Study on Privatization of Minor Irrigation in Bangladesh

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Contents

GLOSSARY AND ABBREVIATIONS

AB	Arab Bangladesh Bank
ADB	Asian Development Bank
Aman	Rain-fed rice grown in July - November
ASSP	Agricultural Support Services Programme
AST	Agricultural Sector Team (a Canadian Government funded Technical Assistance Team)
ATIA	Assisting Transformation to Irrigated Agriculture (a FAO project)
ATP	Agribusiness Technology Project
Aus	Rice grown mainly under rain-fed conditions in March-July
BADC	Bangladesh Agricultural Development Corporation
BARC	Bangladesh Agricultural Research Council
BAU	Bangladesh Agricultural University
BBS	Bangladesh Bureau of Statistics
BCI	Bank of Commerce & Investment
BCCI	Bank of Credit and Commerce International
BCR	Benefit-Cost Ratio
BHP	Brake Horse Power
Bigha	Land measurement unit (one-third of an acre)
BKB	Bangladesh Krishi (Agricultural) Bank
Block	Sub-Union administrative unit comprising a number of villages
Boro	Irrigated rice grown in December - May
BRAC	Bangladesh Rural Advancement Committee
BRDB	Bangladesh Rural Development Board
BRRI	Bangladesh Rice Research Institute
BS	Block Supervisor
BSB	Bangladesh Shilpa (Industry) Bank
BSBL	Bangaldesh Samabay Bank Limited
BSERT	Bureau of Socioeconomic Research & Training (of BAU)
BSRS	Bangladesh Shilpa Reen (Credit) Sangstha (Organization)
BWDB	Bangladesh Water Development Board
CCDB	Christian Cooperation for Development in Bangladesh
CDP	Crop Diversification Programme
CFS	Cubic Feet per Second
CI	Corrugated Iron
CIDA	Canadian International Development Agency
CRWRC	Christian Reformed World Relief Community
Cusec	Cubic feet per second
DAE	Department of Agricultural Extension
DAP	Diammonium Phosphate
Doon	Open-ended canoe-like manually operated irrigation device
DPHE	Directorate of Public Health Engineering
DSSTW	Deep-Set Shallow Tubewell
DTW	Deep Tubewell
EU	European Union
FAO	Food and Agriculture Organization
GOB	Government of Bangladesh
Haor	Saucer-like depression, deeply flooded in the monsoon season
HP	Horse power

HYV	High Yielding Variety
ICB	Investment Corporation of Bangladesh
IDLC	International Development Leasing Company
IEB	Institution of Engineers, Bangladesh
IFDC	International Fertilizer Development Corporation
IFIC	International Finance and Investment Corporation
IFPRI	International Food Policy Research Institute
IIMI	International Irrigation Management Institute
IMP	Irrigation Management Programme
IPDC	Industrial Promotion Development Company
IRDP	Integrated Rural Development Programme
IRR	Internal Rate of Return
IRRI	International Rice Research Institute
JB	Janata Bank
Khatian	Land ledger showing titles of land with plot number
KSB	A Bangladeshi manufacturer of irrigation pump
KSS	Krishak Samabaya Samiti (Farmers' Cooperative)
Lakh	1 lakh = 100,000
LF	Large Farmer
LGED	Local Government Engineering Directorate
LLP	Low-Lift Pump
lps	Litres per second
MCPPI	Mechanized Cultivation and Power Pump Irrigation
MD	Man-day
MF	Medium Farmer
Mha	Million hectare
MOA	Ministry of Agriculture
MPO	Master Planning Organization
NBFI	Non-Banking Financial Institutions
NCL	National Credit Limited
NEMIP	North East Minor Irrigation Project
NGO	Non Government Organization
NMIDP	National Minor Irrigation Development Project
NPW	Net Present Worth
O&M	Operation & Maintenance
PD	Pair-day
POSB	Post Office Saving Banks
PDB	Power Development Board
PROSHIKA	Centre for Human Resource Development
Rabi	Winter dry growing season; non-rice crops grown during rabi
RCP	Rural Credit Programme
RDP	Rural Development Programme
RDRS	Rangpur-Dinajpur Rural Service
REB	Rural Electrification Board
RKUB	Rajshai Krishi Unnayan (Development) Bank
RPM	Revolutions Per Minute
SABINCO	Saudi Arab Bangladesh Investment Corporation
SACP	Special Agricultural Credit Programme
SB	Sonali Bank
SF	Small farmer
SFC	Specific Fuel Consumption
SPSS	Statistical Package for Social Scientists

SSC	Secondary School Certificate
STW	Shallow Tubewell
SYB	Statistical Yearbook of Bangladesh
Thana	Sub-district administrative unit comprising several unions
Tk/Taka	Bangladesh Currency (US$1 = Taka 40, approximately)
TP	Treadle Pump (manually operated irrigation device)
ULC	United Leasing Company
UNDP	United Nations Development Programme
Union	Sub-thana administrative unit comprising several blocks
Upazilla	Former administrative unit, equivalent to a thana
USAID	United States Agency for International Development
WB	World Bank
WHP	Water Horse Power
WM	Water Management

Abstract of Recommendations

Study on Privatization of Minor Irrigation

The policies associated with the privatization of minor irrigation in Bangladesh have included: a) a shift of distribution of equipment and inputs from the public to the private sector; b) the liberalization of: importation of equipment, standardization of scale and quality and the regulation of spacing; c) the dropping of subsidies for irrigation equipment; and d) the sale of publicly owned pumps. The Study finds that the first two of these policy changes have resulted in rapid growth of STWs and (to some degree) of LLPs --- a growth which has been shared by small farmers. The dropping of subsidies on DTWs, however, has highlighted the weaknesses of this technology. DTWs are not financially viable without subsidies --- either for owners or the command areas seen as 'farms.' Even the old level of subsidy is often insufficient to make DTWs competitive with unsubsidized STWs --- and most DTWs exist in locations in which STW technology is possible. Most DTWs do not even have sufficient return over O&M costs to cover the normal annual installments of bank loans covering the subsidized price.

Even for the relatively thriving STWs and LLPs there are areas where there is need for improvement in order to facilitate further development of irrigated agriculture. Many support services are underdeveloped (such as technical and aquifer information services, mechanical training, etc.) and credit is sufficiently inaccessible that farmers often disinvest in land and livestock in order to finance their irrigation equipment. Credit is also a limiting factor for equipment traders. For DTWs there is a question of what to do with the remaining DTWs in the field. Mechanical services and spare parts availability are often inadequate.

Based on the findings of the Study, the following recommendations are made by IIMI in the hope that they will be of use in the further development of the minor irrigation sector in Bangladesh. (A fuller development of these recommendations can be found in the last chapter of this report).

1. **Credit:** Further expansion and maturation of the minor irrigation market as well as the continued expansion of the network of dealers, workshops and other support facilities is being constrained by the lack of readily available credit supplied. Traditional formal credit programs have been unsuccessful in filling this need. Pending the lengthy process of needed general rural credit reform two recommendations are made to specifically target minor irrigation.

   a) Trade credit: Credit funds could be funneled directly through wholesalers and traders to enable small retailers and farmers to purchase equipment on reasonable credit terms. Under such a program, all costs of determining credit-worthiness and credit collection would be the responsibility of the wholesalers and traders. They, in turn, would have to post any collateral for the credit funds. This program would charge market interest rates and be self-supporting.

   b) For very small and landless farmers and women, a credit program through a Grameen Bank type model where loans are made to credit groups rather than to individuals is also a possibility for expanding ownership of minor irrigation equipment by small and landless farmers.

2. **Technical Information:** The Study found a degree of mismatch between engines and pumps --- possibly reducing the life of the pump and at least leading to a waste of fuel and the investment in equipment of more funds than are necessary. It is suggested that two publications (in easily understood language) be distributed free through all wholesale and retail dealers, workshops, credit suppliers, mechanics and extension agents. These guides would be for: a) how to best match engines and pumps given local conditions; and b) the provision of test data for the most popular engine and pump units in the country so that purchasers can make better informed choices.

3. **Hardware:** The low cost of the engines which have come into the country following the privatization policy package has fueled the recent growth of minor irrigation. The trade-off between cheap price and durability is recognized by farmers an the provision of technical information (above) should help buyers make informed choices. The market for equipment, given its low price, has expanded to such an extent that local manufacture of engines might now have sufficient economies of scale to succeed. Because price is so important for farmers it is suggested that encouragement of local manufacture not be done through trade restrictions (which raise price). There appear to be, however, various anomalies in the structure of current import restrictions on raw materials needed for engine manufacture. Attempts should be made to correct this situation so as to allow manufacturers to be more competitive.

4. **Spare Parts:** Local spare parts manufacturing has rapidly developed as the minor irrigation market has expanded. The making of more sophisticated parts would benefit from rationalization of raw material import restrictions (mentioned above). Quality control could be improved by the adoption of a reliable testing and labeling program. Spare parts dealers, who must handle large numbers of different parts, could use information and training on management information and inventory control.

5. **Mechanics:** With the elimination of BADC's mechanics training program there are few opportunities for proper mechanical training and little way of identifying which mechanics have proper training in the maintenance and repair of minor irrigation equipment. A program for training and reliably certifying mechanics could help extend the life of irrigation equipment as well as well as increase its efficiency.

6. **Aquifer Information:** The development and local-level dissemination of easily understood aquifer information would be a support service that could save pump owners from the expense of their present trial and error method of discovering the capacity of their aquifers. While market competition between pumps can appropriately determine command area (taking into account management, inputs, transaction costs, risk, etc. in addition to simple technical pump/engine capacities) the issue of possible, location-specific, long term declines in some water tables and the possible failure of certain aquifers to fully recharge must be addressed by a long-run program of monitoring and modeling of aquifers over time. Such a program would help the country to manage its water resources to optimize their use.

7. **Deep Tubewells:** The poor financial performance of DTWs (especially in comparison to STWs and LLPs) leads to the recommendation that, in areas where STWs can work, a phase out of DTWs might be encouraged. In areas where even deep-set STWs cannot function there is a question of how to enable already present DTWs to keep on functioning. In many areas the private market has not adequately been able to provide support services (repair and spare parts) for DTWs. The Government might establish a private sector program (possibly through an NGO or a Private contractor) to provide support services such as spare parts, mechanics, workshops and field equipment to keep these wells operating until they reach the end of their expected lives. Market rates could be charged the pump owners --- but some subsidy of organizational costs might be necessary to get the program going.

Non-subsidized DTWs are too expensive for individuals or groups to be interested in their purchase. In areas where alternative irrigation methods are not possible, other investment possibilities should be explored (including non-irrigation options). Programs for the spread of high value non-irrigated crops, rural industries, etc., might prove to be much more viable than the expensive DTWs. This point is applicable in the consideration of the replacement of existing DTWs when their useful lives run out as well as in consideration of new irrigation investment in such "high-land" areas.

Study Background, Organization and General Methodology [1]

INTRODUCTION

The International Irrigation Management Institute (IIMI), in association with the Ministry of Agriculture in Bangladesh, has been conducting a two-year study on the privatization of the minor irrigation sector. The purpose of this research is to assist the Government in reviewing the current status and impact of, and options and alternatives for, minor irrigation privatization, at the district and pump command-area levels. IIMI is working with BSERT (the Bureau of Socioeconomic Research and Training of BAU) in implementing this study. This work is funded under a Technical Assistance Agreement (T.A. No. 1822 BAN) between the Government of the People's Republic of Bangladesh, the International Irrigation Management Institute, and the Asian Development Bank. Recommendations are expected to be developed from this study for use by the Government and the Bank for future policy formulation. These recommendations will be determined with consideration to effectiveness, efficiency, equity, interaction with the physical environmental and economic viability.

Field work for this study has resulted in a large amount of data pertaining to issues relevant to minor irrigation privatization. Analysis of this material has resulted in the various research papers included in this document. These papers were presented at a final project workshop held in May 17-18, 1995 at the Bangladesh Agricultural Research Council (BARC) conference facilities.

STUDY DESCRIPTION

As it has been designed, this study of minor irrigation privatization includes relevant national and regional analyses but concentrates mostly on the district and pump-command levels. This research work has taken place mostly in five districts around Bangladesh—two of which (Bogra and Comilla) have been chosen because their minor irrigation development has been historically most advanced. Two other less-advanced districts (Hobiganj and Nilphamari) were selected as was a district more or less in between these extremes (Faridpur). Research tools were designed to examine market conditions for minor irrigation equipment, credit availability and effectiveness, warranty provisions and after-sales service, the provision of support services and associated agricultural inputs, and the role of public agencies such as BADC. At the pump level, the investigation has been looking at coverage, purchase, operation and maintenance and support services, as well as at the impact on farmers, landless groups and local economies, equity, economic viability and some aspects of the irrigation installations' interaction with the physical environment. The effects of privatization policy on demand and prices, taking into account the

[1]This background paper is prepared as part of the Study on Minor Irrigation Privatization in Bangladesh conducted by IIMI (the International Irrigation Management Institute) in association with the Ministry of Agriculture with funding from the Asian Development Bank. Research for the study has been done by IIMI and BSERT (the Bureau of Socioeconomic Research and Training of BAU, the Bangladesh Agricultural University).

impact of any monopolistic behavior, is also being looked at. The various tasks being undertaken to achieve the project's objectives include:

1. a review of previous and ongoing studies (and census results) of minor irrigation and the privatization process in Bangladesh, and a critical examination of the constraints, opportunities and impacts identified therein;

2. socioeconomic studies intended to identify the impacts of the privatization process on farmers and other target beneficiaries.

3. an examination of the district-level and local-level markets for minor irrigation equipment and its installation (including credit, financing arrangements and institutions, costs to the farmer), with a view to identifying the advantages, disadvantages and constraints of alternative methods of equipment distribution;

4. an examination of the district-level and local-level support services (fuel supplies, availability of inputs, servicing support, extension services) and the need, costs and effectiveness of equipment warranty provisions;

5. an examination of linked market development both for the provision of inputs and the sale of crops (i.e., the extent to which the markets are serviced through the same channels and to which the development of one or a subset of these markets facilitates the development of others);

6. a review of, and recommendations for, the district-level and local-level roles of BADC, other Government agencies and cooperatives in the establishment and support of the markets for irrigation equipment and support services;

7. an investigation of the impact of privatization in terms of efficiency, equity and economic viability, using a number of selected case studies of tubewell and low-lift pump sites (water distribution, water sharing/selling, water user groups, command area development and operation and maintenance aspects shall be studied as well as the initial purchasing, location, installation and resource utilization issues);

8. an assessment of the extent to which unregulated expansion of minor irrigation has led to environmental problems such as excessive drawdown leading to reduced availability of drinking water, competition for water between wells, etc.;

9. an examination of the effects of past, current and (by projection) future privatization policy on the demand for, and prices of, irrigation equipment and agricultural commodities, and assessment of the consequences for the farm budget;

10. an examination of the extent to which privatization has led to monopolistic behavior in the distribution of irrigation equipment and control of water, and any consequential loss of development opportunity;

GENERAL METHODOLOGY

Given the wide number of topics to be covered in this integrated minor irrigation study, a methodology had to be devised to get relevant analyzable information from the various types of actors who influence the irrigation scene or are affected by it at the district and local level. Pump owners, irrigating farmers, wage labourers, mechanics, irrigation equipment traders, complementary input dealers and support service providers all had to be included. Questionnaires were separately developed for all of these various categories of people and a sampling scheme devised (see below), which attempted to cluster different interacting groups in the same areas of the five study districts. The collected data was coded and analyzed (often using the SPSS statistical package) and the papers in this volume developed from the results.

Sampling

Between February and June 1994, interviews were conducted with sample pump owners (twice), irrigating farmers (twice), wage labourers (both men and women) in irrigated areas, rural mechanics, traders of irrigation equipment (both new and used), traders of complementary inputs and providers of minor irrigation support services. Technical measurements were made on a subset of the pumps associated with the sample pump owners. Detailed cropping and input/output information was also collected from farmers on a number of systems. In addition, less formal case study interviews were conducted among various traders and pump owners in May and October and with a few national-level importers and spare parts manufacturers at various times. In February 1995, at the beginning of the boro season, reinterviews were conducted with the sample pump owners and equipment traders. As rural credit is seen to be a particularly crucial area in a privatized minor irrigation sector, a specialist team was asked in early 1995 to prepare a report on rural finance for minor irrigation equipment that had more of a national-level focus—to complement the district and local-level work done during the rest of the study.

Details of sample selection are presented below. Broadly speaking, a rationale was developed for choosing a sample of minor irrigation pumps in five districts (three *thanas* each). Samples of farmers and wage labourers were chosen at a subset of the selected pump systems. Mechanics were also selected from the general localities of the pump sample. Irrigation equipment traders, dealers in complementary inputs (diesel/mobil and fertilizer/pesticides) and local officers of a variety of agencies providing support services for minor irrigation were all sampled in the five district headquarters and the thana headquarters—and in smaller towns even more local (when appropriate) in relation to the parts of the selected thanas in which the pump samples were clustered.

Pump owners survey

Out of a total sample size of 240 pump owners, 48 were chosen from each of the study districts. Using AST minor irrigation census data for each selected district it was determined what proportion of irrigated land had recently been covered by each of the main minor irrigation technologies—shallow tubewell (STW), deep tubewell (DTW) and low lift pump (LLP). The 48 sample pumps were chosen by technology type in proportion to the district prevalence of STW, DTW and LLP coverage.

Within each district, a randomized clustering technique was used. One thana was randomly chosen and two neighboring thanas were then picked—again randomly if there were more than two. Within each selected thana, a union was chosen randomly. Within that union a block was picked and within that block a village was chosen as the center of a cluster. As each thana was to have 16 sample pumps, the predetermined number of pumps for each technology category were selected by working outward from the central sample village.

To accommodate the fact that some study districts (Bogra and Hobiganj) each had two very distinct physical environments pertaining to irrigation technology choice, it was decided that in those districts at least one study thana would be from each of the two environmental areas. The third thana was selected to abut one of the others that had been selected.

The distribution of DTWs, LLPs and STWs by district and thana can be seen in Table 1.

Technical measurement pumps

For more detailed technical pump measurements, a subset of the 240 pump-owner survey systems was chosen. Within each study district one of the three study thanas was selected. Within that thana 10 pumps were chosen from the 16 in the original survey. These 10 were chosen randomly and in proportion to the overall district mix of technologies.

Again to accommodate the environmental distinctions in Bogra and Hobiganj districts, portions of the technical measurement samples in those two districts were taken from two different thanas—one each from the two environmental areas.

Irrigating farmers

At each of the ten pumps chosen for technical measurements a sample of seven irrigating farmers was selected at random after a population list of all farmers irrigating within the command area had been prepared. There were 70 farmers in each district and a total sample of 350.

Irrigator/farmer crop budget sample

Of the 70 farmers interviewed in each district, 24 were randomly chosen for further questioning as to details of their crop production so that crop budgets could be devised. In those districts in which the 10 measurement pumps had been divided between two thanas, the 24 crop budget farmers were also selected from the two thanas—with the number in each thana being in proportion to the number of selected measurement pumps. The total number of crop budget farmers was 120.

Men wage labourers

Wage labourers were defined as those who owned no more than half an acre of homestead and cultivable land and who worked as labourers in irrigation (or irrigated crop) related activities in at least part of the irrigating season. A sample was drawn from half of the irrigation units used for measurements. Sample irrigating farmers at those units were asked to name all wage labourers who had worked in their farms during at least part of the 1994 irrigating season. From the resulting list, a total of 30 men wage earners was selected in each district—for a total of 150.

Women wage labourers

For women wage workers, the selection method was the same as for men except that only 15 were selected in each district and the total was 75.

District- and local-level irrigation equipment traders

Within each district, sample traders were selected from the thana headquarters and local market centers associated with the unions from which other parts (pump owners, mechanics, farmers, etc.) of the broader study's samples had been chosen. District headquarter traders were also included if (as in the case of Bogra) the sadar thana was not already part of the original sample. Within each of the selected 5 district headquarters and 11 non-sadar thana headquarters, a population list of traders was developed. This list was divided into two groups: a) those dealing at least with engines or motors, and b) those dealing only in other minor irrigation equipment such as pumps, pipes, filters and spare parts. All the members of the first (engine/motor) category of traders were interviewed as well as 75 percent (chosen randomly) of the second category. In total there were 187 traders—63 in Bogra district, 34 in Comilla, 38 in Faridpur, 23 in Hobiganj and 29 in Nilphamari. Interviews, using a set questionnaire, were conducted during May 1994. In addition, less formal case study interviews of a number of traders were conducted in May and June of that year.

Traders specializing only in second-hand equipment were also sampled. In each of the study area's thana and district headquarters (16 localities given that some of the thanas were also district headquarters), population lists of exclusive second-hand irrigation equipment dealers were devised. Two of these dealers in each locality were selected randomly.

Complementary input traders

In each of the study thanas and district headquarters (16 localities), population lists were drawn up of all diesel/mobil and fertilizer/pesticide traders. In each of the localities, 3 of the diesel/mobil and 3 of the fertilizer/pesticide traders were randomly chosen. The selected diesel/mobil dealers were to include one filling-station and two barrel traders.

Irrigation equipment mechanics

In each of the 15 unions within which the sample pumps were located, a population list of irrigation equipment mechanics was drawn up. Two mechanics from each union were then randomly selected from these lists. In each study thana town, a list was made of all irrigation equipment workshops. One such workshop was chosen randomly from each of those towns—and one mechanic randomly chosen from each of the selected workshops. The total number of mechanic respondents was 45.

Support service agencies

For each district and thana office of relevant support service agencies (BADC, BWDB, BRDB, DAE, DPHE), an interview was conducted by senior research staff of the relevant officer in charge of irrigation or water related activities.

Banks, NGOs and insurance companies

In each district headquarters and one (non-sadar) thana headquarters, officials at the Bangladesh Krishi Bank (BKB) (or the related RKUB in some areas), Sonali Bank (SB) and Janata Bank (JB) were interviewed. In each district headquarters where they had local offices, interviews were arranged with representatives of BRAC, Proshika and RDRS. In each district, the most important local company dealing with irrigation equipment was selected for questions about insurance provision.

Electricity providers

In each study district, a PDB officer was selected for interview in the district headquarters and in one of the thana towns. For REB, an officer was chosen only in the district headquarters. There were, then, 10 PDB and 5 REB officers in total.

Table 1. Distribution of Sample DTWs, STWs and LLPs under the selected thanas of the five study districts.

District/Thana	Number of irrigation units			
	DTW	STW	LLP	Total
Bogra:	9	37	2	48
Dhunat	0	16	0	16
Kahalu	9	7	0	16
Sherpur	0	14	2	16
Comilla:	20	13	15	48
Comilla Sadar	7	4	5	16
Laksham	7	4	5	16
Langolkot	6	5	5	16
Faridpur:	5	39	4	48
Boalmari	1	13	2	16
Faridpur Sadar	3	12	1	16
Modhukhali	1	14	1	16
Hobigonj:	5	3	40	48
Bania Chong	2	0	14	16
Hobigonj Sadar	2	3	11	16
Nobigonj	1	0	15	16
Nilphamari:	7	39	2	48
Kishoregonj	0	16	0	16
Nilphamari Sadar	4	12	0	16
Saidpur	3	11	2	16
All 5 Districts:	46	131	63	240

Source: IIMI/BSERT 1994 Pump Owners Survey in Bogra, Comilla, Faridpur, Hobiganj and Nilphamari districts.

Evolution of Minor Irrigation Privatization in Bangladesh [2]

INTRODUCTION

Minor irrigation plays a crucial role in Bangladesh's agriculture and therefore in the national economy. Given its dense population and level of rural poverty, Bangladesh is very much in need of enhanced crop production. Almost all of its 9.1 million hectares of net cultivable area, however, is already in use and any additional crop output can only come from increasing yield or cropping intensity. Methods that are available to achieve these ends depend heavily on irrigation—particularly minor irrigation technologies comprising low lift pumps (LLPs), deep tubewells (DTWs), shallow tubewells (STWs) and manually operated pumps (MOP), which together are responsible for 80 percent of irrigation coverage in the country.

The start and early growth of minor irrigation relied heavily on public-agency action and support. While the public sector never actually operated more than a small number of pump schemes, agencies have until very recently been variously (and often deeply) involved in the procurement, distribution, installation and maintenance of irrigation equipment as well as in the supply of fuel/oil and spare parts. A process of minor irrigation sector privatization, however, began in the late 1970s. Since that time a number of policies have been instituted, which have had the effect of pulling back the Government's involvement in minor irrigation support and boosting the scope of activity of the private sector.

This paper attempts to examine the minor irrigation sector's evolution from public to private control and assesses the implications of this shift. What is the performance of a private management system in this sector in regards to productivity, equity and sustainability?

CONTEXT OF IRRIGATION DEVELOPMENT

Physical Features

Bangladesh is formed by the delta of the Ganges, Brahmaputra and Meghna rivers. A lack of suitable reservoir locations, the complexity of the deltaic river system and the continuing decline in dry-season river flows, however, make large-scale surface irrigation difficult and such systems make up only 6 to 7 percent of all irrigated area. The country does, however, have fertile alluvial soils and good sources of groundwater. Rainfall is from 1,200 to 3,500 mm per year, which is normally capable of completely recharging shallow aquifers during the rainy season from late May through mid-October. There are

[2]This paper has been prepared as part of the Study on Minor Irrigation Privatization in Bangladesh conducted by IIMI (the International Irrigation Management Institute) in association with the Ministry of Agriculture with funding from the Asian Development Bank. Research for this paper has been done by IIMI and BSERT (the Bureau of Socioeconomic Research and Training of BAU, the Bangladesh Agricultural University)—with M.A.S. Mandal and D.E. Parker having been particularly associated with its preparation.

24,400 million cubic meters of groundwater available for development—enough to irrigate 3.9 million hectares (Pitman 1993).

Cropping System

Rice and jute are the main wet season crops. During the dry winter and spring, the climate is suitable for irrigated rice as well as for wheat, pulses, oilseeds and vegetables. Given the predominance of rice in the Bangladeshi diet, rice has been the main irrigated crop of the dry season. HYV dry season rice, *(boro)*, is transplanted in January/February and harvested in May. With increases in minor irrigation, boro production grew at an annual rate of over 14 percent per year between 1980 and 1992 and could soon rival the monsoon *aman* rice crop in amount of production. This rise of irrigated boro is a major reason for the overall growth rate of 2.86 percent in the nation's annual rice production (Figure 1), a figure slightly larger than the population growth rate.

Crop production inputs such as human labour, draft power and most seeds are generally farmer supplied in Bangladesh. With the shift to HYV technologies, however, there has been a growth in importance of such purchased inputs as chemical fertilizer, pesticides, irrigation and power tiller services, etc., which are marketed through private-sector traders. There has been a concomitant rise in demand for agricultural credit, extension and marketing services that are currently being provided, to varying extents, by both the government and private sectors.

Agrarian Structure

With a rural population of more than 800 persons per square kilometer, Bangladesh is characterized by very small land holdings distributed rather unequally. Half of rural households have no land at all—with the landless working for cash or kind wage labour. Of those with some land, about 70 percent have up to one hectare, though this small farm category constitutes only 29 percent of total farm area. So-called large farms (those having over 3 hectares) cover 25 percent of the land. An average farm has 8 to 10 plots scattered over the territory of one or more villages. Roughly one quarter of the farm land is cultivated under some form of sharecropping or fixed-tenancy arrangement.

Irrigation Technologies

The various minor irrigation technologies differ in coverage and other characteristics. LLPs, while mostly of 1-2 cusec capacity, range from 0.5 to 5 cusecs and lift water from ponds and streams by use of suction. DTWs are normally of 2 cusec capacity and use a force-mode turbine or submersible pump technology. STWs (of 0.5 to 0.7 cusec nominal discharge) use suction-mode pumps. Taken together, these engine/motor driven minor irrigation technologies cover 2.3 million hectares (Mha)—82 percent of coverage by all irrigation technologies combined (Table 1). Of this area, STWs have 1.4 Mha, DTWs 0.4 Mha and LLPs 0.5 Mha.

EVOLUTION OF PUBLIC AND PRIVATE SECTOR INVOLVEMENT IN MINOR IRRIGATION MANAGEMENT

The development of minor irrigation in Bangladesh passed through a series of phases. At first, heavily dominated by the public sector, it underwent a transition period involving both public- and private-sector actors until it became predominantly a private-sector enterprise (see Table 2). This privatization transition roughly parallels that of other parts of the agricultural sector (such as fertilizer distribution, etc.) and has had domestic Bangladeshi inspiration and fitted in with a more general international movement towards the market provision for the production of goods and services.

Public-Sector Initiation Phase: 1951-1974

Prior to 1950, the only irrigation in what is now Bangladesh utilized manual lifting devices such as *doons* (open-ended canoe-like devices) and swing baskets drawing on surface water sources as well as dug wells to tap shallow groundwater aquifers. In the 1950's, however, public-sector attempts to modernize irrigation were institutionalized with the creation of what are now called the Bangladesh Water Development Board (BWDB) in 1959 and the Bangladesh Agricultural Development Corporation (BADC) in 1961. The Agricultural Extension Department (DAE) also started its Mechanized Cultivation and Power Pump Irrigation (MCPPI) program during this early period as well.

BWDB was primarily involved in developing canal irrigation projects but from 1962 to 1968 it also launched a tubewell project in the northwestern part of the country using 380 four-cusec DTWs. For these wells the agency provided electricity generation, pump operation and water distribution to farmers' fields. The project was heavily subsidized and bureaucratically managed and suffered major performance problems in terms of pump capacity utilization, irrigation coverage, water management, O&M and cost recovery from water users (GOB and FAO/UNDP 1977; Hamid et al. 1978; Bottrall 1983).

BADC, as the mainstream organization, entered minor irrigation through an LLP system in 1961 and a DTW program in the following years. The LLPs were initially operated by BADC's own field staff with diesel fuel supplied by the agency and the farmers being required to pay water fees on a unit-area basis. In 1969, BADC started renting the LLPs on a yearly basis and the farmers had to pay for fuel themselves. The DTW program of BADC began with 200 two-cusec wells installed in the Comilla area as an experimental program between 1962 and 1970. These DTWs were about 75 percent subsidized, were much less expensive than the earlier BWDB wells, and were rented to farmers' cooperatives (KSSs) organized by the Integrated Rural Development Program (IRDP). BADC supplied fuel/oil to KSSs, which were responsible for operation and maintenance of these DTWs. These BADC DTWs did have a better performance than the BWDB ones in terms of yield and cost recovery but well capacity was still seriously underutilized (Alam 1975). After Bangladesh's liberation war in 1971, BADC expanded its LLP and DTW rental programs and started to include STW rentals in the early 1970's—the latter of which was converted to a sales program after 1974-75.

