracy.

NOTES

[1]A detailed theoretical discussion on the structure of incentives is presented in Palmer-Jones (1985).

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