Public-Sector Rationalization Phase: 1974-1979

A second phase of public sector control may be characterized by Government attempts to rationalize its minor irrigation program so as to lighten the budgetary and management burden of running an expanded number of pump schemes. By 1980, there were roughly 10,000 DTWs, 35,000 LLPs and 22,000 STWs (Figure 2). BADC maintained its control over DTW and LLP procurement, installation and rental. However, for LLPs, the agency stopped providing a pump operator—which necessitated direct farmer input into O&M activities. Also, STW subsidies were dropped to a very low level and a credit program for STW purchase was put into place through the Bangladesh Krishi Bank.

Private-Sector Expansion Phase: 1979-1984

From the late 1970s through the early 1980s, there was a continued effort to decrease public-sector involvement in minor irrigation and a gathering momentum in private-sector activity. The equipment rental programs were recognized as being too expensive for the public budget and as providing insufficient incentive for farmers to improve capacity utilization (Biswas et al. 1978; GOB/WB 1982; Bottrall 1983). Subsidized spare parts and repairs were also seen as creating a disincentive to the development of local repair facilities and manufacture of spare parts. As a result, there were simultaneous moves to discontinue LLP and DTW rental programs (though remnants of the DTW program lasted several more years) and shift to selling both new and old LLPs and DTWs to groups in the private sector. BADC continued its control of deep tubewell siting and installation and the provision of DTW spare parts and mechanical services through the late 1980s. For STWs, the boost of liberalized credit, decreases in import duties and the involvement of the private sector in equipment importation all led to a rapid increase in the number of wells. By 1983-84, the number of STWs was 120,000—though it was felt that progress could have been even faster if it had not been for cumbersome loan and tubewell sanctioning processes and problems within the agency bureaucracies that still provided spare parts and various other support services (Hamid et al. 1982).

A Return Towards Public-Sector Control: 1984-1987

In the 1983 dry season, there was a greater than expected drawdown of groundwater in a number of northern districts (Gill 1983). The alarm at this event seems to have triggered a response from the public sector that may have been partly a reaction to the erosion of agency control over minor irrigation during the previous decade. Actions taken in 1984 and 1985 included: a) a ban on STW sales in 22 northern subdistrict areas; b) an embargo on the importation of the small diesel engines used in STWs; c) standardization of engine brands; and d) formulation of the Groundwater Management Ordinance imposing a mechanism of spacing requirements on all tubewells. In addition, agricultural loan disbursements were decreased following prior irregularities and large loan repayment defaults. STW engine distributers and importers were also vilified (Palmer-Jones 1988). The result of these various actions was that STW expansion slowed in 1984 (Alam 1984) and practically stopped during 1985

through 1987. Meanwhile, the groundwater level in the northern districts, affected in 1983, had returned to normal in 1984 before any of the changed policies had taken effect.

More Private-Sector Liberalization and Expansion: 1987-

The slow growth of the minor irrigation sector of the previous years prompted the Government to remove the restrictions imposed earlier. In 1987, the ban on importation of small diesel engines was removed. In 1988-89, import duties on irrigation equipment were eliminated and the regulations on engine standardization and tubewell siting were rescinded. Private importation and sales of STWs and LLPs picked up sharply, though there was a temporary slow down following a doubling of diesel fuel prices at the time of the Gulf War. BADC started clearing off its equipment stock. There has been a maturing of the equipment market as it has spread from its earlier concentration in the national and regional centers to more fully served district and subdistrict areas. There has also been a proliferation of spare parts shops, repair workshops and private mechanic services at the local level.

DTW growth, however, has not shown itself to be sustainable in an unsubsidized environment. Major donors had continued to support large subsidies for this technology throughout the 1980s despite the poor economic showing of DTWs and their frequent placement in areas best suited to STWs (Hanratty 1983; Johnson 1985). More recently, both donor and Government policy has turned against DTW subsidies. New DTWs are no longer being purchased. In addition, without an active DTW sales and installation program there has been concern in some regions about the adequate provision of spare parts and major repair facilities for existing engines and pumps. BADC has fully withdrawn from DTW support and the transition to complete private-sector responsibility has been slow.

PERFORMANCE OF MINOR IRRIGATION PRIVATIZATION

The minor irrigation sector's transition from public to private control is now at a fairly advanced state of completion. What, then, has been the sectoral performance record that has accompanied this transition?

Growth in Irrigation Coverage

After 1979, the growth of STWs was very strong—except for the period from 1984-87 when multiple government controls were imposed. Between 1979 and 1984, the number of STWs rose from 22,000 to 147,000—an annual rate of 46 percent (Figure 2). Sales were almost nonexistent in 1985 and 1986, and picked up only marginally in 1987. With the abolishment of the government's restrictive measures in 1987 and 1988, sales again rose and STW numbers swelled at an annual rate of 14 percent, growing from 159,000 in 1987 to 349,000 in 1993. The growth rates of area irrigated under STWs closely reflected those for STW numbers and by 1993 these wells served 1.4 million hectares (Table 3).

During this same period, the number of LLPs (and their associated command area) rose at 4.3 percent a year to a total of 52,000 (496,000 ha) in 1993. DTWs, all installed under heavily subsidized

donor programs through BADC and BWDB, rose at a 5.5 percent rate to 26,000 in 1993—covering 437,000 hectares.

By 1993 the three engine/motor-driven minor irrigation technologies covered 2.3 million ha—26 percent of the nation's net cropped area, 34 percent of potential irrigable area and 82 percent of actual irrigated land. Seasonally, the growth in coverage has led to an increase in boro rice production from 2.6 million MT in 1981 to 6.8 million MT in 1992, an average rate of increase of 9.1 percent (Figure 1). Although the aman (rain-fed) rice crop still accounted for 51 percent of total rice production in 1992, boro's share of production had risen from 19 percent to 37 percent in the preceding decade. The expansion of minor irrigation during this period has provided the possibility of supplemental irrigation during aman, contributing to increases in its yield.

Range of Equipment Choice

The move to the private sector along with the dropping of standardization requirements opened the market to equipment of a wider range of price and scale. When given the choice, prospective pump owners largely opted for the much cheaper (though less durable) Chinese engines over the restricted choices they had previously, been limited to due to standardization policies. It is possible that these less-expensive engines, despite the farmers' awareness of their higher periodic repair costs, may have better fit prospective pump owners' financial conditions than did the more costly ones. In addition, many farmers began to buy from the newly available range of horsepower open to them and thus may have been better able to fit the scale of engine to the amount of land (often fragmented) they wished to irrigate.

Spare Parts and Servicing of Irrigation Equipment

As BADC withdrew from supplying spare parts and providing repair services, there was growth in private-sector activity in these areas—particularly in serving STWs and LLPs. Private workshops grew in most district towns and many subdistrict centers and the number of mechanics in those centers as well as in the villages has also risen. Local manufacturers began to produce pumps and spare parts. The quality and expected life of many of the popular inexpensive domestically produced parts, however, is less than that of imported ones.

DTW repair has become more of a problem since the withdrawal of BADC. The private-sector supply of spare parts for DTWs is not as widespread as it is for STWs and LLPs. In addition, the specialized equipment needed for some types of DTW repairs is not fully available in the private workshops.

Capacity Utilization of Equipment

The operation of DTWs was primarily through a rental arrangement from BADC until the early 1980s when both new and used wells were offered for subsidized sale. As the rental wells were sold very slowly, there were up to 12,000 DTWs under BADC's rental program for a further decade. In practice, the rental arrangement left the management of these wells almost wholly in the hands of some of the

DTW users. BADC continued to be formally responsible for repairs and the irrigators for paying their rent—though in a large number of cases these obligations were not fulfilled. Very often this situation resulted in poor tubewell maintenance as the locus of responsibility became blurred. It is perhaps partly for this reason (as well as due to the greater average age of the rental wells) that during the 1980s a trend seems to have developed in capacity utilization of DTWs (Figure 3). At the beginning of this period there was little difference in irrigated coverage between private and rental wells, with the rental wells perhaps showing a slightly better record. Later in the decade it became more and more common for private DTWs to have larger command areas.

STWs, though serving less land in absolute terms, have always displayed a higher proportionate coverage of their technically feasible command areas than have DTWs. Reasons for this may include:

a) Being unsubsidized, there has been an incentive for STW owners to cover as much land as possible.

b) As STWs are small and flexible they can easily be moved to places where they are best suited, even after their original installation—a characteristic not shared by DTWs. In some areas STW engines are used for more than one boring, increasing their capacity.

c) Management of their relatively small areas is easier than for DTWs, which typically have potential command areas that include the land of well over 100 irrigators.

Over time, for all types of minor irrigation equipment, there has been a slight downward trend in irrigation coverage per machine. Part of this trend can be explained by declining prices of rice and simultaneous increases in the cost of diesel and of inputs such as fertilizer. In some years, in some places, the number of pumping wells may also have caused a sufficiently large seasonal drawdown of the water table so as to affect the area covered. Overall, the reduction in irrigated coverage has been more pronounced among DTWs (both privately and publicly owned) than for STWs and LLPs.

Reliability/Adequacy of Irrigation Water

It is very possible that the reliability and adequacy of the supply of irrigation water in part depends on private, and particularly on unsubsidized, ownership. One comparison between technologies showed that STWs (which are privately owned and almost fully unsubsidized), due to their ease of management and relatively small command areas and volumes of water, had a better management performance ratio (the ratio between the total water applied and the amount of water demanded by the crops) than did DTWs (Dutta 1993). Within a small sample of DTWs, another comparison found that private wells provided water in a more timely and adequate manner than did rental wells (Hakim et al. 1991).

O&M Cost, Water Charge, Yield of Boro Rice

The costs of inputs to privately owned and operated minor irrigation equipment creates a high cash need during the irrigation season. In 1991, this cash need increased dramatically as the price of diesel doubled during the Gulf war and has never returned to its pre-war levels (Table 4). To meet these cash needs most minor irrigation charges have been high. Private wells, both STW and DTW, have in many cases had somewhat higher water fees than have rental DTWs. As a one-fourth crop share has been the most common fee arrangement during boro, the better water delivery of most private wells has been associated not only with better yields (which also depend on input use and soil quality) but also to a higher value of the water charge.

Profitability of Irrigated Boro Rice

The question of profitability is crucial to the sustainability of irrigated agriculture. Irrigated Boro cultivation is still normally profitable, but the profits have, however, declined during the 1980s due to rises in input costs relative to the price of rice (Mandal 1989). Labour and irrigation costs together normally account for two thirds of the total cost of production, so major increases in the prices of these inputs can greatly depress boro rice profitability. Returns to individual tubewell owners, therefore, can be quite unstable from year to year. These returns depend on area irrigated as well as on input costs. Farmers' demand for irrigation coverage fluctuates in response to the profitability of their crops, particularly of rice. For example, the authors found that in areas of Faridpur district, the 1994 irrigation coverage of many wells was 25-30 percent less than that of the previous year because the 1993 price of paddy had been exceptionally low (Tk 4,000/MT) and had discouraged farmers from planting boro in 1994. By contrast, in the Nilphamari area, a high tobacco price in 1993 (Tk 32,000/MT) induced farmers to greatly increase their demand for irrigation in 1994—though a large reported drop in tobacco price in 1994 is likely to again change that story in 1995.

Access of the Poor to Irrigation

With the expansion of minor irrigation there has been an expressed concern as to who has gained access to the benefits of this technology. Small farmers constitute a large proportion of the total irrigators in the typical pump command area but together irrigate only a much smaller proportion of the land. This unequal share of small farmers to irrigated land is structurally embedded in the existing inequality of land ownership distribution. For DTWs, it is also possible that the high transactions costs of organizing big water groups may put small farmers within a well's nominal command area at a relative disadvantage in regards to gaining access to irrigation water. DTW owners may, in places, prefer to attain their actual irrigation coverage by serving a smaller number of relatively large landholders rather than a larger number of small farmers. This latter consideration is unlikely to be very large, however, as plot location relative to the pump site is also important. Nearby plots, whatever their owners' farm size, suffer less conveyance loss than do plots farther away.

When small farmers are looked at not only as farmer irrigators but also as possible tubewell owners, the access question becomes more encouraging. A study by Mandal (1993), for example, demonstrated that small and medium farmers have gradually been gaining access to ownership of STWs since the time when the private sector took over the equipment trade. Small farmers' choices and options to buy irrigation equipment have considerably widened with the liberalization of import rules permitting the sale of low-cost small engines (mainly from China).

The growth in small-tubewell owners has greatly decreased the danger of what were earlier described as "landlords cum water lords." Instead, small operators irrigate whatever land they have, sell water to other farmers and earn only normal profits (after capital and input costs as well as risk are considered). Many of these people have begun to supplement their income with other irrigation related activities—as mechanics, drillers and spare-parts traders.

THE FUTURE: A CONTINUATION OF PRIVATE DEVELOPMENT OR A RETURN TOWARDS PUBLIC-SECTOR CONTROL

The transition from public to private control in the minor irrigation sector would appear, overall, to have had positive results in the nature and pace of expansion of STWs and LLPs. Private pumps seem also to be associated with a somewhat better supply of water—although, of course, at a higher (unsubsidized) water charge.

There are some unresolved issues, however. Public sector support services for a privatized minor-irrigation sector are currently underdeveloped. Such supports as aquifer and market information services, training, and better credit facilities could facilitate the functioning of private sector minor irrigation management. Also, the functioning of existing DTWs (even if few unsubsidized new DTWs are likely to be installed) is something of a concern. The better provision of major repair services for this technology may be of help.

Recently, concerns have also been expressed in some quarters regarding the possible negative impact of increased groundwater extraction through the private sector's expansion of tubewells. By these views, unregulated extraction of groundwater may lead to land subsidence, lowering of the underground water level, and a drying of drinking water pumps and surface water sources. The extent, frequency and duration of such damage is being debated—as there is some evidence (Pitman 1993) that most of Bangladesh's shallow aquifers would appear to be fully recharged each year and that the periods and places of seasonal excessive drawdown are small. During the occasional year of low rainfall or drought, that debate intensifies.

There has also at times been an expressed concern to protect prospective pump owners from unstandardized engines. This implies an assumption that farmers who purchase irrigation equipment are unaware that the inexpensive imported engines which now prevail in the market are less durable and may require more repairs than other options. This assumption may well be unrealistic.

While the development of public policy on these issues in the near future is not clear, the proponents for and against regulation and standardization are likely to continue their debate. From this paper's earlier examination of the evolution of minor irrigation privatization, it was apparent that whenever there was an increase in regulation and control, the result was slow growth in minor irrigation—greatly affecting the

transformation to a more profitable, equitable and productive agriculture. The costs associated with the (so far) limited and infrequent instances of excessive drawdown should be weighed against the likely negative side effects of attempting to solve the problem through reimposition of the previous regulation. Similarly, a position towards standardization should take into account prospective pump owners' financial constraints, their returns from irrigation investment and their needs for scale flexibility with respect to farm size and land fragmentation.

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Table 1. Number of minor irrigation equipment operated and total area irrigated in 1992-93 in Bangladesh.

Irrigation Technology	No. of equipment operating	Area irrigated (ha)	% of total area irrigated by minor irrigation
STW	338,281	1,349,839	50.5
DSSTW	10,594	42,359	1.6
STW TOTAL	348,875	1,392,198	52.1
LLP (<1 CFS)	12,338	44,139	1.7
LLP (1 CFS)	15,429	105,961	4.0
LLP (2 CFS)	24,084	336,065	12.5
LLP (3-5 CFS)	366	9,843	0.4
LLP TOTAL	52,217	496,008	18.6
DTW	25,714	436,857	16.4
TREADLE PUMP	114,421	19,448	0.7
ROWER PUMP	8,307	975	0.04
HAND TUBEWELL	11,990	1,990	0.07
TOTAL MOP	134,718	22,413	0.8
ARTESIAN OR TRADITIONAL	713,660	323,034	12.1
TOTAL MINOR IRRIGATION	1,275,184	2,670,510 (of minor irrigation)	100.0
In Addition			% of all irrigated area
CANAL IRRIGATION	-	172,805	6.0
NATIONAL TOTAL	-	2,843,315	100.0

STW = Shallow Tubewell
DSSTW = Deep-Set Shallow Tubewell
LLP = Low-Lift Pump
DTW = Deep Tubewell
MOP = Manually Operated Pump

Sources: 1) DAE/ATIA (1994)
2) BBS (1992) SYB

Table 2. Involvement of public and private sectors in minor irrigation development in Bangladesh up to 1992.

Public Sector:	**Private Sector:**
Prior to 1950 No government supports for irrigation development exist.	Use of traditional lifting devices from surface sources and dug wells plus pot irrigation for minor crops.
1950 - 1974 Start of Water Development Board (now BWDB) for canal irrigation.	
Start of Agricultural Development Corporation (now BADC) for pumping.	
BADC rents and operates LLPs and supplies fuel with 70-75 percent subsidy.	Farmers pay water fee on unit area basis.
1st Water Resources Master Plan, 1964	
First of BWDB's large scale canal systems built in late 1960's	Use of water by farmers almost free.
LLPs rented on annual basis by BADC starting in 1961	Farmers pay for fuel plus annual rental fee.
BWDB installs and operates 380 four-cusec pumps between 1962 and '66.	Use of water by farmers almost free.
BADC installs and rents out 200 two-cusec pumps at 75 percent subsidy.	Management and operation of tubewells by farmers cooperatives (KSS).
BADC starts supplying diesel for pumps.	
IRDP organizes cooperatives •	
BADC starts renting STWs in 1972	Farmers manage the tubewells.
BADC has a monopoly on procurement, distribution and installation of pumps.	
1974 - 1979 BADC stops operating LLPS in 1975 but continues renting them out.	Farmers operate LLPs themselves
BADC starts selling STWs with little subsidy in 1974/75.	Private farmer management of STWs.
BKB starts providing credit for STW purchase.	
1979 - 1984 Withdrawal in 1979 of remaining STW subsidy.	Private sector begins to import and sell STWs.
Private sector allowed to import and sell STWs from 1974.	Private repair workshops started.
	Private management of STWs by farmers.
Bank loans to purchasers of STW and to importers and distributer allowed in 1979.	Private sector manufactures pumps.
Import duty on STW sets reduced to 15 percent in 1980	
Approval of sanctioning and siting regulations.	

(Continued)

Table 2. (continued).

Public Sector:	Private Sector:
BADC stops renting LLPS and starts selling both new and used LLPs in 1980	
BADC starts selling new DTWs in 1979-80.	O&M by farmers. Large default on bank loans and rent payments.
BADC increases DTW rental fee from Tk. 1200 to Tk. 1800.	Private sector takes over diesel fuel, fertilizer and pesticide trading.
BADC starts offering rental DTWs for sale at subsidized rates in 1981-82.	
Bank loans for DTW purchase provided.	Private workshop and repair facilities grow.
BADC provides mechanics and spare parts service.	
1984 - 1987	
Sale of STWs banned in 22 northern thanas as a reaction to groundwater drawdown in 1983.	Sale of STWs dropped in those districts.
Ban on imports of small diesel engines in 1985.	Private sector trade limited to a few standardized engine brands.
Standardization of engine brands for agricultural use in 1985.	
Bank loans decreased in 1984-85.	
Formulation of groundwater management ordinance and rules in 1985.	Restricted siting of tubewells through spacing regulations and ban on siting within surface water schemes.
1987 -	
Removal of small engine import ban in 1987.	Private sales of STWs picks up from 1987-88.
Removal of import duties on small diesel engines in 1988-89.	Private STW sales sharply increase.
Abolition of standardization restrictions on engines in 1988-89.	Cheaper STWs start selling and multiple engine brands and sizes enter the market.
Withdrawal of tubewell siting restrictions in 1988-89.	
Increase in diesel fuel price from Tk. 6.90 to Tk. 14.14 per litre in 1990-91.	Sale of STWs slows.
Siting restrictions nominally reimposed in January 1992.	STW sales recover in 1991-92.
Siting restrictions again withdrawn in August 1992.	Market for engines, pumps and spare parts spreads.
BADC starts clearing out its stock of irrigation equipment starting in 1990.	Local repair workshops and rural mechanics grow rapidly.

Sources: Bottral 1983
Palmer-Jones 1988
Ministry of Agriculture 1991
David 1994
Hanratty 1983

Table 3. *Total area irrigated by different irrigation technologies from 1982-83 to 1992-93 in Bangladesh.*

Years	Area Irrigated ('000 ha)					
	STW	DTW	LLP	TRADITIONAL	CANAL	TOTAL
1982-83	371.5	234.3	337.1	405.5	160.3	1508.7
1983-84	480.0	263.2	342.0	372.3	136.4	1593.8
1984-85	586.4	286.9	351.3	384.1	147.3	1756.0
1984-86	586.4	303.9	356.1	314.0	163.1	1723.5
1986-87	639.4	317.7	385.7	326.2	155.4	1824.4
1987-88	753.1	344.8	401.8	433.4	114.9	2048.0
1988-89	941.3	380.4	482.4	391.3	169.6	2365.0
1989-90	1037.2	384.1	484.0	477.9	176.4	2559.6
1990-91	1078.5	365.4	513.1	498.2	172.8	2628.0
1991-92	1233.9	433.8	500.2	316.5	172.8	2657.2
1992-93	1392.1	436.7	496.2	322.9	172.8	2820.7

Note: These calculations are based on assumed average command areas of 4 ha per STW, 17 ha per DTW and 9.5 ha per LLP. This assumption may be somewhat unrealistic in that the average command areas per unit of equipment are very likely to have declined over the years due to: a) competition (or encroachment) for irrigable plots between units; and b) the introduction of smaller engines for use with both STWs and LLPs in recent years.

Source: David (1994).

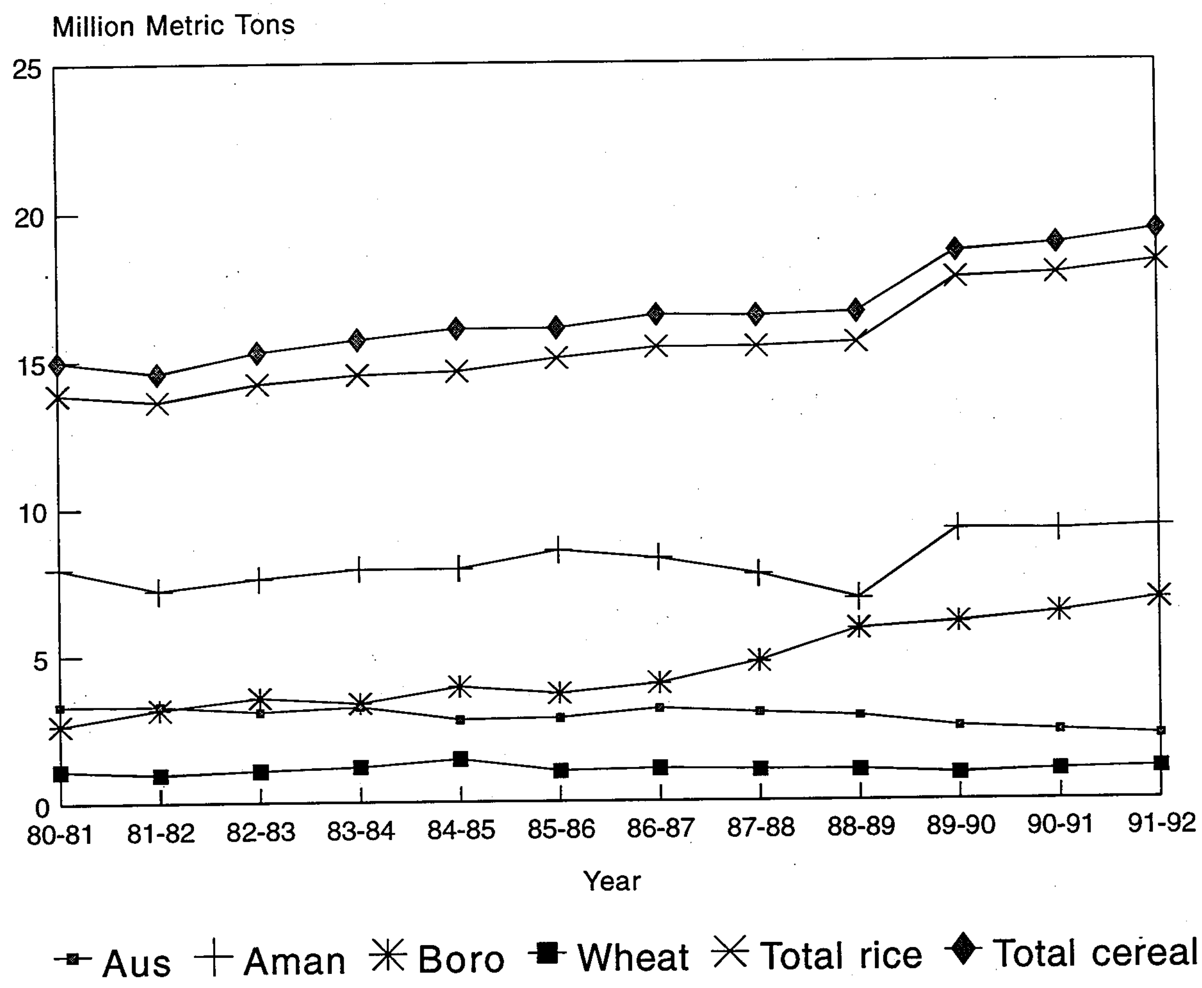
Table 4. Yield of boro rice, O&M costs and water charge in the boro season.

Management system/ Technology	Area irrigated (ha/well)	Yield (MT/ha)	Average O&M cost (Taka/well)	Average O&M cost (Taka/ha)	Average water charge (Taka/ha)	Water charge as as % of O&M cost
Rental DTW (Rajshahi)						
1990	21.6	3.4	36390	1685	3272	194
1991	15.6	4.6	51591	3320	4026	121
Private DTW (Rajshahi)						
1990	23.7	4.8	37921	1602	3928	245
1991	18.01	5.6	62534	3472	6621	190
Private & Rental DTW (Tangail)						
1990	15.78	4.4	37520	2378	5610	236
Private & Rental DTW (Jhenidah)						
1990	19.00	4.29	39980	2104	3490	166
Private STW (Tangail)						
1990	4.28	4.6	12800	2990	5665	196
Private STW (Jhenidah)						
1990	2.52	4.7	7749	3075	6414	208

Notes:
a. Currently US$1 = Taka 40, approximately.
b. Diesel price was raised by the government from Taka 6.90/litre to Taka 14.14/litre.
c. One-fourth share of the crop was paid as water charge for Tangail DTWs and STWs.

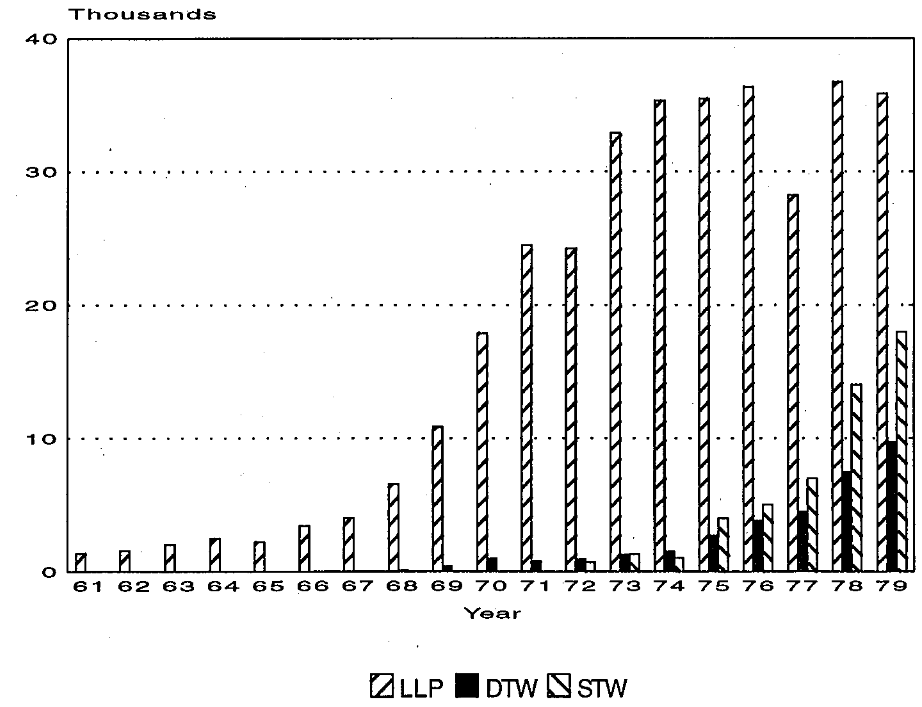
Sources:
i. Data for Rajshahi DTWs are from Hakim et al. 1991.
ii. Data for Tangail and Jhenidah STWs and DTWs were compiled from a Field Survey conducted by Mandal in 1990.

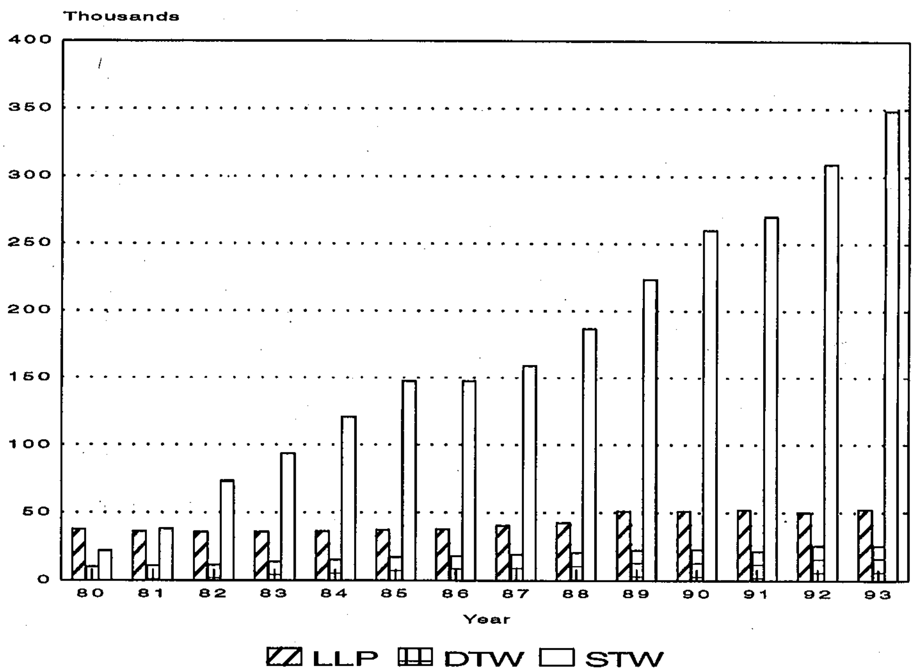
Figure 1. Total cereal production in Bangladesh, 1980-81 to 1991-92.



Source: BBS, 1990; 1992; 1993; Khalil, 1991.

Figure 2. Number of minor irrigation equipment in Bangladesh, 1961-62 to 1992-93.

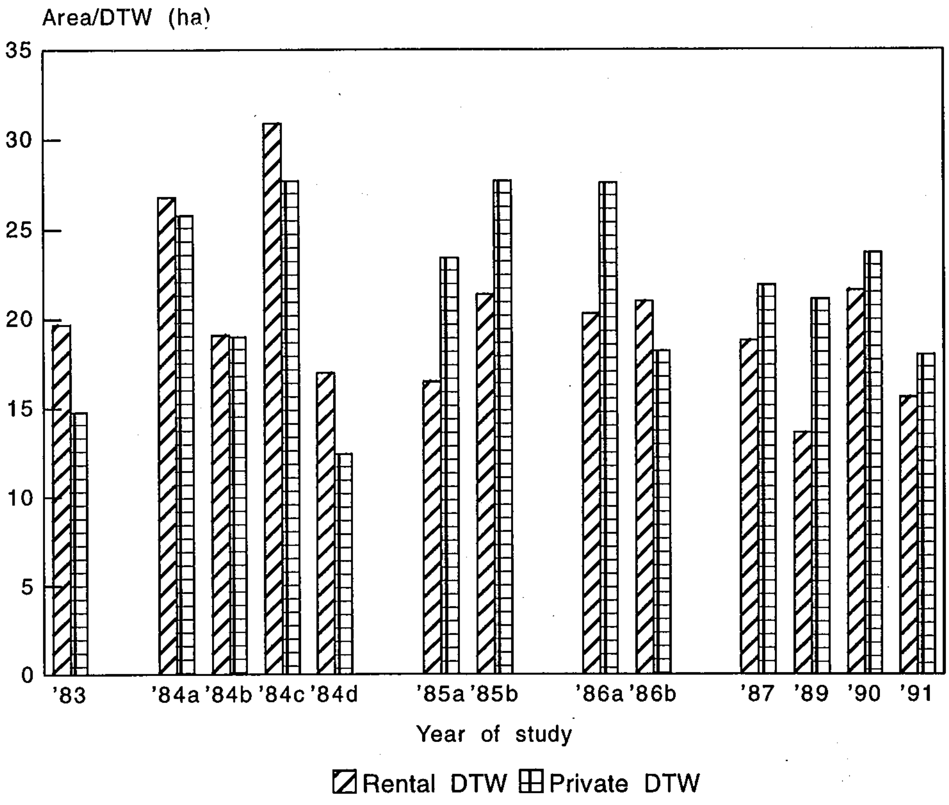




Note: Years refer to financial years, e.g., 80 refers to 1979-80 and so on.

Source: Hanratty 1993; Gisselquist 1991; David 1994; Hamid 1991; BBS 1993; AST 1989.

Figure 3. Irrigated boro area per DTW (ha).



Note:'83 refers to 1983 and so on.

Sources: Data refer to different locations and are collected from different sources. 1983 data on diesel and electrically run DTWs are from Quasem, 1985. 1984a data on electrically run DTWs are from Shikder, 1986. 1984b data on diesel run DTWs, and 1984c data on electrically run DTWs are from Mandal, 1984. 1984d data on DTWs are from Hamid, 1993. 1985a data on diesel and electrically run DTWs, and 1985b data on diesel and electrically run DTWs are from BAU, 1985. 1986a data on diesel run DTWs, and 1986b data on electrically run DTWs are from Mujibullah, 1987. 1987 data on diesel and electrically run DTWs are from Bashar, 1987. 1989 data on diesel and electrically run DTWs are from Akteruzzaman, 1990. 1990 and 1991 data on diesel run DTWs are from Hakim, et at. 1991.

Pump-Level Performance of Minor Irrigation: STWs and LLPs[3]

1. INTRODUCTION

Shallow tubewells (STWs) and low-lift pumps (LLPs) were introduced as part of the minor irrigation sector in Bangladesh through public sector programs. Given that these technologies are small and their operation is of necessity decentralized, there have been elements of private-sector involvement with these irrigation technologies from their earliest days. Agency control of technological choice, importation, and distribution, however, continued well into the 1980s. Along with other privatization policies affecting the distribution of inputs in agriculture, there has been a concerted effort during much of the last decade to turn these functions over to market forces.

For STWs and LLPs, the major elements of privatization policy in this regard have entailed the liberalization of the importation of engines and spare parts by private-sector traders and their distribution through open-market sales (Quasem 1985), removal of engine standardization restrictions, withdrawal of pump spacing and siting regulations, and withdrawal of subsidies on irrigation equipment prices (MOA 1991). As the implementation of these policies continues, there is recognition that there have been real accomplishments of the program—but there is also a need to examine how issues of minor irrigation growth, sustainability and equitable access are faring under market development of minor irrigation (UNDP 1989; Task Forces.. 1991).

One of the most notable impacts of the privatization policy shifts has been that small and inexpensive diesel engines for STWs and LLPs are now widely available in the market. Their number had started to grow in the early 1980s but had slowed by the middle of the decade with the imposition of various regulations (Alam 1984; Palmer-Jones 1988). The full impact of more liberal policies started to take effect in 1987/88. Since that time the market has been dominated by inexpensive engines from China, which have displaced the sale of more expensive (but also more durable) engines which had come mostly from Japan.

How well, then, are STWs and LLPs doing in the field? Papers elsewhere in this document discuss a number of related technical and socioeconomic issues associated with the district and local-level spread of minor irrigation.[4] In this paper the focus will be on the pump-level performance of STWs and

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[3]This paper has been prepared as part of the Study on Minor Irrigation Privatization in Bangladesh conducted by IIMI (the International Irrigation Management Institute) in association with the Ministry of Agriculture with funding from the Asian Development Bank. Research for this paper has been done by IIMI and BSERT (the Bureau of Socioeconomic Research and Training of BAU, the Bangladesh Agricultural University)—with M.A.S. Mandal, W.M.H. Jaim and D.E. Parker having been particularly associated with its preparation, with additional inputs from S.C. Dutta.

[4]See papers in this volume on: Deep Tubewells After Privatization; Minor Irrigation Privatization: Some Equity Issues; Profitability of Irrigated Crop Production Under Minor Irrigation; Technical Aspects Affecting the Selection and Operation of Minor Irrigation Equipment; Water Adequacy Issues; District and Local Level Markets for Minor Irrigation Equipment; Support Services for the Minor Irrigation Sector; Enhancing Rural Finance for Minor Irrigation Equipment .

LLPs—concentrating on issues of profitability, procurement, coverage and prospects for further growth as seen from the pump level. Specific topics include:

a) Pump owners' experience with the procurement of minor irrigation equipment and spare parts.

b) The growth and coverage of STWs and LLPs.

c) The financial viability of STWs and LLPs—both for pump owners as well as for the full irrigated command areas (or "farms") served by the pump schemes.

d) A financial returns comparison of the dominant pre-liberalization technology (some of which is still in the field) and the prevailing post-liberalization technology.

e) Pump owners views of how the future development of minor irrigation can be enhanced.

2. DATA

This study is based on field surveys of 131 STW owners and 63 LLP owners selected from 15 thanas of 5 districts (Bogra, Comilla, Faridpur, Hobiganj and Nilphamari).[5] Bogra and Comilla had been selected as they represent the most-developed minor irrigation areas in the country. Hobiganj and Nilphamari, on the other hand, were relatively late starters—and Faridpur falls somewhere in between. Out of the 131 sample STWs, 120 (81%) had diesel engines and 11 (9%) were run by electric motors. The LLP sample included 46 (63%) diesel and 17 (37%) electric units for a total of 63.

Data were collected through direct interviews with the sample pump owners using structured questionnaires in February and June 1994. A repeat survey of the pump owners was also done in early February 1995 in order to clarify some of the 1994 findings. While the overall financial analysis has been done for all the STWs and LLPs, a comparative financial appraisal is carried out for only STWs with 4-8 horsepower capacity diesel engines representing the dominant pre-liberalization technology as well as the prevailing post-liberalization type.

3. PROCUREMENT OF STW AND LLP EQUIPMENT

As a result of the expansion of market distribution through private-sector traders, a large proportion of STW and LLP engines in the sample were purchased at the district- and thana-market levels (Table 1). With the growth of local equipment shops, equipment buyers could easily verify the quality and prices of engines they wanted to buy. Some farmers, especially those buying an engine for the first time, took

[5]For sampling details and methodology see the paper in this volume on Study Background, Organization and General Methodology.

the assistance of a local mechanic in making their choice—paying a small fee or agreeing to use the mechanic when needed for repairs and servicing.

Some pump owners also bought old engines from other farmers who were either replacing their engines or dropping out of the minor irrigation business. The 1995 repeat survey showed that 4 out of 120 STW owners who were still operating in 1995 had replaced their engines (3 with new engines and 1 with an old engine). Two of the 11 STW owners who had discontinued their operations after 1994 had sold their engines after using them for an average of 6.5 years. Similarly, 6 out of 56 LLP owners still operating in 1995 had replaced their old engines with new or different old engines.

Survey data indicates that there has been a significant reduction of engine prices since the implementation of the liberalization policies of the late 1980s. The Japanese engines that had dominated the market before the liberalization cost the pump owners an average of Tk 35,000—while the presently prevailing Chinese engines of the same horse power (but with less durability and original quality) cost Tk 9,500. This estimate of engine price reduction seems reasonable, given an earlier estimate by Hamid et al. 1982, which showed that a new Japanese engine would cost an average of Tk 22,000 in 1981-82 prices, which was equivalent to US$1,130 at that time.

One of the implications of this reduction in engine price is that the irrigation equipment became much more affordable to interested farmers. Most purchases have been with the owners own funds given the difficulties attendant on getting credit.[6]

4. GROWTH OF STW AND LLP IRRIGATION

In the following sections, three aspects of the growth in STW and LLP irrigation are examined:

- Growth in the number of STW and LLP units
- Changes in area coverage
- Competition in the water market.

4.1 Growth in Number of STWs and LLPs

A complete census taken of all STWs and LLPs in operation in 96 villages in the 5 study districts (9 villages in Bogra, 31 in Comilla, 14 in Faridpur, 29 in Hobiganj and 13 in Nilphamari) shows that there has been a sharp growth in all the districts in terms of the number of operating STWs during the period 1988/89 and 1994/95. There has been a moderate growth in the number of LLPs during the same period. STWs grew at an annual rate of 32 percent, whereas LLPs grew annually at a rate of about 3 percent (Table 2 and Figures 1 and 2). Districts more advanced in minor irrigation development, Bogra and Comilla, showed somewhat higher growth rates per year (39% and 40%, respectively) than did the later

[6]See also the papers from this study on Support Services for Minor Irrigation and on Minor Irrigation Privatization: Some Equity Issues.

starting districts of Nilphamari (32%), Faridpur (26%) or Hobiganj (4%). The latter district has very few shallow tubewells.

As regards LLPs, the districts of Comilla and Hobiganj, which had 55 out of the 63 LLPs in the sample, showed contrasting pictures. While Comilla villages had a moderate increase in number of LLPs of about 19 percent per year, Hobiganj (which is characterized as a surface water irrigation area) had virtually no growth in its number of LLPs. Faridpur had a sharp decline in LLPs due to a reduction of surface water sources.

Treadle pumps, an improved manually operated pump, had a growth of 22 percent per year in Nilphamari, but lost out (-17%) in Bogra. Only one treadle pump existed in the study villages of Faridpur (Table 2).

It might be noted that the observed growth in number of STWs and LLPs is not unidirectional. Every year there are increases as well as decreases in the number of tubewells and pumps. This study's census of operating irrigation equipment in the study's 96 villages in 1994 and 1995 showed that the number of additional STWs and LLPs installed in 1994/95 were more than the number of STWs and LLPs dropped in that year, meaning a net increase of 15 percent for STW and 5 percent for LLP (Figure 3).

4.2 Changes in Boro Irrigation Coverage per Pump

The increased number of tubewell installations generally has been associated with something of a decrease in command area per pump—though the strong increase in the number of pumps has greatly increased total irrigated area. In all the districts (except Nilphamari, which showed some increase in boro coverage per pump) there has generally been some decline in boro irrigation coverage per STW. The overall range has been from 3.56 ha in 1988/89 to 2.80 ha in 1993/94, a reduction rate of about 4 percent per year (Table 3). Generally tubewell owners attributed the reduction in their command area mainly to an increase in the number of installations in their communities—and hence to increased competition between tubewell owners for irrigable plots (a point that is further elaborated in Section 4.3). The lower quartile (in 1993/94) of the 104 STWs had only up to 1.47 ha in boro command area, whereas the upper quartile had more than 3.64 ha. While the command area of the diesel STWs declined by 0.92 ha per pump over the period, electric STWs gained 0.68 ha per pump, conceivably due to a greater discharge from electric pumps.

But what does this reduction in average command area per tubewell mean in regard to growth in total irrigated acreage given that the total number of STWs grew over the period. A crude estimate based on survey data shows that total area irrigated by STWs for boro rice in the study villages (number of STWs multiplied by average command area per STW in the 96 study villages in 15 thanas of the 5 selected districts) grew from 922 ha in 1988/89 to 1823 ha in 1993/94 (a growth rate of 20% per year). This rate of growth is very close to the DAE/ATIA estimate of a 19 percent annual growth in total STW coverage for the period 1990/91 to 1992/93 (DAE/ATIA 1994).

In Nilphamari, there has been an increase in average command area coverage per STW over the period 1988/89 to 1994/95, possibly because STW irrigation has only started to take place recently and competition for boro land is not yet as intense as in other districts. Tobacco is the main irrigated crop in two thanas (Nilphamari sadar and Kishorgonj) under study in Nilphamari district.

Changes in STW command areas were also influenced by the changes in profitability of main irrigated crops of farmers. For example, in Faridpur the average irrigation coverage per STW was considerably reduced in 1993/94 compared to the previous year (1992/93) because the low paddy price in the 1993 boro season in this district discouraged many farmers from growing irrigated boro rice in 1994.

Low-lift pumps, on the whole, showed somewhat of an increase in command area (0.44 ha per pump). This was due mainly to increases in Hobiganj, which counterbalanced decreases in Comilla, the other study districts with a significant number of LLPs.

4.3 Competition in the Irrigation Water Market

The reduction of engine prices has brought about elements of competition in the irrigation water market inducing individuals or groups of farmers to procure tubewells and pumps for irrigating their own land and for selling water to other farmers. All the sample STWs, except one, and all the LLPs were privately owned and managed. 84 percent of the STWs and 73 percent of LLPs were owned by only 1 owner, whereas the remainder were owned by 2 or more owners per pump (Table 4).

There were, on average, 13 irrigating farmers served by each STW (ranging from 1 to 40 farmers) and 34 irrigators served per LLP (ranging from 1 to 150). A case study illustration of how a part-time farmer bought a STW and turned into a full-time farmer irrigating his own land as well as selling water to other farmers is presented below:

Interview with a STW Owner

The present owner of the STW had been working at a printing press for 24 years until recently. But because of the computerization of that work he was made redundant. At that time he was a part-time farmer, but now he regards himself as a full-time farmer. He bought the engine about one year before this coming aus season. Before he bought the engine he had a professional drill a bore, and by using someone else's engine he was able to check whether there was sufficient water. The engine is 8 HP and the bore is 100 feet deep, of which 40 feet is plastic filter pipe. The engine cost him Tk 10,500, the pipe Tk 6,000, the KSB Dhaka pump Tk 2,800, drilling the well Tk 1,500 and he spent another Tk 1,700 on gravel and stones. In addition, he paid Tk 1.500 for transport costs and to construct a small hut for the engine.

Last boro season the owner irrigated 4.8 acres, of which 2 acres belong to him and his 2 brothers. He personally owns 0.8 acres. A total of 11 farmers received water from the STW, including himself and the brothers. If necessary, the STW can potentially irrigate 8 acres (by capacity), but he thought it wiser to first try to serve a smaller area. This was the first time that the fields were irrigated by a well.

The basic idea of installing the well was to have water for his brothers and himself. But as other farmers wanted to buy water they were most welcome. He also charges his brothers for the water they use. After he had calculated all the costs for fuel and his own labor costs, he decided that Tk 800/40 decimal/season (Tk 2,000 acre/season) would be a reasonable price. This is the normal price in this area for STWs. For the boro season he had to supply 8-9 irrigations. Normally, water is supplied to the most distant plot first.

He bought all the equipment from a retailer in Comilla, as there are no other irrigation equipment shops closer to Gazipur. He only went to two different shops. Initially he had thought that he would buy all the equipment from one particular shop, the owner of which is known to him. This man wanted to charge him

Tk 12,000 for the engine. But then he found out that in the other shop the same engine would cost him Tk 10,500, and so he bought all the equipment from the second shop. He chose a Chinese engine because they are the cheapest and spare parts are readily available. He bought the engine by paying cash, but he borrowed Tk 8,000 from a local person and will repay the principal plus Tk 3,000 interest over 2 years.

He didn't take a mechanic along when he went to buy the engine as someone had told him that the shop keepers might charge him Tk 1,000 higher if he went with a mechanic.

Because of the poverty of the farmers there are very few STWs in this village. Another reason for the low number of STWs was the lack of "demonstration effect." Now that he has started you can see that other farmers have picked up the idea to buy a motor or an engine. According to the owner, farmers want to buy their own engines, rather than start a cooperative of engine owners as partnerships always give trouble.

Competition

The competition in the water market, which has been accompanied or promoted by the availability of less expensive engines has, as noted earlier, meant entry as well as exit of pump owners in the irrigation business. For example, 77 out of 131 STWs owners (59%) and 17 out of 63 LLP owners (27%) reported the siting of competing pumps near their own pumps during the last 5 years. The 1995 repeat survey also confirmed that an average of 1.5 STWs (there was a range of 1 to 6) were installed during the preceding year with close to 42 out of 120 STWs in operation. In contrast, 10 out of 120 STW owners reported withdrawal of STWs that had previously been competing with their own STWs—though some of these tubewells only changed sites to nearby locations.

STW owners attributed the growth in siting of competing tubewells to the availability of cheaper STW engines, profits from water selling and conflicts or rivalries with other pump owners. Their estimates of gains and losses in command area due to increasing competition between tubewells ranged from a gain of 0.94 ha to a decrease of 1.78 ha per affected STW—or an average decrease in command area of 0.84 ha.

Scope for Expansion

When asked if there is any scope for expanding coverage of their STWs and LLPs, 70 percent of sample STW owners and 56 percent of LLP owners were affirmative. Those who did not see any scope for expansion of area under their machines (i.e., 30 percent STW owners and 44 percent LLP owners) identified the increased number of installation of competing pumps as the most important reason (frequency of responses were 83 percent for STW and 71 percent LLP).

Nevertheless, 58 percent STW owners and 48 percent LLP owners reported that there were plots left unirrigated within their potential command areas. According to pump owners' opinions, those plots were left unirrigated due to a combination of reasons such as their own cash constraints preventing the coverage of extra land, unsuitability of some plots for irrigation (i.e., sandy soils or high land), farmers' preference for growing of non-irrigated crops in those plots, etc. It is implied that many of the plots that are temporarily unirrigated within the potential command areas could be put under irrigation if the pump owners' cash constraints were to be relaxed and/or if the profitability of irrigated crops were to improve (i.e., through a rise in output prices).

4.4 Crop Coverage

In the past, irrigation has mainly been used for boro rice. Although boro irrigation still dominates for STWs, there is somewhat more of a spread to non-boro rice crops for this technology than for LLPs and DTWs (Figure 4). This is particularly true for STWs with small horsepower engines. These small STW engines are easily moved from one site to another and thus seem more appropriate and flexible for year round irrigation for rice as well as non-rice crops. LLPs were generally used in low land areas particularly suitable for boro irrigation and therefore the use of LLP irrigation for non-boro rice was quite negligible.

5. IRRIGATION WATER CHARGES

The expansion of minor irrigation in the private sector has also given rise to a variety of payment systems for water. Pump owners who are cash constrained generally charge machine rental in cash—which differs depending on whether the pump owner or the irrigating farmer provides the fuel. Those who can pay O&M expenses up front often charge the water users a cash payment or one-fourth to one-third of the crop at the end of the season. For the 28 out of 103 STW owners practicing the crop-share payment system the water charge was 62 percent higher than for those under a cash payment system with managers providing the fuel (Table 5).

In the late-starter or less-advanced districts such as Nilphamari and Faridpur, STW water charges were significantly higher than in the more-advanced minor irrigation districts of Bogra and Comilla. This may be because there is, so far, less intense competition between wells in the late starter districts.

Overall, STW water charges increased by about 41 percent and LLP water charge by 47 percent over the last five years, irrespective of system of payment for water. The observed increase in water charges are more or less in line with the overall increase in O&M costs over the same period (i.e., 98% increase in diesel price, 25 percent increase in wage rate, 23 percent increase in electricity price and 30 to 50 percent increase in prices of spare parts). Further, for tubewells that collected water charges in terms of crop-share, the share payment remained essentially unchanged.

6. REPAIR AND MAINTENANCE SERVICE

This study shows that significantly larger proportions of pump owners reported easier availability of irrigation machines (94%), spare parts (95%), rural mechanics (89%) and tubewell drillers (71%) in 1994 compared to 5 years before. Availability of trained mechanics was reported to be a problem, however. Only 58 percent of STW owners and 67 percent of LLP owners said that mechanics were readily available whereas the remaining pump owners reported delays (sometimes long) (Table 6). Many of the mechanics did not have formal training, which affected their quality of work, but they were also paid lower fees than the more trained ones.

7. O&M COSTS OF STW AND LLP FOR BORO IRRIGATION

Operation and maintenance costs of the tubewells include initial housing and machine overhauling costs, spare parts, cost of fuel/electricity, repair and maintenance, seasonal construction and maintenance of irrigation channels, salary and incidental costs of linemen/drainmen. Average total O&M cost per diesel operated STW (Tk 8,634) was lower than for electrically operated STWs (Tk 14,508). For LLPs, average O&M costs were Tk 14,451 and Tk 32,477, respectively for diesel-operated and electrically operated ones (Table 7). In both cases, electrically operated pumps had larger boro command areas than the diesel operated ones. A comparison of O&M cost per ha between technologies showed that while electrically operated DTWs and LLPs had lower O&M costs than did diesel ones the opposite was true for STWs. Case study interviews at various locations indicated that electric STWs had comparatively more informal or unmetered connections (meaning payment of higher electricity costs based on flat rates or guesstimates) than did electric DTWs and LLPs (which were more established and had more metered connections).

8. RETURNS TO STW AND LLP OWNERS FROM BORO IRRIGATION

Pump owners' gross returns have been estimated on the basis of area irrigated by the pumps multiplied by water charges. Water charge calculations have taken into account different modes of payment for water (e.g., cash payment with fuel provided by managers, cash payment with farmers' fuel, hourly payment with managers' fuel or farmer fuel, payment of crop share, etc.).

Net returns were estimated by deducting O&M costs from gross returns (water sale proceeds from boro irrigation). The pump owners have had, on average, returns of Tk 6,859 per STW and Tk 17,998 per LLP in the 5 study districts (Table 7). Electric STWs and LLPs generally gave higher returns than diesel ones—although the difference was statistically significant only in the case of LLPs. Higher returns to electric pumps were associated with their generally higher command areas. An inter-district comparison showed that the average returns to owners of diesel STWs were higher in more advanced districts (Tk 6,220 in Bogra and Tk 7,874 in Comilla) than in less advanced districts (Tk 2,501 in Hobiganj and Tk 3,708 in Nilphamari), though the differences were not statistically significant. In Faridpur (considered more of a middle-level district in terms of irrigation coverage) STW owners' return of Tk 5,965 was closer to the all-district average. Returns from LLPs did not show any significant difference between districts.

If the returns found in this study were to be compared with past estimates it would appear that there have been reductions over the years. Hamid et al. (1982) calculated returns of Tk 8,396 (US$430 in those days) over O&M cost for IDA STWs in North-West Bangladesh in the early 1980s. This compares to today's return of Tk 6,859, or US$171, as estimated in this study. This trend is also corroborated by earlier finding on declining returns to shallow tubewell owners in areas of Tangail district due to increases in O&M costs relative to rice prices (Mandal 1989).

Although STW and LLP owners on average earned good returns (if not as good as in the past) over O&M costs of boro irrigation, these returns had large variations. Such variations depended on command area, O&M costs, water fee collection and irrigated output prices. A closer look at a more disaggregated

level reveals that the lower quartile of the STW owners had returns only up to Tk 2,000, while the upper quartile had returns over Tk 10,000. There were, in fact, 9 out of 104 STW owners (9%) who were unable to cover the O&M costs of their tubewells from the collection of their water fees for boro irrigation. The estimated losses were due, variously, to very low boro irrigation coverage (i.e., 0.1-0.97 ha) and very high initial overhauling plus repair and spare parts costs. As regards LLP owners, the lower quartile had returns up to Tk 4,000 while the upper quartile had returns of over 30,000 taka.

It is possible that the low returns or losses of some units will be offset in coming years if command areas can be increased or if engines need less repair (or if aged engines are replaced). But it is also possible that a number of pump owners will not be able to increase their command areas due to competition from other pumps—and they may end up stopping the operation of their pumps. As has been noted earlier, 11 out of 131 STWs and 7 out of 63 LLPs in 1993/94 survey ceased operation by the 1994/95 season—due to command area reduction, machine breakdown and loss incurred from the last season boro irrigation.

While emphasis has been given in this discussion to boro irrigation, it is important to recall that the tubewells and pumps were also used for irrigating other crops—which gave additional returns to the pump owners. The estimated average **annual** returns over O&M costs were Tk 7,948 per STW and Tk 19,104 per LLP—although returns from boro irrigation accounted for 86 and 94 percent of those annual returns respectively for STWs and LLPs. What is more important to recognize is that the additional returns from selling water for non-boro irrigation helped 7 out of 9 STW owners to recover the losses they had made from boro irrigation in 1993/94, thus improving the financial viability of those tubewells.

9. OVERALL FINANCIAL VIABILITY OF STWs AND LLPs

Financial viability of STW and LLP has been examined by applying project appraisal techniques for two different levels of enterprise: [7]

a) The irrigation scheme as a whole "farm." In this case, all costs and benefits of the irrigated crops have been considered as well as the costs of buying and running the STW or LLP—irrespective of who paid those costs or got those benefits.

[7]The emphasis in this study is on how the private market is able to handle minor irrigation expansion and support. As a result, financial viability for owners and users of irrigation equipment has been stressed. A full economic analysis (minor irrigation's 'profitability' from a national society's point of view) was not attempted for two reasons. a) To be correctly done, such an analysis would have entailed a full-blown environmental study in order to value water resources used (which was outside the scope of this, more limited, research). b) In addition, such an analysis would have had to compare 'project' results with some next best alternative. For irrigation development an appropriate next best alternative would have been outside irrigated agriculture and possibly outside agriculture altogether. An economic analysis of such a hypothetical project would have been, again, well outside of the scope of this research. In taking a very rough look at other elements of an economic analysis (in which adjustments are made for subsidies, taxes and other distortions to society's valuation of goods and resources) it can be noted that there would be countervailing adjustments. 'Border' price adjustments of benefits (crop production) and costs (fuel, other inputs) as well as adjustments for the use of (possibly) underemployed labour could well come close to balancing each other out. In other words, a partial economic analysis (without a next best alternative and without an environmental valuation of water) might be expected to have results (BCR, IRR, NPW, etc.) quite similar to those of the financial analysis done in this study.

b) The irrigation unit as a water selling business. Here, benefits are only the fees collected by the owner while costs are those associated with STW or LLP investment or O&M.

9.1 Evaluation of Cost and Benefit Items

Cost and benefit streams for STW schemes seen as "farms" and alternately seen as water selling businesses are presented in Appendix Tables A and B. Similar cost and benefit streams for LLPs are given in Appendix Tables C and D. Methods of estimating costs and benefits are discussed below.

As intimated above, for the analysis of the irrigation unit as a "farm" the gross costs include investment cost, O&M cost and production cost, while gross benefits include total value of the main crop product plus byproducts. For the units as water selling businesses, gross costs involve investment and O&M costs only while gross revenue is the income earned from water selling fees.

The investment cost at the very beginning of the project life involved the cost of engines, pumps, filters, etc. The life of STW/LLP projects has been considered to be 10 years and that of engines as 5 years. The salvage value of capital cost (occurring at the end of the scheme's life and at the time of engine replacement in the 6th year) has been assumed at the rate of 10 percent of the original cost and this has been considered as a benefit to the project.

O&M costs included costs of diesel and mobil, repair and overhauling, driver and linemen salaries, etc. Annual overhauling cost has been considered after 3 years of engine life.

For the analyses of STW/LLP schemes as "farms," production cost involved all operating costs (i.e., human labour, animal labour, seed/seedlings, manures, fertilizers and insecticides) except irrigation costs which have been considered separately in the unit's investment and O&M costs. Production costs as well as benefit per STW/LLP vary depending upon choice of crops and the irrigated area under different crops. Distribution of irrigated area for various crops under sample STWs and LLPs is shown in Table 8. These technologies irrigated a variety of crops—although boro and a few other crops were the most important ones in terms of their proportion of total irrigated area per pump. Therefore, for the financial analyses of the irrigation units, the minor crops have been ignored. Thus, in the case of STWs, HYV boro, wheat, HYV aman and potato (which together constituted 91 percent of the total irrigated land) have been considered. For LLPs, HYV boro (which alone represented 93 percent of the total irrigated area), has alone been considered. Therefore, the financial analysis of STWs was based on irrigated area of 3.52 hectares of which 2.63 hectares was under HYV boro. For LLPs it was based on irrigated HYV boro area of 7.71 hectares (quite a bit higher than STW coverage).

For the analysis of the irrigation scheme as a "farm" the benefits foregone (or net benefits without the scheme) have been considered as a cost to the project. Net benefit without the project, then, has been added to gross cost to produce the total cost figures found in Appendix Tables A and C. In the case of STWs, the crops considered without project conditions (i.e., non-irrigated crops) were Local aus, Mustard, Local aman and Potato as against irrigated (with the project) crops of HYV boro, wheat, HYV aman and potato. To arrive at cash flow figures, benefit without project has been subtracted from benefit with project.

Considering recently prevailing interest rates a 12 percent discount rate has been used for calculating BCR and NPW. Since initial investment cost occurred at the very beginning of the project life this cost

has not been discounted in the calculation of the present value of the cost and its year has accordingly been designated as the zero year (Appendix Tables A through D).

For the financial analyses, the STWs and LLPs in two thanas of Nilphamari (Nilphamari Sadar and Kishorgonj) were excluded because the major crop irrigated by the sample pumps in these two thanas was tobacco which is not at all a commonly irrigated crop for the other study districts. Likewise, the analyses have only been done for diesel STW and LLP schemes as diesel engines were so dominant in the field. In the selected 13 thanas, 92 out of 103 STWs (89%) were diesel operated. In the case of LLPs, 46 out of 63 units (73%) were diesel.

9.2 Results of the Financial Analyses of Shallow Tubewells

Table 9 shows that the STW scheme as a "farm" is very profitable. The internal rate of return (IRR) was found to be 61 percent—which is very high in relation to the opportunity cost of capital. For the units as water selling businesses, it was also found that STWs are also financially profitable. The IRR in this case was found to be 24 percent. While risk elements have not been entered into the calculations it can be noted that the price of paddy in 1994 (upon which benefit values from crop share fees are partly dependent) was particularly low. The returns to pump owners would increase if paddy price were to rise—making a generally acceptable rate of return more attractive.

9.3 Result of Financial analyses of Low-lift Pumps

Financial analysis of LLPs as "farms" shows that investment in LLPs is extremely profitable. The BCR was found to be 2.17 and the value of NPW was found to be Tk. 10,61,784 (Table 10). The IRR in this case could not be calculated due to the smallness of the negative value in the initial year compared to very high cash flow figures in the subsequent years. Return to pump owners were also found to be very high. The IRR in this case was found to be 64 percent. This indicates that LLP irrigation is very profitable both when seen as a whole "farm" as well as from the view point of the owners.

The higher profitability of LLP schemes is mainly due to the fact that LLPs generally need to supply less irrigation water compared to STW/DTW. They therefore have lower O&M costs and can cover larger areas. In most of the cases the land under LLP command areas had shallow depths of standing water at the beginning of boro season when transplantation of boro takes place. Since at the initial stage (which may even be for one and half months) little or no irrigation is needed, LLPs can cover larger areas than STWs with the same capacity of engine/motor. Due to less irrigation requirement, pumping costs are usually low.

10. FINANCIAL VIABILITY OF STWs WITH INEXPENSIVE (BUT LESS-DURABLE) ENGINES VERSUS EXPENSIVE HIGHER-QUALITY ENGINES

The financial analyses discussed above considered all STW engines irrespective of their countries of origin or their horse power. But in reality, as a result of the import liberalization policy and withdrawal of engine standardization rules, cheap (though not very durable) Chinese engines (ranging from 3 to 12 horsepower) flooded the irrigation equipment market and rapidly took over from the more costly (though higher quality) Japanese engines. Although these Chinese engines are less durable than the Japanese ones, farmers do buy them because of their relative price.

It is with this backdrop that project appraisal techniques were applied to compare financial viability of STWs with the more recently imported inexpensive Chinese engines versus STWs with the previously dominant expensive Japanese ones. Both of these engines have a wide range of nominal brake horse power and rpm leading to diverse levels of fuel consumption—but units with engines only in the 4-8 hp range are used in the comparison.

It would have been ideal to make this comparison of Japanese and Chinese engines if new Japanese engines were also available in the market. Since these are no longer available a number of assumptions (detailed below) have had to be made for the present analysis.

10.1 Comparative Analysis of STWs as Water-Selling Businesses

Financial analysis was performed from the STW owners' point of view to see whether or not a tubewell owner finds less durable but inexpensive Chinese engines financially viable compared to more durable but expensive Japanese engines. In other words, are the farmers financially better off or worse off by using Chinese engines?

The pump owner generally bears all investment as well as operation and maintenance (O&M) costs in the expectation of revenue (benefit) from water selling. For this analysis the most prevalent payment system for water has been considered where pump owners pay for fuel as well as bear all investment and O&M costs.

For comparative purposes, it was necessary to first select a specific size of engine according to BHP. Since most of the Japanese engines were found in the 4-8 hp group, only STWs with this 4-8 hp range of engines have been considered. In this hp range there were 18 Japanese and 15 Chinese engines. Data relating to investment costs (which includes cost of engine, pump, pipes filters and other accessories) are based on these 33 STWs.

Further considerations were made in relation to command area in estimating O&M costs as well as benefits from the STW projects. Out of the 33 selected STW projects, a few covered very low command areas (underutilizing engine capacity) while others covered exceptionally large command areas (which were perhaps less intensively irrigated). Neither extreme could be seen as representative. To rationalize this problem (which may affect the analysis), STW projects which irrigated HYV boro within the prevalent range of 3 to 9 acres have been chosen. Thus there were 27 STWs which could be used to provide information in relation to O&M costs as well as to benefits derived from the schemes.

To accommodate the more durable Japanese engines the project life of a shallow tubewell has been considered to be 12 years—equivalent to the assumed life of a Japanese engines. It was assumed that

three Chinese engines would be needed in sequence (four years each) to cover the normal productive life of a Japanese engine (the rationale for this is discussed later).

Several assumptions were made to evaluate cost and benefit items of the STW projects with Japanese and Chinese engines. Calculation of investment as well as O&M costs and benefits are discussed below:

10.1.1 Investment cost

Investment cost was divided into two components; cost for engine and cost for other equipment like pump, pipes, filters and other accessories. Among the 33 STWs engines, all the Chinese engines were bought during the period from 1990 to 1994, while all the Japanese engines except one were bought during the period from 1980 to 1986 (one engine was bought in 1989). Therefore, although the current price for a Chinese engine was readily available, prices of new Japanese engines were not available from our pump owners' survey data. The probable prices of new Japanese engines were therefore assessed through some irrigation equipment importers and traders. According to their opinion, the price of a Japanese engine would be about 4 times higher than that of a Chinese engine of the same hp. Based on the recent price data of Chinese STW engines of 4-8 hp as shown in Appendix Table E, the price of a Chinese engine has been considered as Tk 9,500. Further, on the basis of the impression given by the equipment importers/traders and observing past price trends of Japanese engines, the price of a Japanese engine has been considered as Tk 35,000—which is 3.68 times higher than that of a Chinese engine.

Having consulted with importers, traders and farmers, the normal life of a Chinese engine has been considered as 4 years and that of a Japanese engine as 12 years. As a result, a hypothetical project life has been chosen as 12 years—the longer of these two figures. Therefore, during this project life, two replacements of Chinese engines are needed in the 5th and 9th years. Salvage value at the end of engine life (for both Japanese and Chinese engines) has been assumed at 10 percent and this has been considered as an additional benefit for the project.

Cost of pumps, pipes, filters and other accessories for a Chinese engine was found to be Tk 4,581 (Appendix Table F). Since this cost is supposed to be the same for both types of STW projects (with Chinese or Japanese engines), the same cost (a round figure of Tk 4,600) has been considered in both cases. Thus, investment cost for a STW project with Chinese engine was calculated as Tk 14,100 (of which the engine cost was Tk. 9,500) and that with Japanese engine was calculated as Tk 39,600 (of which engine cost was Tk. 35,000). Since initial investment cost occurred at the very beginning of the life of a project, this cost has not been discounted in the calculation of the present value of the cost. The initial investment year has been designated as year zero (Appendix Tables G and H).

10.1.2 O&M costs

O&M costs included the costs for diesel, mobil, spare parts, mechanic charge, remuneration for driver/linemen, costs for channel maintenance, etc. Since siting of STWs is changed after some years or even each year), it has been assumed that installation cost will be involved every alternate year and this cost has been included in the O&M costs.

Again, some assumptions were made regarding repairing and maintenance costs of STWs over the project life. As a Chinese engine is less durable, it has been assumed conservatively that repairs would be needed every year of its life (4 years) while an overhauling cost of Tk. 1000 would be needed for the last two years of that life. On the other hand, for Japanese engines it has been assumed that no repair cost would be needed in the first three years. From the 4th year through the end of its remaining life repair costs would be needed and from the 7th year overhauling cost would be required.[8] O&M costs for producing HYV boro were calculated as Tk. 7,000 of which repairing and mechanics charges were estimated to be Tk 750. The overhauling cost and installation costs were estimated as Tk 1,000 for each case.

10.1.3 Pump owners' income

Pump owners' gross income was derived from revenue earned through water selling. The gross income of the pump owner was derived through multiplying average HYV boro command area by the water charge per unit of land under the water payment system where managers provided fuel.

All costs and benefits have been considered on the basis of an estimated average irrigated area of 2.12 ha under HYV boro crop. There were no significant differences in terms of irrigated area and cropping patterns of the STW projects irrigated by Japanese or Chinese engines and thus the same average irrigated area has been considered in both cases. Although in some cases pump owners were also found to irrigate other minor crops, only the HYV boro crop has been considered in calculating costs and benefits because the pump owners' decision for investing in irrigation equipment largely depends on HYV boro crop irrigation alone. The inclusion of other crops would have increased revenue for both types of project (with Japanese and Chinese engines) but these would have incurred additional costs too. However, the aim here is to compare financial performances of Japanese and Chinese engines and therefore a comparison based only on analysis of the major irrigated crop rather than all crops is unlikely to affect the conclusions.

10.1.4 Results of financial analysis

The results of the financial analyses from pump owners' point of view have been presented in Table 11. Basic data on cost and benefit streams have been presented in Appendix Tables G and H. The analysis clearly shows (through BCR, NPW and IRR figures) that STW schemes with Chinese engines are highly profitable to pump owners. The internal rate of return (IRR) was found to be 37 percent. On the other hand, STW projects with Japanese engines were found to be only slightly profitable with an IRR of 13 percent—which would only marginally cover pump owners' investment and O&M costs.

Therefore, STWs using the cheaper though less durable Chinese engines were found to be much more attractive compared to those with the technically better Japanese engines. Market demand has clearly favoured the cheaper engines in recent years. It would appear that this would be for good

[8]In the paper in this volume on Technical Aspects Affecting the Selection and Operation of Minor Irrigation Equipment it was found that the old Japanese engines had recent repair records which equaled or exceeded that of the Chinese engines. When they were new, however, the Japanese engines were reputed to be relatively trouble free.

reason—as pump owners can make a much higher return from these engines despite having to replace them every few years.

10.1.5 Sensitivity analysis of STWs with Chinese engines assuming an increased price of engine

The financial analysis discussed in the previous sections with respect to Chinese engine considered the 1993-94 engine price of Tk 9,500. The price of the relevant hp Chinese engine (as well as other engines) was found to have increased to about Tk 12,000 in 1994-95 on average (a 26% increase). Therefore, assuming this increased price of engine (keeping all other costs and benefits constant) a sensitivity analysis has been done. The result of the new financial analysis shows that the STWs were financially viable even with this increased level of price for the Chinese engines. The IRR declined somewhat to 29 percent (Table 11).

11. STW AND LLP OWNERS' PERCEPTIONS ABOUT THE PROFITABILITY OF THEIR TUBEWELLS AND PUMPS

Although the above financial analyses indicated that STWs and LLPs appeared to be generally profitable both as "farms" and as water selling businesses, pump owners' own profitability perceptions reveal that the majority of them (70% STW owners and 57% LLP owners) considered that owning their pumps was only marginally profitable (Table 12). About 11 percent of STW owners and 24 percent LLP owners did think that owning their pumps was highly profitable. A relatively small proportion of owners considered STWs and LLPs as just no-loss/no-profit enterprises—and 11 percent of STWs and 10 percent of LLPs were thought of as losing concerns. STW owners' perceptions were mixed across the more advanced and less advanced districts. For example, STW owners who considered their wells as highly profitable were distributed as follows: Bogra 11 percent, Nilphamari 15 percent, Comilla 8 percent and Faridpur 5 percent. Wells were considered marginally profitable by 84 percent in Bogra, 74 percent in Nilphamari, 62 percent in Comilla and 59 percent in Faridpur (with the remainder in each district finding their operations to be break-even or losing concerns). In other words, an advanced district (Bogra) and a late starter district (Nilphamari) led in owners' perception of STW profitability.

A large proportion of STW and LLP owners identified the high costs of diesel/mobil as the most important reason for the marginal profitability of their pumps. This makes sense as 60 percent of O&M costs for these two technologies was spent on diesel/mobil/electricity—whereas costs of engine overhauling, construction/repair of pump sheds and repair costs also accounted for only about a quarter of the total. High cost of repair/maintenance, insufficient land coverage and farmers' unwillingness to pay high water charges were also mentioned as important causes of marginal profitability of pumps.

12. OWNERS DESIRED GOVERNMENT AND PRIVATE-SECTOR ACTIONS FOR MINOR IRRIGATION EXPANSION

A large proportion of STW owners (79%) and LLP owners (65%) thought that there was still scope for expansion of minor irrigation in their localities—mostly through installation of more STWs and better utilization of the existing pumps. LLP owners (mostly in Hobiganj) also thought more area could be covered, mostly by the installation of more pumps. For minor irrigation to expand, however, the pump owners felt that a number of actions were needed from the government and/or private sector. These included reduction of prices of irrigation equipment and of diesel/mobil, better access to loans and increased prices for irrigated crops (Table 13). The desired actions from the private sector included supplies of good quality machines/spare parts and diesel/mobil at low prices, better mechanical services and traders credit for machine purchases (Table 14).

13. SUMMARY AND CONCLUSIONS

Based on the findings discussed above in this paper one can draw the over-all conclusion that the various facets of minor irrigation privatization policy have generally resulted in improved pump level performance with respect to STWs and LLPs. The major findings are the following.

Procurement

The sources of procurement of irrigation equipment have expanded so that farmers can now buy STW and LLPs from district as well as from thana/local level markets with relative ease with respect to their choices about scale and price of the irrigation equipment. The significant reduction in the prices of irrigation engines, spare parts and other accessories (although less durable) has facilitated this increased availability of equipment as the quantities demanded of these items have provided large incentives to traders to expand their enterprises down to the sub-district level.

Growth in Numbers

At the local level there has been steady growth in the number of operating STWs and somewhat moderate growth in the number of operating LLPs. Both more advanced irrigation districts as well as the later starters showed high rates of growth in STW numbers. In Nilphamari, which is endowed with good groundwater irrigation potentials and was a late starter, a rapid growth in STW as well as Treadle Pump irrigation has occurred in the recent years.

Irrigation Coverage

While there has been generally rapid growth in the number of STWs as a direct benefit of reduced prices and easier availability of irrigation equipment, irrigation coverage per tubewell in boro irrigation has declined. The total area irrigated by STWs, however, has increased significantly. The other encouraging

sign is that irrigation equipment was found to have been used for irrigating not only boro but also for other crops, thus increasing the overall coverage per pump and hence income.

Competition

The average boro area per pump has declined because many of the newly installed STWs have taken away land from the command areas of existing wells. There were also tubewells which gained land from other tubewells. There was evidence of competitive siting of wells (entries) by new STW owners as well as the withdrawal of poorly functioning wells (exits) by those who failed to make profits or chose not to stay at their sites for various other reasons. This did not necessarily mean encroachment by tubewells, rather it demonstrated elements of competition in the water market—putting potential challenges to the existing as well as to prospective tubewell owners to improve their management efficiency so as to sell/supply water at cheaper rates than their competitors. It was noted that less intensively developed areas showed higher STW water charges than the more developed and competitive districts.

Returns Over O&M

STW owners earned, on average, good returns over O&M costs --although these returns have declined somewhat over the last few years. There were a few STW owners who failed to cover O&M costs of their tubewells due to very low command areas and/or high repair costs—but for some of these cases this was probably a seasonal rather than a cyclical phenomenon.

Non-Boro Irrigation

The utilization of STWs for irrigating other crops in addition to boro has increased many pump owners' overall returns. STWs showed more diversified irrigation than did DTWs or LLPs.

Financial Analyses of STWs

Financial analyses considering boro as well as other crop irrigation showed that STW schemes were strongly profitable as "farms" as well as water selling ventures. A comparative financial analysis, considering 1994 as well as 1995 engine prices separately confirmed that the inexpensive but less durable Chinese engines that have flooded the market have proved to be highly profitable compared to the more expensive but better quality (technically) Japanese engines. This justifies farmers' high demand for cheaper engines. It may be concluded that the import liberalization policy and deregulation of standardization of diesel engines have favoured the pump owners by enabling them to buy the cheaper (although less durable) STW engines which have the higher return (compared to what was allowed to be imported previously).

Future Scope for STWs and LLPs

Pump owners' opinions were positive about further scope for minor irrigation expansion. Never-the-less, they desired various government and private-sector actions to enhance that expansion. Such actions, according to their opinions, included reduction of prices of engines and diesel/mobil, easy access to bank loans and better output prices. The private sector is further requested to supply good quality mechanical services and spare parts.

LLP Financial Returns

Surface water irrigation by LLPs gave higher returns than for STWs—mostly due to lower pumping requirements and larger command areas. Financial analyses confirmed that LLP schemes were very highly profitable both as "farms" and as water selling businesses. LLP irrigation is location specific, however, depending on the availability of surface water which is increasingly limited. Opportunities for augmenting surface water availability for irrigation purposes, therefore need to be sought and created.

Overall View

Overall, the current liberalized policies concerning importation, standardization, spacing, etc. of irrigation equipment should be continued. Irrigated agriculture has been greatly benefitted by these policies.

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Table 1. Distribution of STW and LLP owners by different sources of procurement of engines, 1994. (percent).

District technology	Local/ thana market	Dis- trict market	Other market	Second- hand market	Farmers	Public agency	NGO	All Sources
Bogra								
STW	45.9	16.3	-	5.4	29.7	2.7	-	100.0
LLP	-	-	-	-	100.0	-	-	100.0
Comilla								
STW	20.0	60.0	10.0	-	10.0	-	-	100.0
LLP	-	30.0	40.0	-	30.0	-	-	100.0
Faridpur								
STW	-	46.9	6.2	3.1	9.4	34.4	-	100.0
LLP	-	-	100.0	-	-	-	-	100.0
Hobiganj								
STW	-	66.7	33.3	-	-	-	-	100.0
LLP	20.0	35.0	22.5	-	7.5	15.0	-	100.0
Nilphamari								
STW	42.1	31.6	5.3	-	7.9	7.9	5.2	100.0
LLP	-	100.0	-	-	-	-	-	100.0

Source: IIMI/BSERT 1994 Pump Owners' Survey in Bogra, Comilla, Faridpur, Hobiganj and Nilphamari districts.

Table 2. Number of shallow tubewells, low-lift pumps and treadle pumps in the sample villages under different districts.

District	STW				LLP				TP			
	88/89	92/93	93/94	94/95	88/89	92/93	93/94	94/95	88/89	92/93	93/94	94/95
Bogra	58	137	165	192	4	8	9	10	17	3	3	-
Comilla	20	42	55	68	18	29	36	39	-	-	-	-
Faridpur	63	137	144	160	17	10	10	9	-	-	1	1
Hobigonj	9	9	9	11	72	70	71	75	-	-	-	-
Nilphamari	109	218	278	318	5	5	7	7	112	185	256	260
All 5 districts	259	543	651	749	116	122	133	140	129	188	260	261

Note: (I) 1993/94 and 1994/95 figures are obtained from Census of irrigation equipment operated in these two years. 1988/89; 1992/93 and 1993/94 figures about the number of irrigation equipment according to pump owners' perception were adjusted according to rates of change based on IIMI/BSERT census figures for 1993/94 and 1994/95.

Sources: (I) IIMI/BSERT Complete Census of minor irrigation equipment in operation in 96 sample villages (9 in Bogra, 31 in Comilla, 14 in Faridpur, 29 in Hobigonj and 13 in Nilphamari) in 1994, updated in 1995.

(ii) IIMI/BSERT 1994 and 1995 Pump Owners' Surveys.

Table 3. *Average boro command area per irrigation unit and annual change in boro command area over time.*

District/power source	1988/89		1993/94		1994 /95[a]		Annual change %
	No. of units	Area (ha)	No. of units	Area (ha)	No. of units	Area (ha)	1988/89 to 1993/94
STW							
Bogra	23	4.07	37	2.15	31	1.81	-9.4
Comilla	5	5.34	13	4.74	11	3.89	-2.3
Faridpur	21	3.08	34	2.41	31	3.76	-4.4
Hobigonj	3	3.82	3	2.75	2	3.35	-5.6
Nilphamari	13	2.70	17	3.53	31	2.34	+6.2
All 5 districts	65	3.56	104	2.80	106	2.78	-4.3
Diesel	59	3.59	93	2.67	95	2.74	-5.1
Electric	6	3.27	11	3.95	11	3.18	+4.2
LLP							
Bogra	1	4.68	2	2.07	2	1.74	-11.2
Comilla	8	15.48	15	12.67	14	12.17	-3.6
Faridpur	4	8.08	4	6.78	3	9.38	-3.2
Hobigonj	31	10.60	40	11.81	35	13.04	+2.3
Nilphamari	2	2.18	2	5.40	2	6.38	+29.5
All 5 districts	46	10.74	63	11.18	56	11.98	+0.8
Diesel	32	7.81	46	7.83	39	7.23	+0.8
Electric	14	17.44	17	20.25	17	22.89	+3.2

a. Boro command area figures for 1994/95 were obtained in mid-February 1995, quite early in the season, when the pump owners irrigated only part of their command areas so that their estimates of total command areas were based on their actual area irrigated up to mid-February plus their expected additional areas to be irrigated later on the season which were likely to be underestimated.

Source: IIMI/BSERT 1994 Pump Owners' Survey in Bogra, Comilla, Faridpur, Hobiganj and Nilphamari districts.

Table 4. *Ownership status of shallow tubewells and low-lift pumps, 1994.*

No. of owners	STW		LLP	
	No. of units	%	No. of units	%
1	110	83.9	46	73.0
2-4	19	14.6	13	20.6
5+	2	1.5	4	6.4
All	131	100.0	63	100.0

Source: IIMI/BSERT 1994 Pump Owners' Survey in Bogra, Comilla, Faridpur, Hobiganj and Nilphamari districts.

Table 5. Average water charge for boro irrigation by STWs and LLPs, by payment systems, 1988/89 and 1993/94.

Payment system	STW				LLP			
	1988/89		1993/94		1988/89		1993/94	
	No.	Tk/ha	No.	Tk/ha	No.	Tk/ha	No.	Tk/ha
Cash (Managers' fuel)	31	4923	61	5799	38	2547	57	3395
Cash (Farmers' fuel)	12	2130	17	2859	2	1646	2	2264
Crop-share (Managers' fuel)	2	9411	28	9369	-	-	4	8422
All systems	45	4378	103	6181	40	2502	63	3679

Source: IIMI/BSERT 1994 Pump Owners' Survey in Bogra, Comilla, Faridpur, Hobiganj and Nilphamari districts.

Table 6. Pump-owners' responses about the status of mechanics services for minor irrigation technologies (% of respondents).

Status	STW	LLP
A. Training of mechanic		
Mechanics have training	69.8	62.8
Mechanics don't have training	30.2	37.2
B. Availability of mechanic		
Available readily	57.5	67.4
Available with some delays	36.3	28.3
Available with long delays	6.2	4.3
C. Quality of mechanic		
Very good	26.3	19.6
Good	41.2	39.1
Fair	32.5	41.3

Source: IIMI/BSERT 1994 Pump Owners' Survey in Bogra, Comilla, Faridpur, Hobiganj and Nilphamari districts.

Table 7. Average boro area , O&M cost and return over O&M cost per STW and LLP, 1993/94.

No. of units and items	STW			LLP		
	Diesel	Electric	All	Diesel	Electri c	All
No. of units	93	11	104	46	17	63
Boro area (ha)	2.67 (1.78)	3.95 (1.89)	2.80 (1.83)	7.83 (5.53)	20.25 (10.59)	11.18 (9.05)
O&M cost (Tk)	8634 (5297)	14508 (12194)	9255 (6542)	14451 (7343)	32477 (11507)	19315 (11763)
Return over O&M (Tk)	5772 (5683)	16045 (16286)	6859 (8043)	12941 (15461)	31680 (21939)	17998 (19187)

Figures in parentheses indicate standard deviation.

Source: IIMI/BSERT 1994 Pump Owners' Survey in Bogra, Comilla, Faridpur, Hobiganj and Nilphamari districts.

Table 8. Distribution of irrigated area under different crops.

Crop	STW		LLP	
	Area (acres)	% of Total Area	Area (acres)	% of Total Area
Local aus	-	-	.09	.44
HYV aus	.01	.10	.02	.10
Jute	.10	1.05	-	-
Local aman	.23	2.41	-	-
HYV aman	.67	7.02	.89	4.33
Mustard	.05	.52	-	-
Potato	.39	4.09	-	-
Sugarcane	.02	.21	-	-
Wheat	1.14	11.95	.09	.44
Local boro	.19	1.99	.31	1.51
HYV boro	6.49	68.03	19.04	92.70
Tobacco	.05	.52	.10	.49
Vegetables	.11	1.15	-	-
Others	.09	.94	-	-
Total	9.54	100	20.54	100.00

Notes: i) Due to very small irrigated area for some crops, the area has been expressed in terms of acreage instead of hectare.

ii) The analysis is based on data collected from 13 sample thanas which excluded Nilphamari and Kishoregonj thanas due to an unusually high proportion of total irrigated land under tobacco in these thanas.

Source: IIMI/BSERT 1994 Pump Owners' Survey in Bogra, Comilla, Faridpur, Hobiganj and Nilphamari districts.

Table 9. *Results of financial analyses of STW schemes as "farms" and as water selling businesses.*

Alternative View Points	BCR at 12% D.F.	NPW at 12% D.F.	IRR (%)
From the view point of the STW scheme as a "farm"	1.25	Tk.98,962	61
From the view point of STW pump owners	1.11	Tk.9,182	24

Source: Calculations based on IIMI/BSERT 1994 Surveys of Pump Owners and Irrigator Farmers in Bogra, Comilla, Faridpur, Hobiganj and Nilphamari districts.

Table 10. *Results of financial analyses of LLP schemes as "farms" and as water selling businesses.*

Alternative View Points	BCR at 12% D.F.	NPW at 12% D.F.	IRR (%)
From the view point of the LLP scheme as a "farm"	2.17	Tk.10,61,784	Undetermined
From the view point of LLP owners	1.40	Tk. 47,548	64

Source: Calculations based on IIMI/BSERT 1994 Surveys of Pump Owners and Irrigator Farmers in Bogra, Comilla, Faridpur and Nilphamari districts.

Table 11. *BCR, NPW and IRR of STW schemes with Chinese and Japanese engines (The STWs as water selling businesses).*

STW Projects with	BCR at 12%	NPW at 12%	IRR%
Japanese Engine	1.13	Tk. 10912	13
Chinese Engine : Assuming 1994 engine price	1.24	Tk. 18591	37
Assuming 1995 engine price	1.15	Tk. 11939	29

Source: Calculations based on IIMI/BSERT 1994 Surveys of Pump Owners and Irrigator Farmers in Bogra, Comilla, Faridpur, Hobiganj and Nilphamari districts.

Table 12. Pump-owners' opinions about the profitability of owning irrigation pumps, 1994.

Opinions	STW	%	LLP	%
a. Highly profitable	14	11	15	24
b. Marginally profitable	92	70	36	57
c. No profit-no loss	11	8	6	10
d. Losing enterprise	14	11	6	10
All	131	100	63	100

Source: IIMI/BSERT 1994 Pump Owners' Survey in Bogra, Comilla, Faridpur, Hobiganj and Nilphamari districts.

Table 13. Pump-owners' opinions about what government could do to expand minor irrigation, 1994.

Expected actions of Government	STW	% of responses	LLP	% of responses
a. Reduce of equipment price	50	38	25	40
b. Reduce of diesel/mobil price	109	83	47	75
c. Increase irrigated crop price	45	34	8	13
d. Provide better access to land	34	26	27	43
e. Provide electricity connections	28	21	10	16
f. Provide insurance for machine and crops	1	0.8	4	6
g. Provide mechanic and repair facilities	3	2	10	16
h. Provide better extension information	4	3	3	5
I. Other reasons	29	22	20	32

Source: IIMI/BSERT 1994 Pump Owners' Survey in Bogra, Comilla, Faridpur, Hobiganj and Nilphamari districts.

Table 14. Pump Owners' opinions about what the private sector could do to expand minor irrigation, 1994.

Expected actions of private sector	STW	%	LLP	%
a. Good quality machines/spare parts at lower prices	98	75	43	68
b. Diesel/mobil supply at lower prices	89	68	37	59
c. Better mechanic and repair service by private workshops	28	21	23	37
d. Traders' credit for machine purchase	26	20	28	13
e. Machine insurance by traders/insurance companies	7	5	4	6
f. Other reasons	15	12	2	3

Source: IIMI/BSERT 1994 Pump Owners' Survey in Bogra, Comilla, Faridpur, Hobiganj and Nilphamari districts.

Appendix Table A. Cost and benefit streams of diesel STW schemes as "farms" (Tk).

Year	Investment cost	O&M cost	Production cost	Gross cost	Gross Benefit	Benefit without project	Net benefit	Total cost	Cash flow
0	22190	0	0	22190	0	0	-22190	22190	-22190
1	0	9160	53932	63092	86314	8899	23222	71991	14323
2	0	9160	53932	63092	86314	8899	23222	71991	14323
3	0	9160	53932	63092	86314	8899	23222	71991	14323
4	0	10113	53932	64045	86314	8899	22269	72944	13370
5	0	10113	53932	64045	87554	8899	23509	72944	14610
6	12400	9160	53932	75492	86314	8899	10822	84391	1923
7	0	9160	53932	63092	86314	8899	23222	71991	14323
8	0	9160	53932	63092	86314	8899	23222	71991	14323
9	0	10113	53932	64045	86314	8899	22269	72944	13370
10	0	10113	53932	64045	88533	8899	24488	72944	15589

Source: Calculations based on IIMI/BSERT 1994 Surveys of Pump Owners and Irrigator Farmers in Bogra, Comilla, Faridpur, Hobiganj and Nilphamari districts.

Appendix Table B. Cost and benefit streams of diesel STWs for pump owners (Tk).

Year	Investment cost	O&M cost	Gross cost	Gross benefit	Cash flow
0	22190	0	22190	0	-22190
1	0	9160	9160	15730	6570
2	0	9160	9160	15730	6570
3	0	9160	9160	15730	6570
4	0	10113	10113	15730	5617
5	0	10113	10113	16970	6857
6	12400	9160	21560	15730	-5830
7	0	9160	9160	15730	6570
8	0	9160	9160	15730	6570
9	0	10113	10113	15730	5617
10	0	10113	10113	17949	7836

Source: Calculations based on IIMI/BSERT 1994 Surveys of Pump Owners and Irrigator Farmers in Bogra, Comilla, Faridpur, Hobiganj and Nilphamari districts.

Appendix Table C. Cost and benefit streams of diesel LLP schemes as "farms" (Tk).

Year	Investment cost	O&M cost	Production cost	Gross cost	Gross Benefit	Benefit without project	Net benefit	Cash flow	Total cost
0	20450	0	0	20450	0	0	-20450	-20450	20450
1	0	15615	123614	139229	202788	16646	63559	46913	155875
2	0	15615	123614	139229	202788	16646	63559	46913	155875
3	0	15615	123614	139229	202788	16646	63559	46913	155875
4	0	17169	123614	140783	202788	16646	62005	45359	157475
5	0	17169	123614	140783	204018	16646	63235	46589	157429
6	12300	15615	123614	151529	202788	16646	51259	34613	168175
7	0	15615	123614	139229	202788	16646	63559	46913	155875
8	0	15615	123614	139229	202788	16646	63559	46913	155875
9	0	17169	123614	140783	202788	16646	62005	45359	157429
10	0	17169	123614	140783	204833	16646	64050	47404	157429

Source: Calculations based on IIMI/BSERT 1994 Surveys of Pump Owners and Irrigator Farmers, in Bogra, Comilla, Faridpur, Hobiganj and Nilphamari districts.

Appendix Table D. Cost and benefit streams of diesel LLPs for pump owners (Tk).

Year	Investment cost	O&M cost	Gross cost	Gross benefit	Cash flow
0	20450	0	20450	0	-20450
1	0	15615	15615	29030	13415
2	0	15615	15615	29030	13415
3	0	15615	15615	29030	13415
4	0	17169	17169	29030	11861
5	0	17169	17169	30260	13091
6	12300	15615	27915	29030	1115
7	0	15615	15615	29030	13415
8	0	15615	15615	29030	13415
9	0	17169	17169	29030	11861
10	0	17169	17169	31075	13906

Source: Calculations based on IIMI/BSERT 1994 Surveys of Pump Owners and Irrigator Farmers in Bogra, Comilla, Faridpur, Hobiganj and Nilphamari districts.

Appendix Table E. Price of Japanese and Chinese engines by year of purchase and by hp.

Year of purchase	Average price of Japanese engine (Tk)		Average price of Chinese engine (Tk)	
	(4-8 hp)	(6-8 hp)	(4-6 hp)	(6-8 hp)
1980		20,000		
1981	14,488			
1982	13,000			
1984	21,800			
1986	28,00	26,500		
1989		30,000		
1990			9,350	10,250
1991			6,300	10,500
1992			6,733	9,500
1993			9,500	8,600
1994			9,00	10,200

Source: IIMI/BSERT 1994 Pump Owners' Survey in Bogra, Comilla, Faridpur, Hobiganj and Nilphamari districts.

Appendix Table F. Breakdown of investment cost of STW equipment.

Cost Item	Costs (Tk)
Pump	1,717
Pipes	1,321
Filters	825
Other components	718
Sub-Total	4,581
Engine: Chinese	9,500
Japanese	35,000

Source: IIMI/BSERT 1994 Pump Owners' Survey in Bogra, Comilla, Faridpur, Hobiganj and Nilphamari districts.

Appendix Table G. Cost and benefit streams for financial analysis of STWs with Chinese engines.

Year	Investment cost (Tk)	O&M cost (Tk)	Gross cost (Tk)	Gross income (Tk)	Cash flow (Tk)
0	14,100	0	14100	0	-14100
1	0	8,000	8000	14100	6100
2	0	7,000	7000	14100	7100
3	0	9,000	9000	14100	5100
4	0	8,000	8000	15050	7050
5	9,500	8,000	17500	14100	-3400
6	0	7,000	7000	14100	7100
7	0	9,000	9000	14100	5100
8	0	8,000	8000	15050	7050
9	9,500	8,000	17500	14100	-3400
10	0	7,000	7000	14100	7100
11	0	9,000	9000	14100	5100
12	0	8,000	8000	15525	7525

Source: Calculations based on IIMI/BSERT 1994 Surveys of Pump Owners and Irrigator Farmers in Bogra, Comilla, Faridpur, Hobiganj and Nilphamari districts.

Appendix Table H. Cost and benefit streams for financial analysis of STWs with Japanese engines.

Year	Investment cost (Tk)	O&M cost (Tk)	Gross cost (Tk)	Gross income (Tk)	Cash flow (Tk)
0	39600	0	39600	0	-39600
1	0	7250	7250	14100	6850
2	0	6250	6250	14150	7850
3	0	7250	7250	14150	6850
4	0	7000	7000	14100	7100
5	0	8000	8000	14100	6100
6	0	7000	7000	14100	7100
7	0	9000	9000	14100	5100
8	0	8000	8000	14100	6100
9	0	9000	9000	14100	5100
10	0	8000	8000	14100	6100
11	0	9000	8000	14100	5100
12	0	8000	8000	17600	9600

Source: Calculations based on IIMI/BSERT 1994 Surveys of Pump Owners and Irrigator Farmers in Bogra, Comilla, Faridpur, Hobiganj and Nilphamari districts.

Figure 1. Growth in number of STWs in the sample villages.

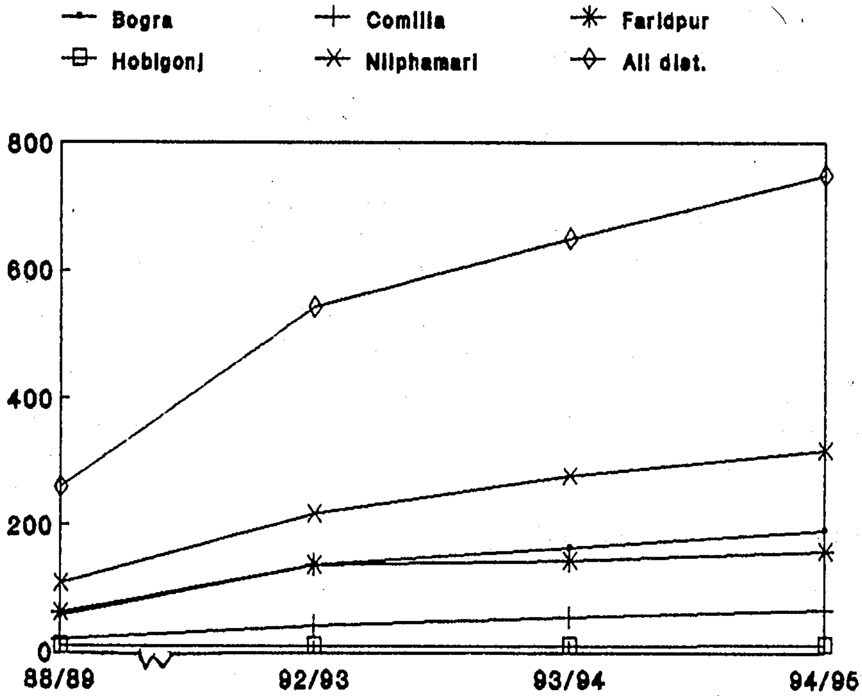
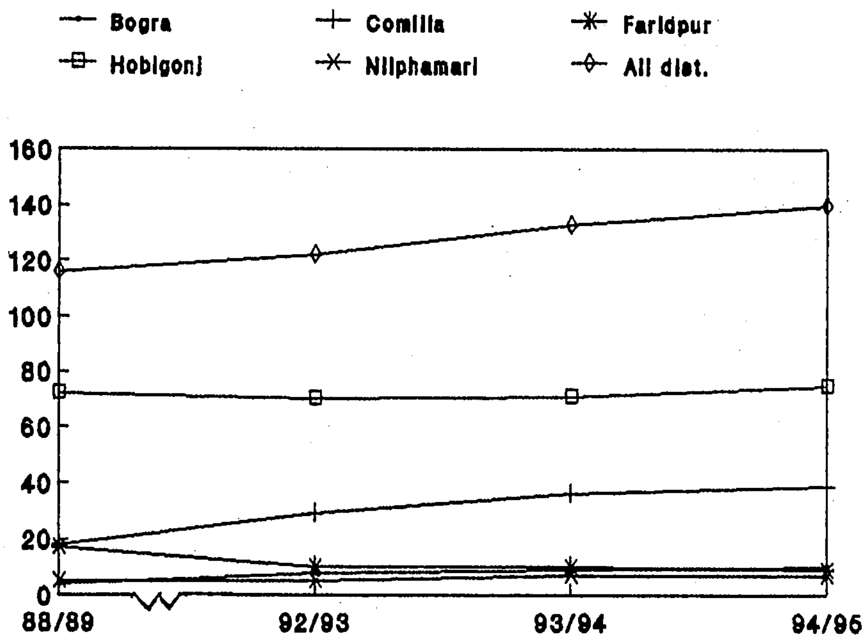
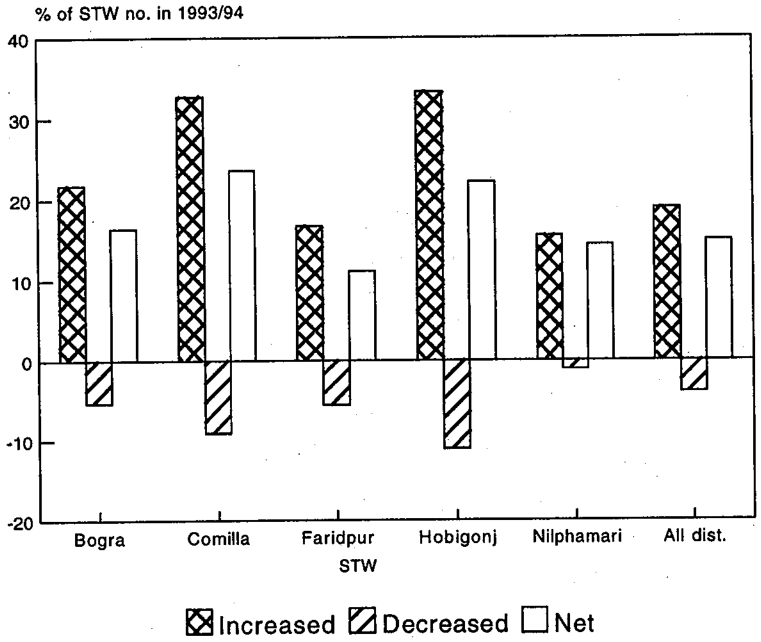


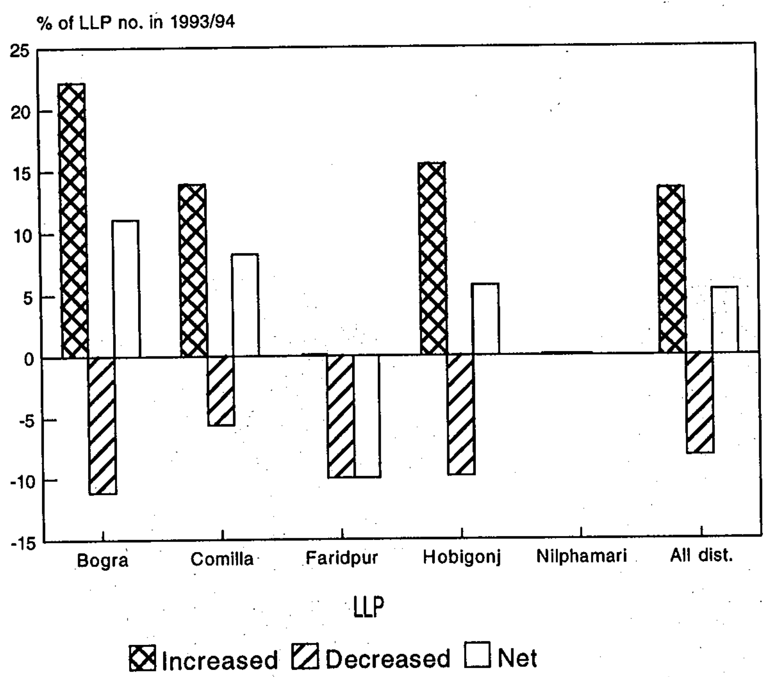
Figure 2. Growth in number of LLPs in the sample villages.



Source: IIMI/BSERT Pump Owners' Survey, 1994.

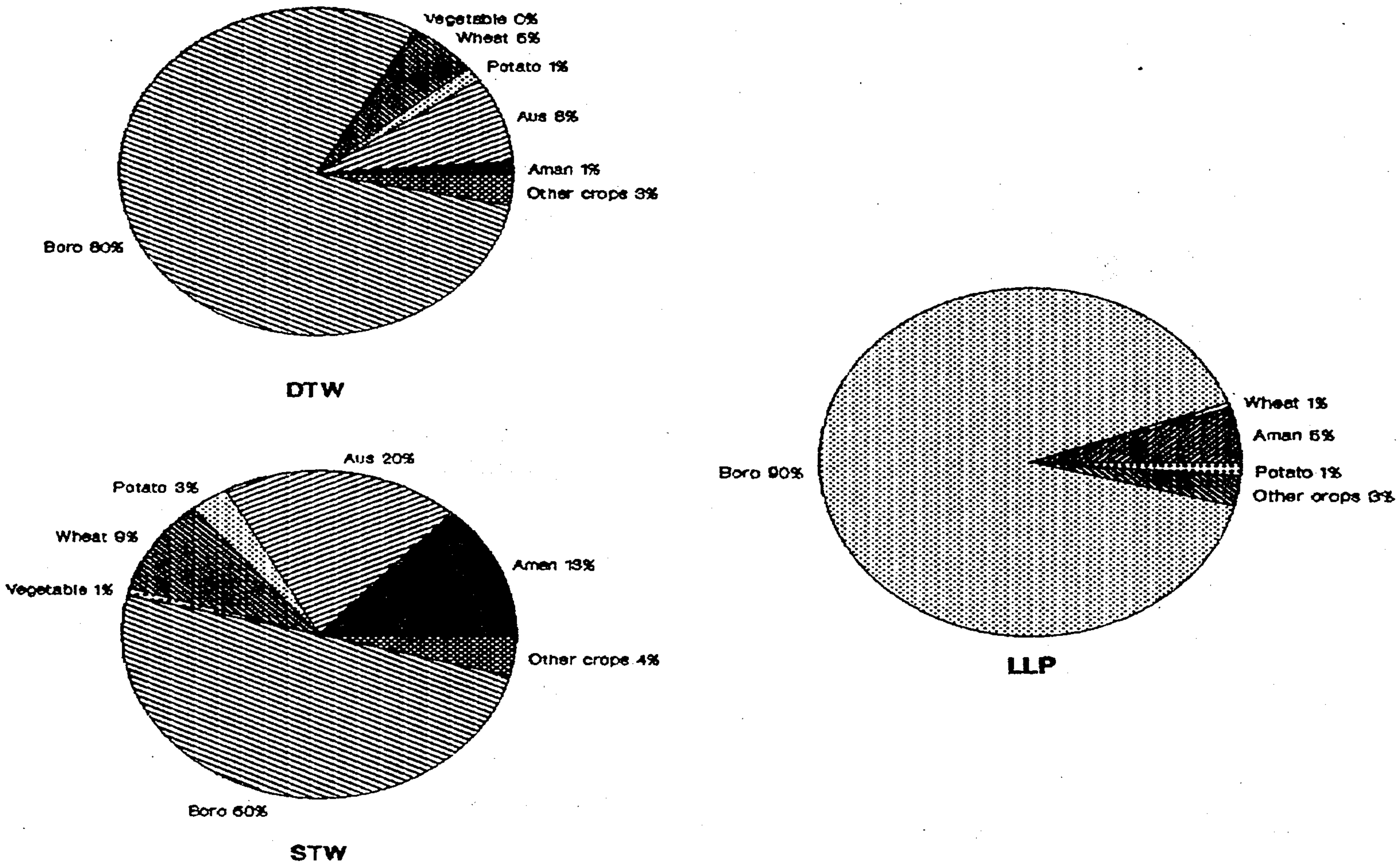
Figure 3. Changes in number of irrigation units in the sample villages between 1993/94 and 1994/95.





Source: IMI/BSERT Irrigation Equipment Census in 1994, Updated in 1995.

Figure 4. Distribution of annual irrigated area per pump between crops, 1993/94.



Source: IIMI/BSERT Pump Owner's Survey, 1994.

Deep Tubewells after Privatization [9]

1. INTRODUCTION

After years of being heavily subsidized and mostly owned and provided inputs and services by the public sector, deep tubewells (DTWs) in Bangladesh are now very much out on their own. The subsidies and services have been dropped and many of those units which had been installed in areas ideal for shallow tubewells (STWs) have found themselves out-competed for command area by the rapid recent development of the smaller, more flexible technology. [10] DTW owners, unlike STW operators, have often been finding that the local market has had problems providing adequate supplies of spare parts and mechanical services for their units. All of this is in distinct contrast to the condition of the STW and LLP (low lift pump) parts of the minor irrigation sector —where the privatization policies of the 1980's have led to rapid growth and development.

What is to become of the DTWs in the country in these circumstances? There were 34,000 DTWs in 1992-93—of which 8,286 (24%) were out of operation (DAE/ATIA 1994). The 25,714 operating DTWs in the same year had an estimated command area of 436,857 ha which accounted for about 16 percent of the total area irrigated by minor irrigation technologies. Many of the DTWs installed in the 1970's, of course, will soon have finished their normal working lives. Given the present unsubsidized price, they are unlikely to be replaced by new DTWs when that happens. Some of these wells are located in areas in which STWs cannot work so these areas are likely to lose part of their irrigated area. Many wells, however, still do have left a number of years of technically feasible life—assuming that they have access to sufficient local spare parts and mechanical services. Will the local private market be able to cater to the needs of these units? If not, who will, if anyone? Even if spares and repairs become available, will DTWs in areas with growing STW development be able to compete with the less expensive and more easily managed technology? If not, should they be simply allowed to die out as with any other uncompetitive business enterprise which cannot perform as well as its rivals?

This study addresses a number of issues coming out of the uncertain DTW scenario described above. An examination is made along the lines of the following questions:

a) What has happened to the procurement, distribution and installation of DTWs under the relatively recent privatized system of ownership and management?

[9] This paper has been prepared as part of the Study on Minor Irrigation Privatization in Bangladesh conducted by IIMI (the International Irrigation Management Institute) in association with the Ministry of Agriculture with funding from the Asian Development Bank. Research for this paper has been done by IIMI and BSERT (the Bureau of Socioeconomic Research and Training of BAU, the Bangladesh Agricultural University)—with W.M.H. Jaim, M.A.S. Mandal and D.E. Parker having been particularly associated with its preparation, with additional inputs from S.C. Dutta.

[10] The poor economic showing of DTWs and their frequent placement in areas best suited to STWs has been noted by Johnson (1985), among others.

b) In areas suitable for STWs, what has been the impact of recent STW development on DTW command area and performance?

c) How profitable is DTW irrigation—with and without subsidies.

d) How well is the local private sector providing repair and parts services for DTWs and how might that provision be improved?

e) What role, if any, should or can the public sector play in the provision of support services to DTWs.

2. BACKGROUND

Deep tubewells (DTWs), the pioneer groundwater irrigation technology in Bangladesh, were introduced in Bangladesh in the mid-sixties with heavy public sector involvement with respect to installation, operation and maintenance of the pumps. After the then Water and Power Development Board had installed about four hundred large capacity DTWs in the northern districts, BADC (the Bangladesh Agricultural Development Corporation) became the sole authority for import, distribution, installation and maintenance of DTWs. From the beginning, DTW prices were heavily subsidized and the farmers' groups managed this technology by paying nominal rental charges (which increased only marginally over the years) to BADC.

In the mid-eighties the Government started to sell DTWs to groups and individuals rather than retain public ownership. These sales included new wells as well as ones which had been rented. Sales of the rental DTWs, in particular, were slow and a good number are understood to have not yet been actually sold. Some are non-functioning and others are being operated by local farmers despite their ownership uncertainty. From the early 1990s all subsidies on DTW sales were dropped and BADC started offering the wells only at full cost. As the privatization process progressed, BADC also started phasing out its provision of various support services, especially the supply of DTW spare parts and of its trained mechanic services for repairing of DTWs. Supplies of spare parts and of repair and maintenance services are now provided solely by private sector traders and workshops, if they are provided at all. Private mechanics appear to be lacking some of the heavy equipment necessary to deal with major DTW breakdowns.

The present survey, which covered a total of 96 villages in the selected five districts, show that there were 36 functioning DTWs in 1988/89 in these villages and the number increased to 59 in 1992/93 (a 16% growth per year). There has, however, been only one more DTW installed (or possibly rehabilitated) in 1994/95. This virtual halt to new DTW development is quite typical of the whole country.

3. METHODOLOGY

For the Study on Privatization of Minor Irrigation (which looks at STWs and LLPs in addition to DTWs) five districts were selected for examination of district and local level aspects of the minor irrigation performance in a newly privatized context. Two of these districts (Bogra and Comilla) were chosen because they represent the most advanced minor irrigation areas in the country. Two others (Hobiganj and Nilphamari) are later starters in this field—while Faridpur falls somewhere in between. Surveys of pump owners, irrigating farmers, mechanics, traders, support service providers, etc., were conducted in selected thanas of these districts and technical measurements were taken at a sub-set of the sample irrigation units.[11]

The collected data includes information on 46 DTWs in operation in 1993/94 (though three of these were no longer running in 1994/95). All these wells were operated by force mode centrifugal pumps. Eighteen out of the 46 had 20-44 horse power diesel engines while 23 were operated by 20-30 horse power electric motors and 5 DTWs were operated by a combination of diesel and electricity. DTW engines/motors under this study include different makes and models from a variety of countries such as Bangladesh, China, England, India, Italy and Japan. These wells have a nominal discharge of 56 LPs.

4. PROCUREMENT AND INSTALLATION OF DTWs

Some of the sample DTWs (29 out of 46) were purchased new by their present owners and others were already used at the time of sale (mostly having been BADC rental wells). As a result, their subsidized prices varied from Take 146,000 to 175,000 for new DTWs and from Take 35,000 to 75,000 for old DTWs. 19 out of the DTWs (41%) had been installed in 1990 or later so were in quite new condition. While most of both the old and new DTWs were bought from BADC, about 20 percent (6 units) were reported to have been procured with the support of other organizations such as BRAC.

Almost all the old DTWs were in running conditions when these were bought, except for one which had been out of operation for about 3 years. About half of the DTWs that had been under BADC rental arrangements prior to selling were managed by formal BRDB-KSSs, whereas the remainder were managed by informal farmer groups.

44 percent of the DTWs were purchased with the owners' own funds, about 37 percent were bought with bank loans and 17 percent with a combination of the two. About 53 percent of owners who bought DTWs with bank loans reported that they were up on their instalment payments, while 42 percent were in arrears. Given the widespread national reports of default on loan repayment, these proportions of DTW owners reporting they were up on their payments may seem somewhat overestimated.

About half of the owners reported facing problems of various kinds while procuring their DTWs. The majority of the respondents facing problems (70%) reported the cumbersome and time consuming process of new DTW purchase as the main problem. For old DTWs, the major problems were associated with the fixation of purchase price (which would vary with age and condition of engine and pumps) as well as payment of illicit amounts in fixing that price. This latter case corroborates the findings on rent

[11]For sampling details see the paper on Study Background, Organization and General Methodology in this volume.

seeking from the selling of rental DTWs by the agency and is considered as one of the reasons for the slow rate of turnover of the publicly owned DTWs to private farmers (Mandal 1986).

The installation of DTWs requires heavy drilling equipment and specialized techniques and is done usually by private sector drillers on contract with BADC. The speed with which BADC managed to install new DTWs was reported to have been reasonably fast—with installation time averaging about 3.5 months (ranging from 0.3 months to 15 months). In 18 out of 29 cases of new DTW installation, however, the DTW owners reported having paid an average of more than Take 5,800 to the agency and the drillers in excess of the official price. It may be assumed, however, that a portion of these extra payments were more in the form of food and entertainment naturally supplied during the few weeks of the installation job, rather than being entirely extortions.

Much of the above description of procurement and installation of DTWs pertains more to the time of public sector management of these functions rather than to the more recent privatized era. Very few DTWs have been sold since the dropping of subsidies as prospective owners have found them too expensive. The sales of existing (as opposed to new) pumps were sales by the public sector agency rather than by private traders. It has not really been possible, then, to compare procurement and installation by private vs public actors—except to say that there haven't been sales under the private sector as unsubsidized wells will not move on the market.

5. MANAGEMENT OF DTWs

5.1 Ownership and Share of DTWs

DTWs ownership varied by what type of irrigation groups were formed or who contributed capital for buying the units. Among the 46 sample wells, private owners had 31, KSS groups 8 and BRAC (Bangladesh Rural Advancement Committee) groups 5—and 2 were not yet sold and were being run under informal arrangements by local farmers (Table 1). Privately owned DTWs had an average of 13 owners while the KSS groups included 61 owners and the BRAC groups 68. While ownership was, therefore, more widely distributed in the cooperative and NGO wells, it is not clear whether this translated into a broad distribution of management control.

An average DTW irrigated the land of about 90 farmers—the actual number ranging from 4 to 215 with a median value of 75. Having such a large numbers of clients means that DTW owners/managers have to seek the cooperation or participation of a large number of farmers generally coming from more than one villages. This implies that a great deal of effort must go into contracting and negotiating with irrigator-farmers regarding mobilization of funds for buying diesel/mobil or getting electricity connections, fixation and collection of water fees and scheduling of on-farm water distribution. The larger the number of irrigator farmers and the size of command area, the higher are what economists call the transactions costs. Such costs rise further with variation of soil type (with different water requirements) in the command area and with the level of fragmentation of client farmers' land. It is in this context that the management of a DTW can be seen as much more onerous and costly than STW management. A case study illustration of DTW management is presented below.

Interview with a DTW Owner

DTW history: The DTW was installed in 1982. It was first rented out by BADC until 1990, when the present owner purchased the it. The original rental price in 1982 was TK 3,600 per year. This rental included the cost of spare parts in excess of Tk 1,000/year as well as associated mechanical services. After three years BADC increased the rent to Tk 5,000. During this rental period there were not have any major problems with the engine. Furthermore, if need be, the group could request the services of one of BADC's mechanics if necessary.

In 1990 BADC instituted a policy to sell DTWs to both individuals and farmer groups. At this time, the present owner, decided to buy the DTW. He paid Tk 45,600. He also changed the well from a diesel engine to an electric motor. For this he paid Tk 30,000 plus Tk 10,000 for incremental costs.

Operation Costs and Fees: The total seasonal cost for electricity for the well is Tk 35,000. In addition, the owner pays around Tk 7-8,000 for labor and materials. He charges the water users Tk 400 per bigha per season, plus Tk 3 per Kw, which is slightly higher than the normal consumer price of Tk 2.5 per unit. The owner feels he has to charge more because he doesn't succeed in recovering electricity costs from all his water users. It takes approximately 100 units per bigha per season to irrigate.

The present policy is to try to recover 50 percent of the fees per farmer before the start of the irrigation season. The rest may be paid after the season. Most farmers prefer to pay in small installments. However, electricity has to be paid on the day of use.

Water Distribution: Water is sold to 40 farmers, who together own 54 bigha. There is not a users' committee, but if there are problems the users discuss how to solve it. Before the start of the season the farmers are invited for a religious function (with sweets etc.,) and informed that the owner will soon start selling water. Farmers have to contact him to be registered for water service. Usually there are not that many farmers who want to take water at the same time but in case this might happen, the person who is first to register will get water first. However, in case of emergency the owner normally may give preference to another farmer first. Every morning the owner keeps 'office' for about 2 hours at a place where farmers know they can contact him. Normally farmers book their water turn two days in advance.

Problems: The owner is satisfied with his DTW but he has never considered buying a second one. Some time ago he faced some competition from a STW owner but was able to protect his command area as farmers prefer buying water from a DTW since it takes less time for the water to reach their fields. The only problem he has now is to find a private mechanic who can maintain and repair the pump. He has never tried to contact BADC because he believes that since BADC has sold the DTW they no longer have any responsibility.

DTW management has also a huge implication for cash availability by the tubewell owners for operation and maintenance of the wells. For example, one sample owner had to incur a total O&M cost of TK 45,748, of which about three quarters was spent on diesel/mobil, rehabilitation and repair and maintenance services which require before or during the season (Appendix Table A). In addition there were the costs of managers, drivers and lineman's services, channel construction and other associated expenses. It is possibly due to this huge cash requirement that relatively fewer DTWs than STWs used a crop share system of payment for water.

5.2 Change in Boro Area Irrigated by DTW

One of the facets of minor irrigation privatization is that the liberalization of diesel engine imports with the concomitant reduction in engine prices and the withdrawal of previously imposed spacing restrictions has led to a growth in number of shallow tubewell installations. For example, 16 out of the 46 sample DTW owners/managers reported that other machines (primarily STWs) were sited close to their own wells. This they attributed to the withdrawal of spacing regulations, the recent availability of cheaper STW engines and conflicts with/between irrigator farmers. The repeat survey of 1995 confirmed that during the period from 1993/94 to 1994/95, 1 to 2 STWs were installed close to 10 out of the 43 DTWs still in operation.[12] Eleven out of the 17 owners of DTWs which lost command area (in the main irrigation season) over the last few years reported an increase in number of competing wells (mainly STWs) as the main reason for declining area per well. (By contrast, 7 out of 11 owners of DTWs which had gained some main season coverage over time attributed this gain to increases in irrigation demand and improvements in their water conveyance systems.)

STWs were installed in neighboring sites as well as in sites actually previously commanded by existing DTWs and have often resulted in a reduction of the command areas of both DTWs and other STWs. However, there have also been countervailing cases where STWs have subsequently changed sites or have ultimately been withdrawn due to technical problems or financial losses. In those cases DTW command areas have sometimes been enhanced. For instance, the 1995 repeat survey of pump owners showed that STWs formerly situated close to three of the sample DTWs had been withdrawn—to the effect that some of the plots previously irrigated by those STWs had been added to the area of the DTW. In other words, competition between DTWs and STWs does not always mean that DTWs lose out.

Survey results presented in Table 2 show that DTW command areas have been reduced (for whatever reason, not necessarily due to STW competition) by about 1.66 percent per annum over the period 1988/89 to 1993/94. In 1994/95 there are indications that this trend may have continued[13] This trend of declining command area, it might be noted, is also found for sample STWs in this study.[14]

It has often been the competition of other wells that has affected command area. There are, however, other forces such as the type of management system and the power source of DTWs which also influence changes in coverage. For example, Table 2 shows that the sample of electrically operated DTWs have generally had a significantly larger command areas (24.08 ha) than the diesel operated wells (15.26 ha).

About half of the DTW owners (46%) said that there were no opportunities for expanding the command areas of their wells. Their constraints were often ascribed to the increased competition of other units (as discussed above)—but also included cash constraints, low capacity engines and the growing of non-irrigated crops within the nominal command area of the well. Many owners (24%) also cited village

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[12]Similar instances of close siting of STWs and LLPs are discussed in the paper on Pump Level Performance of Minor Irrigation: STWs and LLPs in this volume.

[13]The 1995 figures, though, may have been underestimated as the owners were interviewed only quite early in the season when their expectation of the full command area may not have been fully accurate.

[14]See the paper on Pump Level Performance of Minor Irrigation: STWs and LLPs in this volume.

rivalry as precluding the inclusion of some potential irrigators with land within the potential command area.

5.3 Repair and Maintenance of DTWs

As the privatization process developed, the provision by BADC of repair and mechanical services together with the supply of spare parts ceased. It is now mainly the private sector workshops and private mechanics who are gradually replacing BADC in providing these services. Actually, the work is usually done by former (as well as existing) BADC mechanics who are associated with local workshops and who provide repair services. For major DTW breakdowns the BADC mechanics have, at times, managed to get access to BADC tools and equipment and perform the repair jobs purely as private contracts.

The number of irrigation mechanics is limited in a given locality. Only 62 percent of DTW owners reported that mechanics were readily available—with the remaining owners reporting that they get mechanics only with some delay. As regards training, DTW mechanics were reported to have more formal training and therefore better quality of work, compared to those working for STWs and LLPs. The deep tubewell owners generally complained about the shortage of good quality mechanics in general and trained DTW mechanics in particular.

The procurement of DTW spare parts appeared also to be a problem as the DTW owners had to get supplies of the most frequently broken spare parts from the larger stores located in the district and thana level markets rather than locally. District headquarters average 29 km in distance from sample DTWs while thana headquarters were 17 km away on average so delays in repair are frequent.

5.4 Irrigation Water Charges

It is through the water fees that they charge that pump owners pay for O&M costs and try to earn a profit. Has there been an increase in such charges following the privatization of DTWs? The answer to that question is somewhat clouded by the fact that water charges varied a good deal between management systems, between water payment systems and between power sources (Table 3). For instance, for the 5 DTWs which collected water fee in terms crop share (one-fourth to one-third of the harvest), the average water fee was calculated to be more than double the rates charged by the 33 units which had a fee per unit of irrigated land (and for which the DTW owners supplied fuel). The diesel operated DTWs charged about 53 percent higher water fees than the electric DTWs. Private DTWs and BRAC units charged higher water fees than KSS DTWs, but the difference was not significant. Keeping this diversity in mind, it can be seen that water charges have generally increased by about 34 percent over the period from 1988/89 to 1993/94.

In looking only at 12 former BADC rental wells which are now run privately, seven units had a fee increase (averaging 49%) after privatization and 3 wells had a decrease (of 22%) (Table 4). The average was a 22 percent increase (a bit lower than the overall rise noted above).[15]

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[15]A study by Hakim, Ghani and Parker (1991) found also found somewhat higher water charges among private DTWs compared to BADC rental wells.

In general, it should be noted that the increases in water charges over the last several years have been more or less in line with the overall increase in O&M costs during this period. During the period from 1988/89 to 1993/94, diesel price increased by about 98 percent, labour wage rates by 25 percent, electricity price by 23 percent and spare parts prices by 30 to 50 percent.

5.5 O&M Costs and Returns to DTW Owners

The collection of water charges under various modes of payment constituted the tubewell owners' returns from water selling. One pertinent question is whether the DTW owner's returns over O&M costs were attractive enough to take up DTW water selling as a business. In the present survey, a DTW owner, irrespective of management system, spent an average of Tk 45,748 on O&M and had an average return above costs of TK 38,970 (Table 5).

These average returns hide the large variations in returns between various DTWs irrigating boro rice. While about a quarter of the DTW owners' got no more than Tk 20,000 over O&M costs, about 10 percent earned over Tk 90,000. Roughly 70 percent of the DTW owners earned less than TK 43,000 (Figure 1) which has been estimated as the annual installment owed for a loan for a DTW purchased at the former subsidized price of Tk 175,000. In other words, only about 30 percent of DTW owners would be able to generate enough returns to pay loan installments for subsidized DTW prices, let alone the question of what would have to be paid annually for a loan on an unsubsidized DTW costing Tk 700,000. The financial analysis in Section 5, below, provides more information regarding the profitability (or lack thereof) of DTW investments.

6. FINANCIAL VIABILITY OF DTWS

Major financial questions exist regarding DTWs in their present privatized environment.[16] There is concern as to:

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[16]The emphasis in this study is on how the private market is able to handle minor irrigation expansion and support. As a result, financial viability for owners and users of irrigation equipment has been stressed. A full economic analysis (minor irrigation's 'profitability' from a national society's point of view) was not attempted for two reasons. a) To be correctly done, such an analysis would have entailed a full-blown environmental study in order to value water resources used (which was outside the scope of this, more limited, research). b) In addition, such an analysis would have had to compare 'project' results with some next best alternative. For irrigation development an appropriate next best alternative would have been outside irrigated agriculture and possibly outside agriculture altogether. An economic analysis of such a hypothetical project would have been, again, well outside of the scope of this research. In taking a very rough look at other elements of an economic analysis (in which adjustments are made for subsidies, taxes and other distortions to society's valuation of goods and resources) it can be noted that there would be countervailing adjustments. 'Border' price adjustments of benefits (crop production) and costs (fuel, other inputs) as well as adjustments for the use of (possibly) underemployed labour could well come close to balancing each other out. In other words, a partial economic analysis (without a next best alternative and without an environmental valuation of water) might be expected to have results (BCR, IRR, NPW, etc.) quite similar to those of the financial analysis done in this study.

(a) Whether or not a DTW system is profitable as a whole—considering the production benefits of its irrigated acreage and the costs both of producing that crop production as well as of providing the actual irrigation.

(b) Whether or not a DTW is profitable to its owner—considering irrigation fees as the benefits and only the tubewell capital and O&M expenses as costs.

For the analysis below, the first case ("a" above) is one where the entire DTW system has been considered as a "farm" and all the costs and benefits of that system have been considered (whoever incurs the costs or gets the benefits). For the second case ("b"), a DTW is seen as a business that produces and sells water—and the profit or loss is entirely that of the owner. Here the financial return on the equity capital of the owner is examined.

Since there is no longer a subsidy on DTWs, the above issues have been examined basically with respect to DTWs under unsubsidized conditions. For comparison, however, the financial viability of these systems is also examined under the kind of subsidized conditions formerly prevailing.

6.1 Methodology for the Financial Analyses

6.1.1 DTW Sample

For the financial analysis, 37 (15 diesel and 22 electric) of the 46 DTWs in the study sample were analyzed. Four sample wells in two thanas of Nilphamari were excluded as their main irrigated crop was tobacco and they did not, therefore, represent the usual irrigated crop choice in Bangladesh. Of the remaining DTWs, 5 were operated by both diesel and electricity. These 5 DTWs were initially operated by diesel but were given electricity connections later on, although the diesel engines were kept as a standby arrangement. In the case of electricity failure or when electric connections are cut off for non-payment of electricity bills, these DTWs are run by diesel engines. These 5 DTWs have not been considered in the financial analysis due to complications in sorting out costs according to sources of power for DTW operation.

6.1.2 Analytical Technique

Investments in DTW irrigation projects are made for a long period. Since there is a flow of benefits and costs over that period, a simple analysis of annual costs and returns is inadequate. Therefore, project appraisal techniques were used to analyze the financial viability of the tubewells. Such discounted measures of project worth as Benefit-Cost Ratio (BCR), Net Present Worth (NPW) and Internal Rate of Return (IRR) were utilized.

In the recent past a 15 percent discount rate was usually used for financial project appraisal in Bangladesh. Since interest rates in recent years have come down to some extent, a 12 percent discount rate has instead been used for calculating BCR and NPW. However, a 15 percent discount rate has also been used as part of the sensitivity analysis.

6.1.3 *Alternative Conditions Considered for Financial Analyses*

It is important to look at the financial viability of a scheme under a variety of assumptions. Conditions are not everywhere the same and they may change over time. The analyses in this paper examine a number of alternative scenarios:

Diesel vs electric. As discussed earlier, financial analyses have been performed considering the DTW (with its command area and crops) as a farm as well as looking at the tubewell as a water selling business unit (from the pump owners' point of view). The financial viability of a DTW irrigation system largely depends on its command area which differs greatly according to power source (diesel or electricity) by which the engine is operated. Financial analyses, therefore, have been performed separately considering DTWs operated by diesel and by electricity.

Subsidized vs unsubsidized. As investment cost is likely to greatly affect profitability, and as the presently unsubsidized DTWs were so recently subsidized that a comparison is of interest, separate analyses have been done for subsidized and unsubsidized DTWs.

Command area change. It has earlier been reported that command areas of DTWs have been gradually declining on average. How this decline may affect profitability, therefore, is also explored.

Input and output prices. Naturally the financial profitability of an irrigation project is sensitive to input and output prices. Considering recent price increases of rice and fertilizer, sensitivity analyses of the financial viability of DTWs have also been performed with respect to changes in input-output prices.

6.2 Costs and Benefits of DTW Irrigation

To evaluate costs and benefits in this financial analysis of irrigation projects, market prices which prevailed during the period of 1993-94 have been used. Benefits for the tubewells considered as whole "farms" were naturally composed of the aggregate production value of the irrigated crops grown (including main product and byproduct). Since the harvest prices are generally lower than prices at other times, sensitivity analyses have been performed using increased prices of paddy and wheat. For tubewells when considered as a water selling business, benefits are the water fees collected and received by the DTW owner.

Cost components to be used in the various analyses have been categorized as follows:

(a) Investment cost (used for both "farm" and pump-owner analyses)

(b) Operation and Maintenance (O&M) costs (used for both "farm" and pump-owner analyses)

(c) Crop production cost (used for "farm" analysis only)

(d) Benefits foregone (net benefit without the irrigation scheme). (used for "farm" analyses only)

6.2.1 Investment Cost

Various aspects of the investment costs used in the analysis are as follows:

Unsubsidized Cost. DTWs today are available at an unsubsidized cost of about Tk 700,000.

Subsidized Cost. Prior to the withdrawal of the subsidy, the price of a DTW was Tk 175,000 on credit and Tk 140,000 if paid in cash—although the full unsubsidized price of a DTW was Tk 600,000. Very few wells were sold for cash so the 175,000 credit price is much more representative of the subsidized cost—so this figure is used in the present analyses. For the credit purchase for subsidized wells, initially a down payment of Tk 6,500 was deposited and the remaining amount was supposed to be paid in 12 equal half-yearly installments. For each of the six years of payment the repayment was calculated to be Tk 42,686.67, as follows:[17]

Subsidized DTW cost	: Tk 1,75,000
Down payment	: Tk 6,500
Credit	: Tk 1,68,500
Number of installments	: 12
Repayment period (Year)	: 6
Interest rate	: 16 %
Principal amount/6 months	: Tk 14,041.67
Average interest/6 months	: Tk 7,301.67
Total instalment/6 months	: Tk 21,343.33
Total yearly instalment	: Tk 42,686.67

Life of the DTW and its components. In relation to investment cost, some assumptions have been made with respect to life of a DTW scheme as well as its engine and pump. Based on experience from other relevant studies (Jaim 1993) as well as discussion with BADC personnel, life of a DTW scheme has been considered 20 years. The life of a DTW engine (in the case of diesel operated DTW) and pump were considered 10 and 12 years respectively. The cost of engine and pump was found to be Tk 100,000 in each case. For both engine and pump, salvage values at the end of their productive lives have been considered to be 10 percent of their purchase prices (or Tk 10,000 for each) and these have been included in the benefit stream for the project.

6.2.2 O&M Cost

O&M costs of a DTWs included the cost of energy (diesel or electricity), spare parts, mechanics' services, drivers' charge, linemens' charge, channel maintenance cost, etc. Among these, the cost of energy was most important. Pump owners keep some kind of account or can usually recall from memory more or less accurate figures for diesel and other O&M items. In the case of electrically operated DTWs,

[17]*Source:* Adapted from Mayer (1991).

they usually get periodic electricity bills based on meter readings. Annual overhauling cost which is needed at the beginning of the boro season has also been included in the O&M cost category.

6.2.3 Crop-Production Cost

Production costs included costs of human labour, animal labour, seed/seedlings, manures, fertilizers and insecticides. The cost of irrigation has been considered separately in the investment and O&M categories. Production costs (as well as benefits) per DTW vary depending upon choice of crops and area irrigated for different crops. Both irrigated area as well as choice of crops under DTW schemes were found to have varied significantly with respect to power source by which DTWs were operated. Therefore, production costs (and benefits) have been estimated on the basis of actual irrigated command area and the distribution of crops under sample diesel and electricity operated DTWs included in the study. The command area as well as the distribution of area irrigated for different crops are presented in Table 6.

While command area and the irrigated area of various crops differed by whether the unit was diesel or electric, boro rice was found to be the single largest irrigated crop in both—covering 93 percent of irrigated area in the electric schemes and 74 percent for the diesel units. The second most important crop under diesel operated DTWs was wheat which represented another 21 percent of the total irrigated area. Wheat area under electric units, however, was found to be negligible. Areas under other crops like jute, mustard, sugarcane, tobacco, vegetables, etc., were found to be negligible for both diesel and electric wells—so the contribution of these minor crops has been ignored in calculating benefits and costs of the schemes. For diesel units, then, the crops included in the analysis include HYV boro and aman rice as well as wheat (which together covered 99 percent of the irrigated area of the sample diesel schemes in the study). For electrically operated units, the crops included are HYV boro and aus (which covered 97 percent of the irrigated area).

6.2.4 Benefits Foregone

In order to produce irrigated crops, farmers had to forego benefits from non-irrigated crops which they would have grown without irrigation. Therefore, net benefit without irrigation has been considered as a cost to the irrigation scheme for the "farm" analysis. Under diesel operated DTWs, the non-irrigated crops which were considered were local aus, local aman and mustard. In the case of wells operated by electricity, non-irrigated local aus was considered as the fore-gone crop.

6.3 Financial Analyses for the DTW Irrigation System as a "Farm" and for the DTW Owner as a Water Seller.

Analyses are made separately for diesel and electric DTWs—both as full irrigated "farms" and as water selling businesses. Calculations are done separately using subsidized and unsubsidized tubewell prices. Sensitivity analyses are done to see the effects on profitability of different assumptions about input and output prices and changing command areas.

6.3.1 Unsubsidized DTWs

Assumptions and Estimations

Basic data related to financial analysis of DTWs (as a "farm") operated by diesel and electricity are presented in Appendix Tables B and C respectively. The tables show the flow of costs and benefits over the 20 years of project life. The initial investment of Tk 700,000 is assumed to come at the very beginning of the project and has therefore been counted as occurring in year zero and not discounted (unlike other costs and benefits occurring in different years).

Considering the lives of engines and pumps, Appendix Table B shows replacement costs of these items (Tk 100,000 each) in the 11th and 13th years respectively for diesel wells. The replacement cost of pumps for electricity operated DTWs has been shown in the 13th year (Appendix Table C).

O&M costs for diesel and electric DTWs were found to be very close. But electricity operated wells irrigated more land than did diesel ones which means that per hectare O&M costs for electric tubewells were much less than that of diesel operated DTWs. Per hectare O&M costs for diesel units, then, were found to be Tk 2,361 while the corresponding costs for electric DTWs were only Tk 1,784. Annual overhauling costs were needed at the beginning of the boro season were found to be Tk 3,963. It was assumed that this overhauling cost would be needed starting with the third year of project life. Further, for a diesel operated DTW there would be no overhauling costs in the 11th and 12th years when there would be a new engine. The tables also show the flow of annual production costs under diesel and electricity operated DTWs.

Gross benefits for each year except the 11th, 13th and 20th years in the case of diesel DTWs were the same. In the case of electric DTWs, except for the 13th and 20th years, gross benefits for all years were also the same. In those particular years salvage values of pumps and engines (for diesel DTWs) have been added. Net benefits without the irrigation scheme as well as cash flows for diesel and electric wells can also be seen from the Appendix Tables.

For the financial analysis of a DTW "farm," gross cost includes investment cost, O&M costs and production cost. The net benefit in this case is the difference between gross benefit and gross cost. The cash flow is derived by subtracting net benefit without the scheme from net benefit with the irrigation scheme. Again, total cost has been calculated by adding net benefit without the well and gross cost of the scheme.

For the case of financial analysis from the pump owner "water seller" point of view, gross cost involved only investment and O&M costs, while gross benefit included revenue earned through water selling only. The figures for investment and O&M costs can, again, be seen in Appendix Tables B and C. Gross benefit (from water selling) for diesel operated DTW was found to be Tk 90,035 per year, while for electricity operated DTW it was Tk 85,938. The cash flow in this case is simply the difference between gross benefit and gross cost in each year.

Results

The results of the financial analyses for unsubsidized DTWs under the above conditions are presented in Table 7.

The DTW as a "farm:" It can be seen that unsubsidized **diesel** DTWs are not financially viable. The values of BCR were found to be 0.93 at a 12 percent discount rate and 0.90 at a 15 percent rate. The corresponding NPW values at 12 and 15 percent discount rates were found to be large negative values of -Tk 241,435 and -Tk 313,365, respectively. For unsubsidized **electric** DTWs, on the other hand, some degree of financially viability is shown. The BCR, NPW and IRR in this case were found to be 1.09, Tk 401,177 and 21 percent respectively. Electrically operated DTWs had less O&M costs per hectare compared to diesel wells. Also, due to having more average command area, the benefits of electric systems are higher. The value of IRR (21%), however, is not so attractive as to convince farmers to buy a DTW at unsubsidized prices given such risk factors (not included in the analysis) of breakdown expectations, unavailability of spare parts, uncertainty of electricity supply, possible command area reductions due to technical or social problems, etc.

The DTW as a water selling business: Financial analysis from the view point of pump owners showed that an unsubsidized DTW would not be financially profitable irrespective of whether it is diesel or electric. In the case of **diesel** operated DTW, at a 12 percent discount rate the BCR was found to be only 0.61 and the NPW was negative at -Tk 438,264. The corresponding values of BCR and NPW for **electric** DTWs were found to be 0.60 and -Tk 437,749 respectively. The values of BCR and NPW were found to drop further when benefits and costs were discounted at 15 percent. IRR for both electricity and diesel operated DTWs could not be calculated as the values of NPW were negative in both the cases.

Sensitivity Analyses

The financial analyses reported above with respect to diesel and electric DTWs used the same irrigated command area over the entire project life. Survey findings, however, showed that there has been a gradual decrease in command area of DTW over time. Further analysis has been done, therefore, to see what happens to financial viability when command area decreases from the existing level.

Further, the already reported results were based on 1993-94 input-output prices. The input-output price relationship is likely to vary over time. For example, in 1995, the price of rice (also wheat) as well as of fertilizer are higher than they were in 1994. This may happen in other years too. Therefore, analyses have also been done to examine how sensitive is the financial viability of DTWs as "farms" with respect to changes in prices of cereals (paddy, wheat) and fertilizers.

Sensitivity analysis with respect to command Area

Sensitivity analysis with respect to decreased command area has been done only for electric DTWs as a "farm"—as the diesel "farm" units as well as both electric and diesel pump owner models already showed negative returns even with their 1994 command areas and a further reduction would add little information. The pump owners' survey data showed that during the last five years, command area of electric DTWs has decreased by about 2 percent per year. On the basis of this it has been assumed that from the second year of the life of the scheme the command area of electric DTWs would be decreased

by 2 percent.each year. That means that, through gradual reduction in command area, in the 20th year the coverage would be 15.70 hectares.

With the above assumptions as to decreasing command area the value for BCR at 12 percent discount rate for electric DTWs was found to be 1.06 and the value of IRR was found to be 18 percent (Table 8). This compares with the previous IRR of 21 percent assuming constant command area over the project life. Therefore the analysis indicates that even with a decrease in command area by 38 percent over the project life, the electric DTWs can be financially viable, although marginally. Risk, it should be remembered, would decrease the return further. Given the high real costs of borrowed capital as well, the investment is not attractive.

Sensitivity analysis with respect to changes in input and output prices

Sensitivity analyses with respect to increases in prices have been done for diesel DTWs which had previously been found to be financially not viable. The intention was to examine whether a diesel well could be financially viable if the prices of output (particularly paddy) were to increase. Again, what would happen to the financial viability of these DTWs if fertilizer prices also increased. Since increased price of output will further improve the results of electric DTWs (and as the additional cost of fertilizer is less than the additional benefit from an increased price of output), sensitivity analyses have not been performed with respect to electric tubewells.

In this connection, separate analyses for diesel operated DTWs have been performed considering four different scenarios as follows:

(a) 50% increase in paddy and wheat prices,
(b) 25% increase in paddy and wheat prices,
(c) 50% increase in paddy and wheat prices, and 100% increase in fertilizer prices
(d) 25% increase in paddy and wheat prices, and 50% increase in fertilizer prices.

The results of these sensitivity analyses are also presented in Table 8. They show that the diesel operated DTWs could be marginally financially viable if the output prices were assumed to be increased by 25 percent. With such an increase of output prices, IRR was found to be 18 percent. Even with a 50 percent increase of fertilizer price, with the same level of increased output price, the IRR was found to be 15 percent and the corresponding BCR was 1.04 at a 12 percent discount rate. Under the assumption of a 25 percent increase in output (paddy and wheat) price and 50 percent increase in fertilizer price, if a 15 percent discount rate were used the BCR would be 1.00. This is a break-even position.

Further, with a 50 percent increase in output prices, the IRR was found to rise up to 29 percent. And with both a 50 percent increase in output prices and a 100 percent increase in fertilizer price the IRR would be 25 percent. Output prices, then, were found to have significant effects on the financial viability of DTWs even if fertilizer price were also to increase to a large extent. The results indicate that unless output prices, particularly the price of paddy, increase substantially (say about 25%), the unsubsidized diesel DTWs will not be financially viable.

Sensitivity analyses with respect to the pump owner as water sellers were not done in connection with changes in input and output prices since the pump owners are not directly affected by an increased

price of fertilizer and also they are not directly benefitted by an increased price of output, except in systems where they collect water charges in terms of crop share.

6.3.2 Subsidized DTWs

In the case of credit purchased subsidized DTWs, the investment cost in the initial year was only Tk 49,187 which included an annual installment of Tk 42,687 and down payment of Tk 6,500. The annual installment continued up to the 5th year of the project life. All other costs and benefits were assumed to be the same as for unsubsidized DTWs. The flow of costs and benefits throughout the project life can be seen in Appendix Tables D and E. The results of the financial analyses considering DTWs purchased on credit can be seen in Table 7.

BCR and NPW figures imply that the credit purchased subsidized DTWs as "farms" are somewhat profitable. Again, risk has not been included in the analysis. As with unsubsidized wells, compared to diesel units there are higher values of BCR and NPW for electric DTWs.

From the pump owners' point of view the DTWs were also marginally profitable if risk is ignored. The IRR value for diesel DTW was found to be 22 percent and that for electric units was 20 percent. It may be recalled from an earlier section of this paper that annual returns over O&M costs would cover the yearly loan installment for only 30 percent of the sample DTW owners (see Figure 1). 42 percent of loan-purchased DTWs were in arrears on their bank loans. A much higher rate of return would be needed to make these wells truly attractive—even at the subsidized price.

6.3.3 Financial Analysis of DTWs Assuming Investment as a Sunk Cost (or Zero)

As a part of the present privatization policy, BADC is no longer providing mechanical services and spare parts to the existing DTWs. The private sector, however, has not fully taken up the task of providing these necessary supports to the existing DTWs. If this situation continues in the coming years, many of the existing DTWs will stop operating before the end of their expected productive lives. Therefore, considering the investment as a sunk cost (equaling zero) the question is whether it is worth providing mechanical services to the existing DTWs for the rest of their normal lives.

It is useful in this regard, then, to examine how financially viable these DTWs are assuming a zero investment cost. The sample DTWs which had been bought in new condition were found to be 5 years old on average. Therefore, these DTWs have on average about 15 years of remaining life. Financial analysis in this case has been done assuming only the remaining 15 years. Since investment cost has been treated as sunk cost which is zero, only O&M costs and production costs have been considered in this case. The results of the analyses are presented in Table 8.

The values of BCR and NPW at a 12 percent discount rate show a fairly good return to the electric DTW "farm" (and a marginal return for diesel ones) if the wells are given needed support (i.e. if mechanical services are made available) to run properly for the rest of their potential project lives. In this case, BCR and NPW at 15 percent discount rate have not been calculated since this would only marginally affect those values while the conclusion will remain the same. Therefore, the findings indicate that even after privatization of irrigation, support may be worthwhile (particularly in repair and maintenance) to run the existing DTWs.

7. DTW OWNERS' PERCEPTIONS ABOUT THE PROFITABILITY AND PROBLEMS OF THEIR WELLS

7.1 Profitability Views

Generally the low or negative returns to investment by the water selling DTW owners that are reported above are corroborated by sample owners' views. Survey findings in this regard show that 22 out of 46 DTWs (about 48%) considered owning a DTW for irrigation as only marginally profitable, while 19 DTW owners (41%) considered it as just a break-even or losing concern. Only 5 DTW owners thought that owning DTWs was highly profitable (Table 9). It should be noted that all of the respondents had purchased their wells at subsidized prices so were viewing their units in that light, not as unsubsidized wells. The possible reasons for DTWs being only marginally profitable or worse were identified by the DTW owners as the high cost of diesel/mobil, electricity, repair and maintenance, and insufficient land covered by their wells.

7.2 Problems and Views on Remedies

Now that DTWs are privatized and BADC no longer is providing support services for repair and maintenance of DTWs, it is important to know what the DTW owners' perceptions are with respect to their problems and about what can be done to improve DTW irrigation. The main problems cited by the respondent DTW owners are (Table 10):

a) DTW spare parts are not readily available.
b) Local workshop facilities are inadequate.
c) DTW sinking/resinking is difficult due to the absence of the technical support that used to be provided by BADC.
d) Management of big irrigator groups is difficult (DTW groups have an average of about 90 irrigator farmers). This problem is particularly complicated when lands are highly fragmented and plot owners come from different villages—meaning high contractual, negotiation and water fee collection costs for the DTW owners.

The pump owners noted a number of possible actions which they thought could be taken to improve DTW irrigation management. They would like (Table 11):

1) Reimposition of the subsidy on equipment.
2) Easy provision of bank loans for DTW purchase.
3) More provision of electricity connections to DTWs.
4) Agency help or advice on improved channel construction.

Contrary to expectations, very few DTW owners suggested that STWs be restricted in DTW command areas. Perhaps many of them also own STWs.

DTW owners were also asked their opinions about the possibility of expanding minor irrigation (not only through DTWs) in their respective localities. Only about half of them (24 out of 46 DTW owners) thought that there was scope for expansion of minor irrigation. It might be noted that 12 owners thought that more STW installations would be the best way to expand minor irrigation while only 7 preferred more DTWs for that purpose and 10 thought that better utilization of existing wells would suffice.

Opinions were also sought about what could be done by the government and private sector to expand minor irrigation in their localities. Respondents identified the reduction of cost of diesel, the provision of electricity connections and the reduction of electricity costs, as well as the lowering of DTW prices as their desired help from the government. Their wishes from the private sector included mainly the supply of good quality spare parts, mechanical services and diesel/mobil by the private traders—all at cheaper prices than at present.

8. SUMMARY AND CONCLUSIONS

Procurement

All the deep tubewells (DTWs) under this study were purchased at subsidized prices. While some of the previously BADC rental DTWs were purchased by farmers with their own funds, many of the DTWs, especially the new ones, were purchased with bank loans which many of the DTW owners have not repaid. Despite relaxation of rules for selling of DTWs, about half of the sample DTW owners faced practical problems of cumbersome official processes in procuring DTWs, especially regarding the fixation of the price for old BADC rental DTWs.

Management

DTWs command area is gradually being reduced due to competition from STWs which are now easily available at low cost and can be installed in any suitable site. Previous spacing regulations, which could give legal protection to DTW command areas, have been withdrawn—which has added to the shift of land from deep tubewells to the more easily managed shallow tubewells. DTW owners have also had problems of cash constraints and rivalry with farmers which not only limited their command areas but also often excluded non-irrigated plots that could potentially have been irrigated. Furthermore, management of the big groups of farmers typical of DTW irrigation has led to difficulties and high contractual costs, which also limits the expansion of DTW coverage..

Water Charges

There is little evidence that DTW water charges have increased after turning the previously rental DTWs to private ownership—at least if irrigation related input prices (diesel, mechanics, spare parts, etc.,) are taken into account.

Unsubsidized Financial Viability

The findings suggest that with an unsubsidized price, a diesel DTW would not be financially viable although electric DTWs with large command area could be marginally viable—assuming risk is ignored.

Output Prices and DTW Financial Viability

To make the diesel operated unsubsidized DTW "farms" financially viable a higher output price would be needed. With higher output price (say a 25% increase) even with higher fertilizer price (of 50%) the unsubsidized DTW could be financially viable (barring risk), although marginally. Therefore, other things remaining the same (i.e. command area, input prices, etc.), a higher output price is a precondition for making an unsubsidized diesel operated DTW financially viable as a "farm." However, although an unsubsidized DTW scheme seen as a "farm" might become financially viable under the conditions as stated above, it appeared still to be a bad investment from the pump owner's (or water seller's) point of view. These findings help explain why DTWs have not been selling since the dropping of their subsidy.

Subsidized DTW Financial Viability

The somewhat more positive results relating to DTW sales at subsidized prices indicate that some level of subsidy would be necessary if either the DTW schemes as "farms" or as water selling businesses are to be financially viable (though many owners of subsidized wells today see them as not being very profitable). Whether or not such a subsidy would be justified for an technology showing such poor unsubsidized financial returns, however, is a political question.

Viability of Existing DTWs

Of more immediate concern is what should happen to existing DTWs. Financial analyses indicate that such wells (at least those located in areas where STWs cannot replace them) do have a positive financial return when treating their investment as a sunk cost. Such wells are currently having problems getting adequate mechanical services and spare parts. It is probably worthwhile to develop temporary programs (until the DTWs have finished their productive lives) which can help the private market provide these services.

Owners' Desired Actions from the Public and Private Sectors

According to DTW owner's opinion, to make DTW investment profitable, government should reduce DTW price, provide bank loans on easy terms, provide more electricity connections and advice on improved channel construction. Since only a small proportion of DTW owners identified restriction of STW installation in DTW command area as a means to expand command area, the findings suggest that

spacing regulations might not have much relevance to improving DTW performance—though some land is being shifted over to STWs in a number of systems. From the private sector the DTW owners wanted a supply of good quality spare parts, mechanical services and diesel/mobil at cheaper prices.

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Table 1. Ownership status of sample deep tubewells, 1994.

Ownership status	No. of DTWs	%	Average no. of owners	Average shares (%)
Private	31	67.4	13 (1-64)	41 (1.6-100)
KSS	8	17.4	61 (10-168)	4 (0.6-10)
BRAC	5	10.9	68 (30-120)	1.8 (0.7-3.3)
Not sold	2	4.3	1	100
All	46	100.0	27 (1-168)	32.9 (0.6-100)

Figures within parenthesis indicate range

Source: IIMI/BSERT 1994 Pump Owner's Survey in Bogra, Comilla, Faridpur, Hobiganj and Nilphamari Districts.

Table 2. Average boro command area per DTW and annual change in boro command area over time.

District/power source	1988/89		1993/94		1994 /95[a]		Annual change (%)
	No. of units	Area (ha)	No. of units	Area (ha)	No. of units	Area (ha)	1988/89 to 1993/94
Bogra	7	32.06	9	33.45	9	31.37	+0.87
Comilla	11	20.61	20	19.25	18	16.16	-1.32
Faridpur	3	17.84	5	13.06	5	11.15	-5.36
Hobigonj	2	24.78	5	18.23	4	22.70	-5.29
Nilphamari	3	19.03	4	21.10	7	13.86	+2.18
All 5 districts	26	23.51	43	21.56	43	19.00	-1.66
Diesel	7	14.91	16	15.26	16	12.13	+0.47
Electric	16	26.80	22	24.08	23	21.82	-2.03
Diesel+electric	3	26.01	5	30.59	4	30.23	+3.52

a. Boro command area figures for 1994/95 were obtained in mid-February, 1995, quite early in the season when the pump owners had irrigated only part of their command areas. As a result, their estimates of total command areas were based on their actual area irrigated up to mid-February plus their expected additional areas to be irrigated later on in the season which were likely to be underestimated.

Source: IIMI/BSERT 1994 Pump Owners' Survey in Bogra, Comilla, Faridpur, Hobiganj and Nilphamari districts.

Table 3. Average water charge for boro irrigation by DTWs in 1988/89 and 1993/94.

Management/payment mode/power source	1988/89		1993/94		% Change over 1988/89
	No. of DTWs	Water charge (Tk/ha)	No. of DTWs	Water charge (Tk/ha)[1]	
A. Management system					
Private	NK	NK	29	4064	NA
KSS	NK	NK	7	3714	NA
BRAC	NK	NK	5	5622	NA
Not yet sold	NK	NK	2	4726	NA
B. Payment system					
Cash (MF)	22	3194	33	3878	+21.1
Cash (FF)	2	1647	5	2223	+35.0
Crop-Share (MF)	1	4940	5	8468	+71.4
C. Power source					
Diesel	NK	NK	16	5416	-
Electric	NK	NK	22	3528	-
Diesel+electric	NK	NK	5	3433	-
D. All DTWs	25	3140	43	4219	+34.4

NK. = Not known. NA. = Not Applicable. MF. = Managers' fuel. FF. = Farmers' fuel.

1. Duncan Multiple Range Test shows that water charge under crop share payment system was significantly higher than the other two systems at the 5 percent level. Difference in water charge between diesel and electric DTWs was also significant at the 5 percent level.

Source: IIMI/BSERT 1994 Pump Owners' survey in Bogra, Comilla, Faridpur, Hobiganj and Nilphamari districts.

Table 4. Changes in water charge for boro irrigation for DTWs previously rented but currently privatized.

Change in water charge	No. of DTWs	Water charge (Tk/ha)		% Change
		Last year of rental system	1st year under private ownership	
Increased	7	1729	2576	+49.0
Decreased	3	3677	2882	-21.6
Unchanged	2	-	-	0

Source: IIMI/BSERT 1994 Pump Owners' Survey in Bogra, Comilla, Faridpur, Hobiganj and Nilphamari districts.

Table 5. Average boro area, O&M cost and return over O&M cost for DTWs under different management systems, 1993/94.

Management systems	No. of DTWs	Boro area (ha)[1]	O&M cost (Tk)	Return over O&M cost (Tk)
Private	29	20.69 (8.98)	43144 (22783)	36017 (26954)
KSS	7	32.13 (10.74)	62129 (16828)	54991 (28322)
BRAC	5	17.03 (8.54)	43914 (18454)	46961 (41899)
Not yet sold	2	8.50 (8.58)	30750 (24819)	5736 (8451)
All DTWs	43	21.56 (10.42)	45748 (22228)	38970 (29612)

a. Duncan Multiple Range Test indicate that KSS DTWs had significantly higher command area than other groups at the 5 percent level. Neither O&M cost nor return over O&M cost was significantly different between groups at the 5 percent level.

Figures in parentheses indicate standard deviation.

Source: IIMI/BSERT 1994 Pump Owners' Survey in Bogra, Comilla, Faridpur, Hobiganj and Nilphamari districts.

Table 6. Distribution of irrigated area by crops under diesel and electric DTWs.

Crops	Diesel-operated DTWs Area (Acres)	Diesel-operated DTWs % of Total Area	Electricity operated DTWs Area (Acres)	Electricity operated DTWs % of Total Area
HYV aus	-	-	3.09	4.80
Jute	-	-	0.28	0.44
HYV aman	2.17	4.43	-	-
Mustard	-	-	0.03	0.05
Potato	-	-	0.76	1.18
Sugarcane	-	-	0.02	0.03
Wheat	10.12	20.70	0.22	0.34
HYV boro	36.21	74.05	59.48	92.48
Tobacco	0.40	0.82	-	-
Vegetables	-	-	0.33	0.51
Others	-	-	0.11	0.17
Total	48.90	100	64.32	100

Note: Due to very small areas of some crops; the areas are shown in terms of acres instead of hectares.

Source: IIMI/BSERT 1994 Pump Owners' Survey in Bogra, Comilla, Faridpur, Hobiganj and Nilphamari districts.

Table 7. Financial analysis of DTW under various alternatives.

Appraisal from alternative view points	Alternative conditions for capital cost	Alternative energy sources for DTW operation	Results of financial analysis				
			BCR		NPW (Tk)		IRR
			at 12% D.F.	at 15% D. F.	at 12% D. F.	at 15% D. F.	
From the view point of DTW project as a whole	Unsubsidized capital cost of DTW (Tk 700000)	Diesel	0.93	0.90	-241435	-313365	Indeterminate
		Electricity	1.09	1.06	401177	225859	21%
	Subsidized capital cost of DTW (Tk 175000)	Diesel	1.08	1.07	255491	194317	Indeterminate
		Electricity	1.23	1.21	898103	731672	Indeterminate
From the view point of DTW pump owners	Unsubsidized capital cost of DTW (Tk 700000)	Diesel	0.61	0.54	-438264	-475669	Indeterminate
		Electricity	0.60	0.53	-437749	-477083	Indeterminate
	Subsidized capital cost of DTW (Tk 175000)	Diesel	1.08	1.06	49774	32017	22%
		Electricity	1.10	1.08	59178	41420	20%

Source: Calculations are based on IIMI/BSERT 1994 Pump Owner's and Irrigator Farmers' Survey in Bogra, Comilla, Faridpur, Hobiganj and Nilphamari districts.

Table 8. *Sensitivity analyses of unsubsidized DTWs under various assumptions (analyses of DTW projects as "farms").*

Alternative assumptions	Energy source for DTW operation	Results of financial analyses		
		at 12% D.F.	NPW (Tk) at 12% D.F.	IRR
1. Assuming reduction in command area (from 2nd year) by 2% per year	Electricity	1.06	262,438	18%
2. Assuming 25% increase of paddy and wheat prices	Diesel	1.07	254,997	18%
3. Assuming 50% increase of paddy and wheat prices	Diesel	1.43	774,202	29%
4. Assuming 25% increase of paddy and wheat prices and 50% increase of fertilizer price	Diesel	1.04	173,601	15%
5. Assuming 50% increase of paddy and wheat prices and 100% increase of fertilizer price	Diesel	1.14	611,417	25%
6. Assuming 15 years remaining life of DTW project and sunk cost of DTW, zero	Diesel	1.14	212.148	Undetermined
	Electricity	1.28	557,048	Undetermined

Source: Calculations are based on the IIMI/BSERT 1994 Pump Owners and Irrigating Farmers' Surveys in Bogra, Comilla, Faridpur, Hobiganj and Nilphamari Districts.

Table 9. *DTW owners' perceptions about the profitability of owning irrigation pumps.*

Opinion	No. of responses	% of responses
a. Highly profitable	5	11
b. Marginally profitable	22	48
c. No profit-no loss	11	24
d. Losing enterprise	8	17
All	46	100

Source: IIMI/BSERT 1994 Pump Owner's Survey in Bogra, Comilla, Hobiganj and Nilphamari districts.

Table 10. Responses about the technical and management problems faced and foreseen by the DTW owners, 1994.

Problems	No. of respondents[1]	% of respondents
a. Spare parts not readily available	11	26.2
b. Inadequate local workshop facilities	10	23.8
c. Inadequate private mechanics to replace BADC mechanics	6	14.3
d. BADC mechanical support available at high cost	4	9.5
e. DTW sinking/resinking difficult	10	23.8
f. Encroachment of DTW command area by STWs	8	19.0
g. Management of DTW groups difficult	9	21.4
h. Other problems	13	31.0

1 There were 42 responses and 4 non-responses.

Source: IIMI/BSERT 1994 Pump Owners' Survey in Bogra, Comilla, Faridpur, Hobiganj and Nilphamari districts.

Table 11. Opinions of the DTW owners about measures that might be taken for improvement of DTW irrigation.

Suggested measures	No. of respondents[1]	% of respondents
a. DTW price can be reduced	19	41.3
b. Easy provision of loan for DTW purchase	15	32.6
c. Restricting STWs in DTW command area	4	8.7
d. More electricity connections	21	45.7
e. Help/advice in improved channel construction	18	39.1
f. Bank loan for water conveyance system	12	26.1
g. Training for group management	5	10.9
h. Subsidy for major repair/rehabilitation work	8	17.4
I. Ensuring availability of DTW spare parts	1	2.2
j. Other suggestions	14	30.4

1 There were 46 responses and no non-responses.

Source: IIMI/BSERT 1994 Pump Owners' Survey in Bogra, Comilla, Faridpur, Hobiganj and Nilphamari districts.

Appendix Table A. Average operation and maintenance cost of DTW for boro irrigation, 1993/94.

Cost items	Cost (Tk)	% of total cost
a. Initial overhauling	3944	8.6
b. Diesel/mobil/electricity	25550	60.0
c. Spare parts & repair	3179	6.90
d. Managers + drivers or lineman	9246	20.0
e. Channel construction & other costs	3828	8.5
Total cost	45747	100.0

Source: IIMI/BSERT 1994 Pump Owners' Survey in Bogra, Comilla, Faridpur, Hobiganj and Nilphamari districts.

Appendix Table B. Cost and benefit streams of diesel operated DTW, assuming unsubsidized price of DTWs.

Year	Investment cost	O&M cost	Production cost	Gross benefit	Benefit without Pro.	Gross cost	Net benefit	Cash flow	Total cost
0	700000	0	0	0	0	700000	-700000	-700000	700000
1	0	46370	277896	443180	49322	324266	118914	69592	373588
2	0	46370	277896	443180	49322	324266	118914	69592	373588
3	0	50333	277896	443180	49322	328229	114951	65629	377551
4	0	50333	277896	443180	49322	328229	114951	65629	377551
5	0	50333	277896	443180	49322	328229	114951	65629	377551
6	0	50333	277896	443180	49322	328229	114951	65629	377551
7	0	50333	277896	443180	49322	328229	114951	65629	377551
8	0	50333	277896	443180	49322	328229	114951	65629	377551
9	0	50333	277896	443180	49322	328229	114951	65629	377551
10	0	50333	277896	453180	49322	328229	124951	75629	377551
11	100000	46370	277896	443180	49322	424266	18914	-30408	473588
12	0	46370	277896	453180	49322	324266	128914	79592	373588
13	100000	50333	277896	443180	49322	428229	14951	-34371	477551
14	0	50333	277896	443180	49322	328229	114951	65629	377551
15	0	50333	277896	443180	49322	328229	114951	65629	377551
16	0	50333	277896	443180	49322	328229	114951	65629	377551
17	0	50333	277896	443180	49322	328229	114951	65629	377551
18	0	50333	277896	443180	49322	328229	114951	65629	377551
19	0	50333	277896	443180	49322	328229	114951	65629	377551
20	0	50333	277896	463180	49322	328229	134951	85629	377551

Source: Based on IIMI/BSERT 1994 Pump Owners and Irrigator Farmers' Survey in Bogra, Comilla, Faridpur, Hobiganj and Nilphamari districts.

Appendix Table C. Cost and benefit streams of electricity operated DTWs assuming unsubsidized price of DTW.

Year	Investment cost	O&M cost	Production cost	Gross benefit	Benefit without Project	Gross cost	Net benefit	Cash flow	Total cost
0	700000	0	0	0	0	700000	-700000	-700000	700000
1	0	45187	400738	653479	54512	445925	207554	153042	500437
2	0	45187	400738	653479	54512	445925	207554	153042	500437
3	0	49150	400738	653479	54512	449888	203591	149079	504400
4	0	49150	400738	653479	54512	449888	203591	149079	504400
5	0	49150	400738	653479	54512	449888	203591	149079	504400
6	0	49150	400738	653479	54512	449888	203591	149079	504400
7	0	49150	400738	653479	54512	449888	203591	149079	504400
8	0	49150	400738	653479	54512	449888	203591	149079	504400
9	0	49150	400738	653479	54512	449888	203591	149079	504400
10	0	49150	400738	653479	54512	449888	203591	149079	504400
11	0	49150	400738	653479	54512	449888	203591	149079	504400
12	0	49150	400738	663479	54512	449888	213591	159079	504400
13	100000	49150	400738	653479	54512	549888	103591	49079	604400
14	0	49150	400738	653479	54512	449888	203591	149079	504400
15	0	49150	400738	653479	54512	449888	203591	149079	504400
16	0	49150	400738	653479	54512	449888	203591	149079	504400
17	0	49150	400738	653479	54512	449888	203591	149079	504400
18	0	49150	400738	653479	54512	449888	203591	149079	504400
19	0	49150	400738	653479	54512	449888	203591	149079	504400
20	0	49150	400738	663479	54512	449888	213591	159079	504400

Source: Based on IIMI/BSERT Pump Owners and Irrigator Farmers' Survey, 1994.

Appendix Table D. Cost and benefit streams of diesel operated DTWs assuming credit purchased subsidized price.

Year	Investment cost	O&M cost	Production cost	Gross benefit	Benefit without project	Gross cost	Total cost	Net benefit	Cash flow
0	49187	0	0	0	0	49187	49187	-49187	-49187
1	42687	46370	277890	443180	49322	366953	416275	76227	26905
2	42687	46370	277890	443180	49322	399953	416275	76227	26905
3	42687	50333	277890	443180	49322	370916	420238	72264	22942
4	42687	50333	277890	443180	49322	370916	420238	72264	22942
5	42687	50333	277890	443180	49322	370916	420238	72264	22942
6	0	50333	277890	443180	49322	328229	377551	114951	65629
7	0	50333	277890	443180	49322	328229	377551	114951	65629
8	0	50333	277890	443180	49322	328229	377551	114951	65629
9	0	50333	277890	443180	49322	328229	377551	114951	75629
10	0	50333	277890	453180	49322	328229	377551	124951	-30408
11	100000	46370	277890	443180	49322	424266	473588	18914	79592
12	0	46370	277890	453180	49322	328229	373588	128914	-34371
13	100000	50333	277890	443180	49322	424266	477551	14951	65629
14	0	50333	277890	443180	49322	328229	377551	114951	65629
15	0	50333	277890	443180	49322	328229	377551	114951	65629
16	0	50333	277890	443180	49322	328229	377551	114951	65629
17	0	50333	277890	443180	49322	328229	377551	114951	65629
18	0	50333	277890	443180	49322	328229	377551	114951	65629
19	0	50333	277890	443180	49322	328229	377551	114951	65629
20	0	50333	277890	463180	49322	328229	377551	134951	85629

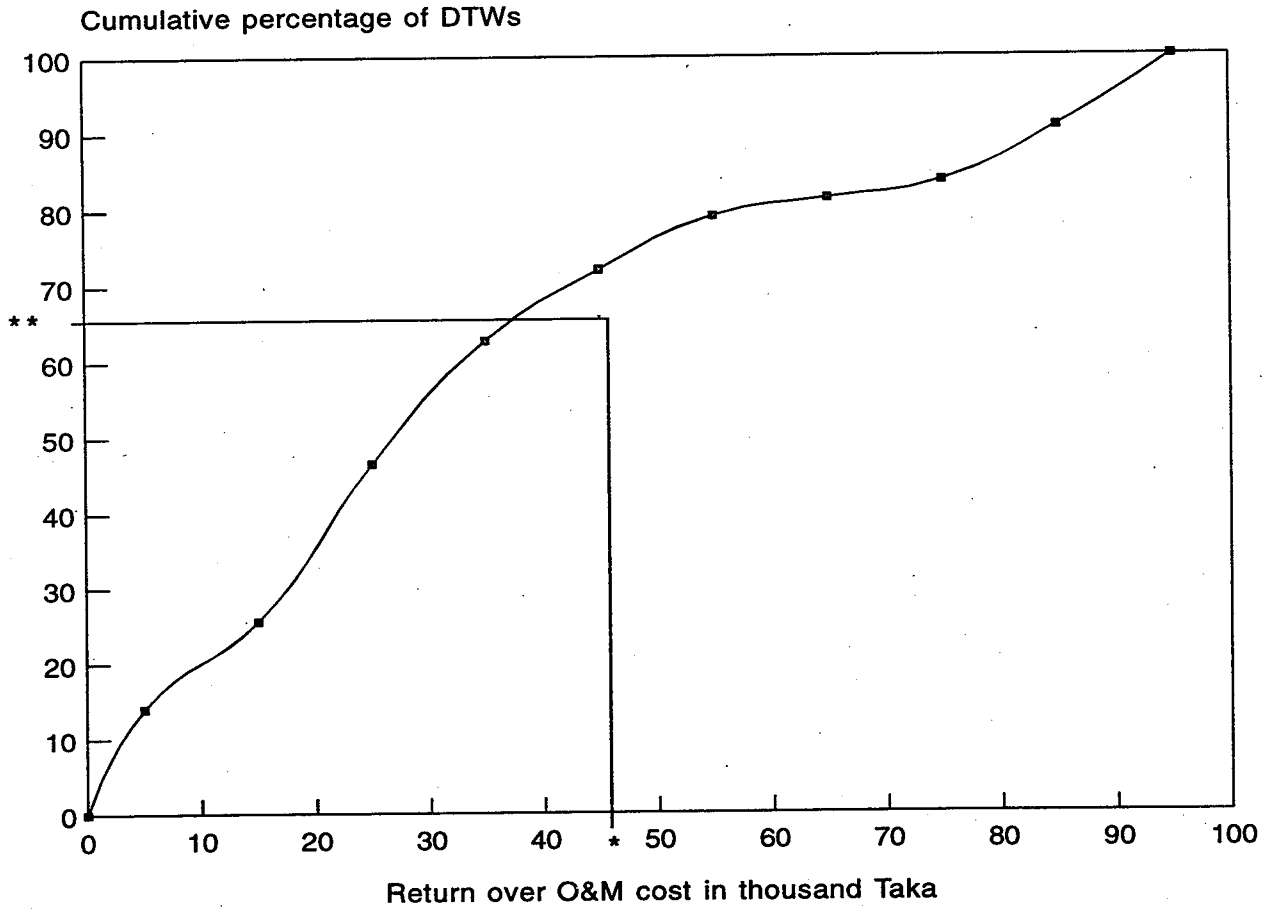
Source: Based on IIMI/BSERT 1994 Pump Owners and Irrigator Farmers' Survey in Bogra, Comilla, Faridpur, Hobiganj and Nilphamari districts.

Appendix Table E. Cost and benefit streams of electricity operated DTWs assuming credit purchased subsidized price.

Year	Investment cost	O&M cost	Production cost	Gross benefit	Benefit without project	Gross cost	Net benefit	Cash flow	Total cost
0	49187	0	0	0	0	49187	-49187	-49187	49187
1	42687	45187	400738	653479	54512	488612	164867	110355	543124
2	42687	45187	400738	653479	54512	488612	164867	110355	543124
3	42687	49150	400738	653479	54512	492575	160904	106392	547087
4	42687	49150	400738	653479	54512	492575	160904	106392	547087
5	42687	49150	400738	653479	54512	492575	160904	106392	547087
6	0	49150	400738	653479	54512	449888	203591	149079	504400
7	0	49150	400738	653479	54512	449888	203591	149079	504400
8	0	49150	400738	653479	54512	449888	203591	149079	504400
9	0	49150	400738	653479	54512	449888	203591	149079	504400
10	0	49150	400738	653479	54512	449888	203591	149079	504400
11	0	49150	400738	653479	54512	449888	203591	149079	504400
12	0	49150	400738	663479	54512	449888	213591	159079	504400
13	100000	49150	400738	653479	54512	549888	103591	49079	604400
14	0	49150	400738	653479	54512	449888	203591	149079	504400
15	0	49150	400738	653479	54512	449888	203591	149079	504400
16	0	49150	400738	653479	54512	449888	203591	149079	504400
17	0	49150	400738	653479	54512	449888	203591	149079	504400
18	0	49150	400738	653479	54512	449888	203591	149079	504400
19	0	49150	400738	653479	54512	449888	203591	149079	504400
20	0	49150	400738	663479	54512	449888	213591	159079	504400

Source: Based on IIMI/BSERT 1994 Pump Owners and Irrigator Farmers' Survey in Bogra, Comilla, Faridpur, Hobiganj and Nilphamari districts.

Figure 1. Distribution of DTWs with respect to return over O&M cost for boro irrigation, 1994.



* Approx. Tk. 43,000 is the Annual Loan Installment on a Subsidized DTW Costing Tk. 175,000

** 70% of DTW Owners had a Return over O & M Cost less than or equal to one Annual Loan Installment

Source: IIMI/BSERT Pump Owners' Survey, 1994

Profitability of Irrigated Crop Production under Minor Irrigation[18]

1. INTRODUCTION

The various facets of agricultural sector privatization have affected irrigator farmers in various ways. Within minor irrigation the availability of less expensive engines of a wider array of sizes than in the past and the retraction of spacing regulations have together encouraged increased installations of pumps. This has meant that farmers now have more opportunities to put their land into irrigated crop production. The other associated parts of agricultural privatization have included market distribution of fertilizers, pesticides and power tillers as well as open market procurement of rice. All these actions are likely to have affected farmers' choices about crops, cropping intensity, water charges, cost of production and the profitability of irrigated crops versus non-irrigated crops.

There have been some concerns expressed about the profitability and productivity of irrigated agriculture, especially with reference to the various privatization actions mentioned above. The purpose of this paper is to investigate a few of the issues relating to the profitability to irrigator farmers of using minor irrigation. Specifically, the paper seeks to answer a number of questions:

a) What are the crops normally grown under irrigated as well as non-irrigated conditions?

b) Have farmers' area and cropping intensity under irrigation increased?

c) Has there been any change in the yields of irrigated crops over the years?

d) How profitable are irrigated crops versus non-irrigated crops?

e) What are the incremental values created due to irrigated crop production?

2. METHODOLOGY

In order to examine these issues, crop budget data collected from five study districts (Bogra, Comilla, Faridpur, Hobiganj and Nilphamari) have been used.[19] Input-output data were collected for all irrigated

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[18]This paper has been prepared as part of the Study on Minor Irrigation Privatization in Bangladesh conducted by IIMI (the International Irrigation Management Institute) in association with the Ministry of Agriculture with funding from the Asian Development Bank. Research for this paper has been done by IIMI and BSERT (the Bureau of Socioeconomic Research and Training of BAU, The Bangladesh Agricultural University) --- with M.A.S. Mandal and W.M.H. Jaim having been particularly associated with its preparation.

[19]For sampling details see the paper on Study Background, Organization and General Methodology in this volume.

and non-irrigated crops grown by sample farmers beginning with the 1993 aus season through the 1994 boro season. Data were collected through direct interviews with the farmers in two sessions between February and July, 1994. Input-output data were collected with respect to the largest plot under each of the crops.[20] Input data (both home supplied and purchased) were collected according to crop operations. Output data were collected for main product and by-products.

In this analysis two levels of costs are examined—cash costs and full variable costs. While cash costs included farmers' cash expenses (i.e. out of pocket expenses), full variable costs included not only these purchased inputs but also the imputed costs of home-supplied inputs such as labour. Fixed costs such as land rental, depreciation of farm implements, etc. are not considered here.[21]

Output value is taken as the sum of the value of the main crop output as well as its by-products. Farmers' returns from individual crops were calculated using two methods:

a) returns over cash cost (output value minus cash costs)

b) gross margin (output value minus all variable costs)

3. RESULTS AND DISCUSSION

3.1 Crops Grown and Changes in Boro Area per Farmer

Farmers grew a variety of irrigated crops, but 104 out of the 120 sample farmers (87%) included HYV boro using irrigation among their plots. The proportions of farmers growing any other individual irrigated crops were relatively small (Table 1).

In all of the study districts except Bogra, those irrigator farmers who irrigated both in 1993/94 and in 1988/89 had some increase in their area under irrigation. Overall, there was an 11 per cent increase in irrigated area per farmer over this interval—with the fastest growth being in Nilphamari and Hobiganj which are relatively late-comers to irrigation development compared to such advanced districts as Bogra and Comilla (Table 2). The observed rapid growth in the number of minor irrigation units, then, has also been associated with an increase in area irrigated per farmer.

3.2 Cropping Patterns and Cropping Intensity

A large number of cropping patterns were reported by the sample farmers—but the major patterns for land under irrigation were:

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[20]The advantage of this method is that it minimizes errors that farmer respondents may make in aggregating inputs and outputs for different plots under each crop.

[21]Fixed costs were, however, considered in the project analyses done of the financial viability of irrigation schemes.

1. Irrigated boro	T.aman	Fallow	
2. Boro	Fallow	Fallow	
3. Tobacco	T.aus	T.aman	(in Nilphamari)

Irrigated boro appeared to have replaced pulses and vegetables in many areas. There have not been any systematic changes in these patterns.

Under non-irrigated conditions the most common patterns were:

1. Aus/Jute	T.aman	pulses
2. Aus/aman (mixed)		pulses/vegetables
3. T.aman	fallow	fallow

Cropping intensity in irrigated lands of sample farmers was 190 per cent in 1993/94 and 185 per cent in 1988/89—with this difference being statistically significant. There was virtually no difference in cropping intensities between irrigated and non-irrigated plots in either year. It seemed to be the case that in many areas with irrigation facilities, farmers grew one or two good crops and left their lands fallow the rest of the time. This still meant higher income for them than growing lower value crops under non-irrigated conditions.

3.3 Change in Yields of Irrigated Crops Over Time

This survey results produce mixed evidence about the change in yields of different irrigated crops. For irrigated boro only about a quarter of the respondent farmers reported an increase, whereas 65 per cent reported decreases and the remainder had no change in yields in the current year compared to 5 years ago. For other irrigated crops there were mixed responses as well.

3.4 Profitability of Crops

The irrigated crops considered for profitability analyses were HYV boro, HYV aman, HYV aus, wheat, tobacco and potato, while the non-irrigated crops considered were local aus, local aman, HYV aman, jute, potato, pulses, mustard and sugarcane. All the observations of tobacco came from Nilphamari where tobacco was the main irrigated crop in some scheme.

Table 3 shows that return over cash costs for the irrigated crops ranged from Tk 7,029 (for wheat) to Tk 17,341 (for potatoes) per hectare while return over full cost ranged from Tk 1,707 (wheat) to Tk 7,931 (potato). HYV boro, as the main irrigated crop for most farmers, gave good returns over cash cost (Tk 11,504) and good gross margins (Tk 5,246), indicating a reasonably good total income from boro production in 1993/94.

It can be seen that returns over cash cost were two to four times higher than gross margins for all of the individual crops. Although gross margins for most of the crops were not particularly high, the returns over cash cost were much better. It is generally family labour which accounts for the major difference between gross margin and return over cash cost—so this (labour) part of crop production

expense forms a part of family income. Detailed estimates of various components of costs and returns for irrigated and non-irrigated crops are given, respectively, in Appendix Tables A and B.

The gross margin of HYV boro is 1.6 times higher than its competing crop HYV aus. Further, it can be seen from Table 3 that irrigated HYV boro is much more profitable than irrigated wheat (which included both local and HYV varieties). Tobacco was found to be more profitable than HYV boro but this was mainly due to the low price of paddy that prevailed during 1994 in contrast to tobacco's price that year which was quite high.

Gross Margins as well as returns over cash costs from non irrigated crops are presented in Table 4. A comparison of irrigated crops with their competing non-irrigated crops shows that the gross margin of HYV boro was 2.4 times higher than local aus and 2.1 times higher than jute. The gross margin of irrigated potato was 2.8 times higher than for non-irrigated potato.

4. SUMMARY AND CONCLUSIONS

The real benefits of irrigation are, perhaps, best understood in terms of the incremental value that accrues to the irrigator farmers. The increase in HYV boro cultivation as a result of irrigation expansion has undoubtedly replaced many non-irrigated crops—but this would appear to be justified for the farmers as the incremental values (in terms of gross margin per ha) that have been created due to irrigation appear to be quite high. (Table 5).

Over-all, then, irrigation seems to be a quite profitable choice for farmers. The level of that profit, though, does depend on the cost of irrigation and other major inputs as well as on the price of crop output. The cost of irrigation as well as the price of output can be seen to have played dominant roles in determining the profitability of HYV boro, the main irrigated crop, in recent years. Irrigation costs for HYV boro constituted 34 percent of total cash cost and 24 percent all variable costs. As irrigation is such a large part of variable costs it follows that an increase in water charges could affect crop profitability to a large extent. Compared to the cost of irrigation, an increase in fertilizer cost is likely to have a much smaller effect on farmers' crop profitability—as the cost of fertilizers were found to be only 14 percent of cash cost and 10 percent of total variable costs for HYV boro. As for output price, it should be remembered that the HYV boro profitability figures which have been shown in Table 3 are based on the 1993-94 harvest price (Tk 5.60 per kg of boro paddy) which was fairly low compared to most years. With higher paddy prices the profitability of HYV boro would be much higher than shown. For example, with a 25 percent increase in paddy price, Gross Margin of HYV boro would increase from Tk 5,246 to Tk 11,822.

Table 1. Number and proportions of sample farmers growing irrigated and non-irrigated crops during 1993/94.

Crops	Irrigated		Non-irrigated	
	No. of farmers	% (N=120)	No. of farmers	% (N=120)
HYV boro	104	87	-	-
Local boro	8	7	-	-
HYV aus	18	15	4	3
Local aus	-	-	41	34
HYV aman	18	15	28	23
Local aman	2	2	58	48
Wheat	11	9	-	-
Tobacco	24	20	-	-
Potato	9	8	15	13
Jute	-	-	34	28
Pulses	-	-	20	17
Mustard	3	3	13	11
Sugarcane	-	-	13	11
Vegetables	11	9	-	-

Source: IIMI/BSERT 1994 Crop Budget Survey in Bogra, Comilla, Faridpur, Hobiganj and Nilphamari districts.

Table 2. Changes in average boro area per farmer.

District	Average boro area (ha)		Change (%)
	1988/89	1993/94	
Bogra (64)	0.79	0.78	- 1
Comilla (31)	0.58	0.62	+ 6
Faridpur (60)	0.30	0.32	+ 7
Hobigonj (52)	1.41	1.72	+ 21
Nilphamari	0.52	0.57	+ 10
All Dist. (221)	0.76	0.84	+ 11

Source: IIMI/BSERT 1994 Crop Budget Survey in Bogra, Comilla, Faridpur, Hobiganj and Nilphamari districts.

Table 3. Farmers' profitability of irrigated crops during 1993/94(Tk/ha).

Costs and Returns	HYV boro	HYV aus	HYV aman	Wheat	Potato	Tobacco
Gross return	26302	17776	20962	13585	32691	24054
Cash cost	14798	9550	6059	6556	15344	10430
Variable costs	21056	14596	14189	11878	24754	16617
Return over cash cost	11504	8226	14903	7029	17347	13624
Gross Margin	5246	3180	6773	1707	7937	7437

Source: IIMI/BSERT 1994 Crop Budget Survey in Bogra, Comilla, Faridpur, Hobiganj and Nilphamari districts.

Table 4. Farmers' profitability of non-irrigated crops during 1993/94(Tk/ha).

Costs and Returns	L.aus	L.aman	HYV aman	Jute	Potato	Pulses	Mustard	Sugarcane
Gross return	11348	11268	17930	14677	24694	9429	9572	36859
Cash cost	5713	4462	5614	7277	14590	2454	2810	18394
Variable costs	9189	8235	11652	12128	21879	4542	5328	30351
Return over cash cost	5635	6806	12316	7400	10104	6975	6762	18464
Gross Margin	2159	3033	6278	2549	2815	4887	4244	6508

Source: IIMI/BSERT 1994 Crop Budget Survey in Bogra, Comilla, Faridpur, Hobiganj and Nilphamari districts.

Table 5. Incremental benefits (gross margin) from main irrigated crops in 1993/94.

Irrigated crops grown	Non-irrigated crops foregone	Incremental gross margin (Tk/ha)
HYV boro	Local aus	3,087
HYV boro	Jute	2,697
HYV boro	Pulses	359
HYV boro	Mustard	1,002
HYV aus	Local aus	1,021
Potato (Irrig)	Potato (non-irrig)	5,122

Source: IIMI/BSERT 1994 Crop Budget Survey in Bogra, Comilla, Faridpur, Hobiganj and Nilphamari districts.

Appendix Table A: Costs and returns per hectare of irrigated crops.

Input/output & cost/return	HYV boro		HYV aus		HYV aman		Wheat		Potato		Tobacco	
	Quantity	Value (Tk)	Quantity	Value (Tk)	Quantity	Value (Tk)	Quantity	Value (Tk)	Quantity	Value (Tk)	Quantity	Value (Tk)
Inputs												
Human labour (MD)	196	8687	190	6930	158	5946	105	3976	245	8675	252	7601
Animal labour (PD)	24	1974	23	1123	35	2035	38	3499	35	1988	53	2494
Mechanical power (hr)	2	667	-	-	-	-	-	-	-	-	-	-
Seed/seedlings	-	1700	-	1658	-	2101	-	602	-	6653	-	1557
Manures	-	316	-	987	-	487	-	250	-	1625	-	721
Fertilizers (kg)	330	2143	257	1713	310	1981	250	1848	586	4014	437	2926
Pesticides	-	465	-	337	-	341	-	0	-	222	-	0
Irrigation	-	5023	-	1928	-	1690	-	1702	-	1577	-	1317
Costs												
Total variable cost	-	21056	-	14596	-	14189	-	11878	-	24754	-	16617
Total cash cost	-	14798	-	9550	-	6059	-	6556	-	15344	-	10430
Output												
Main product (kg)	4630	25254	3628	16816	4087	20152	2115	13429	8715	32691	1434	23603
Byproduct		1048		960		810		156	-	-		451
Returns												
Gross return	-	26302	-	17776	-	20962	-	13585	-	32691	-	24054
Return over cash cost	-	11504	-	8226	-	14903	-	7029	-	17341	-	13624
Gross margin	-	5246	-	3180	-	6767	-	1707	-	7931	-	7437

Source: IIMI/BSERT 1994 Crop Budget Survey in Bogra, Comilla, Faridpur, Hobiganj and Nilphamari districts.

Notes: MD Man-day.
PD Pair-day.

Appendix. Table B. *Costs and returns per hectare of non-irrigated crops.*

Input/output & cost/return	Local aus		Local aman		HYV aman		Jute		Mustard		Pulses		Potato		Sugarcane	
	Quantity	value (Tk)	Quantity	value (Tk)	Quantity	value (Tk)	Quantity	value (Tk)	Quantity	value (Tk)	Quantity	value (Tk)	Quantity	value (Tk)	Quantity	value (Tk)
Inputs																
Human labour (MD)	123	4986	108	4252	164	6165	173	6800	67	2521	41	1669	229	8111	274	10826
Animal labour (PD)	22	1776	18	1538	23	1335	34	2921	16	1336	16	1487	48	2753	15	1428
Seeds/seedlings	-	862	-	976	-	1720	9	761	26	561	45	991	502	6654	-	13150
Manures	-	392	-	240	-	560	-	381	-	60	-	23	-	2085	-	239
Fertilizers (kg)	164	1075	163	1081	245	1603	176	1171	124	824	51	372	368	2567	411	2812
Pesticides	-	99	-	149	-	268	-	94	-	26	-	-	-	69	-	1898
Costs																
Total variable cost	-	9189	-	8235	-	11652	-	12128	-	21879	-	4542	-	5328	-	30351
Total cash cost	-	5713	-	4462	-	5614	-	7277	-	14590	-	2454	-	2810	-	18394
Output																
Main product (kg)	2085	10504	1942	10252	3392	16726	1633	12343	606	9214	547	9022	6486	24694	35863	35556
Byproduct		844	1016		1204		2334		358		407					1303
Returns																
Gross returns		11348		11268		17930		14677	9572	9429		24694		36859		
Return over cash cost		5635		6806		12316		7401		6762		6975		10104		18465
Gross Margin		2159		3033		6278		2550		4244		4887		2815		6508

Source: IIMI/BSERT 1994 Crop Budget Survey in Bogra, Comilla, Faridpur, Hobiganj and Nilphamari districts.
Notes: MD Man-day.
PD Pair-day.

Minor Irrigation Privatization: Some Equity Issues [19]

INTRODUCTION

The program for the privatization of minor irrigation sector in Bangladesh has included a number of aspects—including import liberalization, abolition of standardization and spacing regulations, and the sale of publicly owned minor irrigation systems (DTWs, STWs or LLPs). The program was initiated in the 1980s and by 1994 the sector was almost fully privatized.

As part of the policy debate over time, however, concerns have been raised regarding the equity implications of implementing this privatization program within the rather inequitable agrarian structure of rural Bangladesh.[20] There has been speculation that private sector control would lead to monopolization by large farmers of the ownership of minor irrigation equipment—and of the benefits associated with that ownership (Quasem 1985). Large and rich farmers, it is argued, already dominate the ownership of land, the most important productive asset. Privatization of minor irrigation would additionally give them control over water, another vital productive resource. Large farmers (the so called landlords) would then also become water lords. Small and marginal farmers, with only limited access to irrigation facilities, would then become dependent on large farmers not only for land but also for water. It has been further argued that the dominant access of large farmers to land and other resources would also enable them to monopolize access to support services and inputs such as credit, fertilizers and pesticides.

Given that much of the privatization process has been completed, it should be possible to assess whether or not (or to what degree) the above equity concerns have been realized. This paper, using data from five study districts, seeks to address a number of equity access issues:

a) Who has access to the ownership of minor irrigation equipment?

b) Who has access to irrigated acreage ?

c) Who has access to other related resources or benefits?

d) Have early owners of irrigation equipment accumulated more assets (including land) than late buyers?

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[19]This paper has been prepared as part of the Study on Minor Irrigation Privatization in Bangladesh conducted by IIMI (the International Irrigation Management Institute) in association with the Ministry of Agriculture with funding from the Asian Development Bank. Research for this paper has been done by IIMI and BSERT (the Bureau of Socioeconomic Research and Training of BAU, the Bangladesh Agricultural University) — with M.A. Hakim, D.E. Parker and M.A.S. Mandal having been particularly associated with its preparation, with additional inputs from R.N. Ali.

[20]See the paper on The Evolution of Minor Irrigation Privatization in Bangladesh in this volume.

In order to approach these questions of equity or differential access most comparisons in this paper are made between farm size groups. Both irrigating farmers and pump owners have been stratified into three farm size categories—small farmers being defined as operating up to one hectare, medium farmers from 1.01 to 3.00 ha and large farmers having more than 3.00 ha of land.

Data has been derived from that collected for the IIMI minor irrigation privatization study in five districts—Bogra, Comilla, Faridpur, Hobiganj and Nilphamari. The surveys under that study which are of most relevance to this paper are ones sampling pump owners, irrigating farmers and both men and women wage labourers.[21]

RESULTS AND DISCUSSION

Socioeconomic Characteristics: Pump Owners and Farmers

Various socioeconomic characteristics of the sample pump owners and irrigating farmers are presented in Table 1. For both groups the main occupation is agriculture. Pump owners, however, do display larger farm sizes (2.87 ha vs 1.25 ha) than do irrigating farmers—and they have, on average, higher educational levels. Family size is also somewhat higher among the pump owners.[22]

Pump Ownership

Access over time

A distribution of sample STW, DTW and LLP systems existing in each year from 1982 to 1994 has been developed and separated into the three farm size categories.[23] These distribution streams are presented in Tables 2, 3, 4 and (for STWs) in Figure 1. An examination of these distributions reveals:

a) STW and DTW ownership in the study districts has not been monopolized by large farmers as a group in spite of their having more farm land and better education. All categories of farms have access to the ownership of these two types of irrigation systems with the largest single group of

[21]For details on the surveys and sampling see the paper titled Study Background, Organization and General Methodology in this volume.

[22]Family has been defined to include all members of a household eating food cooked in the same 'chula' or hearth.

[23]The figures in any given year are cumulative up to that point. Thus equipment owners who bought their pumps in 1982 were counted in 1982 as well as in all subsequent years up to the survey in 1994, etc. However, the actual ownership distributions (as opposed to these approximations) in any given year would have included some pump owners who have dropped out sometime before 1994 and so were unavailable for sampling in the 1994 survey used in this study. If the dropout rate for a particular category of farm size was higher than for other categories, then, the sample distributions presented in Tables 1-3 and in Figure 3 might under-represent that category. A problem in earlier years of the sequence (particularly for DTWs and LLPs) is that the number existing was quite small so that the addition of one more pump in a given category sometimes causes a disproportionate shift in the share distributions.

owners not being large farmers but medium farmers. In the case of LLPs, however, large farmers have retained their majority (predominantly in Hobiganj).

b) Over the years small farmers' share of STW ownership has increased markedly. In 1982 small farmers constituted only 14 percent of the total owners while in 1994 they were more than 27 percent. As against this, the share of large farmers has fallen and that of medium farmers, by and large, has remained constant. In the case of DTWs also, small farmers have been able to increase their share.[24] For LLPs, however, the share of small farmers has varied a good deal over the years—though their share in 1994 was higher than what it was in 1982.

Access Across Districts

In Figure 2 the cumulative percentages of farm size by STW ownership is presented for each of the study districts. It can be seen that in the Bogra and Comilla areas (where minor irrigation development has been most advanced) small farmers have actually dominated the distribution of STWs. Farmers with only one hectare or less owned 80 percent of the sample STWs in Comilla and 60 percent in Bogra. By contrast, in the later-developing districts of Faridpur, Hobiganj and Nilphamari, the small farm category had only 10 percent to 30 percent of the STWs (though for Hobiganj the figures may be distorted by the small number of sample STWs).

For DTWs presented in Figure 3 the small farm category of owner/managers (who were actually mostly part owners rather than full owners) in Comilla ran 60 percent of the sample wells. Small farmers were not so dominant in DTW ownership in the other districts—but there were only moderately small numbers of sample DTWs in those districts. For LLPs (Figure 4) the only districts with sufficient numbers of pumps to compare were Hobiganj and Comilla. 80 percent of the Comilla LLPs were owned by small farmers—but large farmers were completely dominant in Hobiganj.

On balance, rather than promoting monopolization of irrigation equipment ownership by large farmers, the provision of inexpensive and appropriately sized equipment made possible by the privatization policies has expanded the access of small farmers to irrigation system ownership. This has especially been evident in the more advanced (in a minor irrigation development sense) districts for all three technologies.

Irrigated Land

There are several approaches to study the equity issue regarding access to irrigated acreage. One approach has been to compare the benefits of irrigated and rain-fed farms. Irrespective of their size, farms having access to irrigation can be expected, in general, to be better off and to receive more output and income per hectare than farms without irrigation (Haque 1975 and Hamid 1982). Irrigated farms, having more crop production, also have the opportunity to make more productive use of their owners' family labour. Thus any program that helps bring more farmland under irrigation tends to enhances equity

[24]Most of the sample DTWs have more than one owner, however, so a distribution based on one manager/owner (as in this analysis) ignores the presence of other owners who may be of different farm sizes.

in rural areas. The program for the liberalization policies associated with the privatization of minor irrigation have been able to increase area under irrigation significantly in the last decade.[25] As a result, the growing number of farmers (of various farm sizes) receiving irrigation have been able to increase their incomes which has had area-wise equity improvement implications.

Another approach to examine equity issues has been to compare the relative shares of irrigated acreage of farms of different size categories. This method has been used in this paper. Sample farmer figures are presented in Table 5. It can be seen that:

a) Although in 1994 large farmers had more irrigated acreage per person than did the other size groups, the distribution was not as highly inequitable as some might apprehend. In 1994 small farmers, who constituted 62 percent of the total sample farmers, cultivated 38 percent of the irrigated acreage of the full sample. The middle size farmers' share of the irrigated acreage approximated their proportion in the sample (with 29 percent of the sample farmers having 36 percent of the irrigated land in 1994).

b) The share of small farmers in irrigated acreage actually increased between 1989 and 1994 (Figure 5). By rising from 29 percent in 1989 to 38 percent in 1994 there was a nine percent rise in the share of the group as a whole—and this rate of increase being higher than the rate of increase in their relative number, the share of irrigated land per small farmer actually increased by 21 percent over what it had been in the earlier period.

The figures in Table 5 can be supplemented by Gini ratios computed for 1989 and 1994. For the 280 sample farmers who had some irrigated land in both 1989 and 1994 the Gini ratio of irrigated land decreased from 0.395 to 0.279. If all 350 farmers irrigating in 1994 (whether or not they irrigated in 1989) were to be considered, the Gini ratios changed from 0.355 in 1989 to 0.256 in 1994. Both pairs of figures confirm that access to irrigated acreage by small farmers has improved between the two points in time.

Financing Irrigation Equipment and O&M

Equipment Bank Credit

Access to bank credit for financing purchases of minor irrigation equipment has been rather limited to all categories of our sample pump owners. As can be seen in the Table 6, of the 233 sample irrigation equipment owners who answered these questions, only 44 (or 25 percent) made their purchase with bank loans. The table also reveals that if all technologies are considered together, access to bank loans is not dominated to any significant extent by any farm size category. Large farmers as a group had 16 percent of the loans, middle farmers 24 percent and small farmers 13 percent. Even when different technologies are taken separately, the access pattern does not change very much across farm categories.

[25]See the paper in this volume on The Evolution of Minor Irrigation Privatization in Bangladesh.

One much reported reason why farmers in general (and particularly small farmers) do not want to approach banks to get credit is the long time taken to get loans due partly to the complicated lending procedures of the banks. Sample pump owners who had taken loans were asked how long their loans had taken to get. The small farm group was in the most disadvantageous position in this respect in that they spent more than three times the number of days taken by large framers to get a loan—and about two times more days than medium farmers. Taking owners of all three irrigation technologies together, a small farmer had to spend an average of 306 days to get a loan, a large farmer took 90 days and a medium farmer 158 days. When STWs, DTWs and LLPs are considered separately, the picture is only slightly better. For example, for STW bank loans, a small farmer had to spend an average of 181 days while a large farmer spent only 38 days and a medium farmer 113 days. For DTWs the corresponding figures for small farmers was 473 days, for medium farmers 261 days and for large farmers 360 days. In the case of LLPs, the one large farmer responding took 180 days. It is obvious that for all categories of farmers the time taken to get an equipment loan was unreasonably long—and for small farmers it was particularly bad.

Other Sources of Equipment Funds

If bank credit was not the major source of funding, what sources did the pump owners use to buy their equipment and what was the pattern of access to these sources for different farm categories? For answer one can turn to Table 7 where it can be seen that besides using their savings for irrigation equipment purchases, farmers took credit (which included bank and other credit sources), sold land, livestock and other assets, mortgaged out their land and used some unidentified fund sources. Multiple sources of funds were often used (which is why the percentages do not total 100). Among all of these sources the use of savings has been mentioned by a large majority of farmers in all farm size categories—69 percent of small farmers, 56 percent of medium farmers and 75 percent of large farmers. Savings is followed by credit which has been used mostly by medium farmers. Large farmers, as was noted earlier, do not seem to have dominated credit as a source of finance. Land sale as a source has been reported by only 1 percent of large farmers as against 10 percent and 9 percent respectively by medium and small farmers. All categories of farmers have resorted to land mortgage to meet their capital costs but, as expected, small farmers have used this source more than medium and large farmers. As to livestock sale, all categories have used this source of fund and there is not much difference across size categories.

O&M Funds

To finance O&M costs small farmers depended very heavily on savings, somewhat on credit and a bit on the sale of miscellaneous assets (Table 8). Middle and large farmers, while also using these sources, were able to also turn at need to land mortgage. The number of pump owners using bank credit for financing O&M costs was very small in total—being only 12 (5%) out of 240. Of these 12 pump owners, 5 owned STWs, 2 had DTWs and there were 5 with LLPs. This O&M credit has not been dominated by large farmers but rather by middle farmers. Of the 12 pump owners with O&M loans, 6 were mid-size farmers, 4 large and 2 were small.

Funding Overview

The picture that emerges from the above discussions is that access to bank credit has been limited to all categories of sample pump owners. To buy equipment most farmers have used their own savings which was supplemented by land and livestock sale and land mortgage. Overall, in financing equipment purchases and O&M costs no particular farm category seems to have had a significant advantage over other categories in the sense of being able to gain access to institutional sources of capital. Given the general reliance on disinvestment of other assets (land and livestock, etc.) to finance irrigation equipment and operation, all categories of farmers, however, would appear to need much better access to institutional sources of credit.

Equipment and Related Input Availability

Sample pump owners' opinions were sought as to the availability of irrigation equipment and other related inputs in 1989 and 1994. It can be seen in Table 9 that pump owners with large or medium sized farms seemed not to have any appreciable advantage over small farm pump owners in terms of the level of availability of irrigation equipment and other related inputs in both 1989 and 1994. Further, availability of equipment and all other inputs except credit and extension would appear to have improved for all categories of farms in 1994 over 1989. Equipment and input supply seem to have been farm-size-neutral in general under the private market distribution system.

Water Adequacy and Timeliness

As reported by sample irrigating farmers, water control in terms of adequacy and timeliness seems quite satisfactory for all size categories of farmers (Table 10). Most of the farmers reported to have received adequate water in a timely manner in both early and late parts of the irrigating seasons of 1989 and 1994. However, water control, according to farmers' opinions, appears to in general have deteriorated to a small extent in 1994 over 1989. Among different farm categories, some of both the large and small farmer groups claim to have lost some degree of their water control in 1994 over 1989—but middle farmers showed a small improvement in the same interval (though the difference between groups was not statistically significant).

Benefits to Early Adopters

Adoption theories suggest that early adopters of a new technology receive more income/benefits from the technology than late adopters. Early adopters are expected to invest a significant portion of their extra income in real assets such as land, housing, livestock, etc. So one approach to examine whether early adopters have received more benefits is to see whether asset accumulation is positively related to years of ownership of irrigation equipment and adoption of irrigated crop production. In following this approach with the group of sample pump owners no statistically significant relationship could be

discerned between the year of ownership of equipment and asset accumulation during the last three years (1991-94). Only the last three years were asked about for reasons of accuracy of recall by the respondents. It is possible, therefore, that early adopters might have accumulated extra assets (compared to later adopters) during some period prior to the last three years.

Benefits to Landless Men and Women Laborers

Benefits to landless labourers from the liberalization of regulations pertaining to minor irrigation equipment standardization and importation (i.e., privatization) could take place due to the resulting increase in irrigation facilities. Additional irrigation could mean increased employment opportunities and higher wages due to extra crop production and the concomitant extra crop production and processing work. The landless might also be expected to benefit indirectly from the decrease in rice prices resulting from increased production due to expansion in irrigated rice acreage.

Samples of both men and women wage labourers were asked about their work and wages in 1994 compared to five years earlier. Both groups reported to have received more work in 1994 than in 1989 and to have received increased wages. On average, male labourers' work that directly involved irrigation or on irrigated crop production and processing functions constituted 60 percent of their total work in 1989. This proportion increased to 72 percent in 1994. The corresponding figures for female laborers was 39 percent in 1989 and 46 percent in 1994. When irrigation-related work was disaggregated into such broad groupings as crop production, crop processing etc., both male and female sample laborers reported increased employment opportunities in all work categories.

In 1994 sample male labourers were reported to have earned, on average, an annual wage (in both cash and kind) of Tk 12,100 and female labourers Tk 11,479. Both categories of workers have reported that the wages they received in 1994 were higher than that they got in 1989—though it is not known if this was true only in terms of Taka wages or also in real terms. Respondents also held the opinion that due to recent development of irrigation they were better off in 1994 than they had been in 1989.[26]

SUMMARY AND CONCLUSIONS

From the findings discussed above one can conclude that there is very little evidence in the study areas that the expansion of minor irrigation associated with the liberalization and privatization policies of the 1980s in Bangladesh have led to major equity problems. In fact, farmers with no more than one hectare of land (categorized as being in the small farm group) would appear to have had expanded opportunities to own irrigation equipment and irrigate their lands. Specifically:

a) Small farmers in the past several years have actually formed a growing proportion of total pump owners. This trend has been most noticeable in districts such as Bogra and Comilla which are

[26]A recent study (Rahman and Hossain 1992) also shows that irrigation development improves opportunities for the rural landless male and female labourers, helping to reduce poverty.

most developed in minor irrigation. The opportunity to purchase inexpensive equipment of a range of size appropriate to small operators has been, perhaps, the driving force behind this growing small farmer irrigation participation.

b) As irrigation has expanded, small farmers have had growing opportunities to irrigate their lands. Such farmers have had an increasing share of an expanding irrigated area.

c) Access to credit for irrigation equipment purchase or O&M expenses has been limited for all farm-size categories of pump owners. Credit which has been dispensed has not been monopolized by any particular group.

d) There is no evidence that early adopters of irrigation technology have been accumulating relatively more assets (land, housing, livestock, additional irrigation equipment, etc.,) in recent years than have later adopters. In other words, whatever asset accumulation advantage early adopters may have had in the past (if any), such an advantage has not been increased during the period following the policy changes associated with privatization.

e) Both rural male and female wage labourers would seem to have benefitted from increased work and wage opportunities brought about by the expansion of irrigation.

The above does not mean that all is equitable in rural Bangladesh or even in areas under minor irrigation. There are many ways in which small farmers and landless men and women are severely disadvantaged relative to more wealthy groups. However, the evidence from the study areas does indicate that the equity trend associated with minor irrigation expansion in a more privatized setting has been generally positive.

There are, though, ways in which minor irrigation development could be made to further contribute to better opportunities for those with less assets and income. Small farmers have been found in this study to be enthusiastic investors in minor irrigation equipment. They (as well as others) have, however, been often forced to resort to the disinvestment of some of their other assets (land, livestock, etc.,) in order to purchase irrigation equipment. Small farmers, having less such assets to dispose of, are at a disadvantage in fund generation relative to other farmer groups. This has, no doubt, prevented some small farmers from entering the minor irrigation business. An improvement in the provision of credit to small farmer prospective pump owners would help to overcome this impediment—and would help build on the momentum small farmers have (without help) already developed. To be effective, such credit must be available with much simpler procedures and less delay and hassle than is presently true.

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Table 1. Socioeconomic background of pump owners and irrigating farmers.

	Pump owners	Farmers
Occupations (%)		
Agriculture	86.3	87.6
Service	8.3	3.5
Business	5.4	4.9
Other	-	4.0
Literacy (%)		
Illiterate	8.8	37.7
Primary	32.1	21.4
Higher Secondary	40.0	21.4
Graduate +	-	6.4
Family Size	9.3	6.4
Farm (Hectares)	2.87	1.25

Source: IIMI/BSERT 1994 Pump Owners and Farmers Surveys in Bogra, Comilla, Faridpur, Hobiganj and Nilphamari Districts.

Table 2. *Shallow tubewell (STWs) ownership: Percent of owners in each farm size category existing in each year.*

Year	Farm category			
	SF	MF	LF	Total 'n'
1982	14 (2)	57 (8)	29 (4)	(14)
1983	17 (3)	61 (11)	22 (4)	(18)
1984	16 (4)	64 (16)	20 (5)	(25)
1985	13 (4)	67 (20)	20 (6)	(30)
1986	18 (7)	61 (23)	21 (8)	(38)
1987	17 (7)	59 (24)	24 (10)	(41)
1988	22 (11)	58 (24)	20 (10)	(45)
1989	23 (14)	56 (34)	21 (13)	(61)
1990	23 (18)	56 (44)	21 (16)	(78)
1991	24 (22)	54 (49)	21 (19)	(90)
1992	22 (24)	55 (59)	23 (25)	(108)
1993	25 (31)	52 (65)	23 (29)	(125)
1994	27 (35)	50 (66)	22 (29)	(130)

Note: Figures in parentheses are actual number of owners in each farm size category existing in each year.
Source: IIMI/BSERT 1994 Pump Owners Survey in Bogra, Comilla, Faridpur, Hobiganj and Nilphamari Districts.

Table 3. Deep tubewell ownership: Percent of owners in each farm size category existing in each year.

Year	Farm size category			
	SF	MF	LF	Total 'n'
1982	14 (1)	71 (5)	14 (1)	(7)
1983	17 (1)	75 (6)	17 (1)	(8)
1984	33 (2)	67 (6)	11 (1)	(9)
1985	30 (3)	60 (6)	10 (1)	(10)
1986	27 (3)	64 (7)	9 (1)	(11)
1988	27 (5)	57 (8)	7 (1)	(14)
1989	33 (5)	60 (9)	7 (1)	(15)
1990	31 (8)	58 (15)	12 (3)	(26)
1991	31 (11)	58 (21)	11 (4)	(36)
1992	29 (12)	59 (24)	12 (5)	(41)
1993	29 (13)	58 (26)	12 (6)	(45)

Note: Figures in parentheses are actual number of owners in each farm size category existing in each year.
Source: IIMI/BSERT 1994 Pump Owners and Farmer Surveys in Bogra, Comilla, Faridpur, Hobiganj, and Nilphamari Districts.

Table 4. *Low-lift pump ownership: Percent of owners in each farm size category existing in each year.*

Year	Farm size category			
	SF	MF	LF	Total'n'
1982	17 (1)	17 (1)	66 (4)	(6)
1983	20 (2)	10 (1)	70 (7)	(10)
1984	36 (5)	7 (1)	57 (8)	(14)
1985	33 (5)	7 (1)	60 (9)	(15)
1986	33 (6)	11 (2)	56 (10)	(18)
1987	33 (7)	10 (2)	57 (12)	(21)
1988	28 (7)	20 (5)	52 (13)	(25)
1989	24 (7)	21 (6)	55 (16)	(29)
1990	28 (9)	19 (6)	53 (17)	(32)
1991	23 (9)	20 (8)	57 (23)	(40)
1992	24 (10)	21 (9)	55 (23)	(42)
1993	24 (14)	22 (13)	54 (32)	(59)
1994	25 (15)	22 (13)	53 (32)	(60)

Note: Figures in parentheses are actual number of owners in each farm size category existing in each year.
Source: IIMI/BSERT 1994 Pump Owners Survey in Bogra, Comilla, Faridpur, Hobiganj and Nilphamari Districts.

Table 5. Farmers' access to irrigated acreage: Share of farm category (percent) in 1989 and 1994.

Year	Farm size category		
	SF	MF	LF
1989	29.35 (58)	35.64 (32)	34.7 (10)
1994	38.1 (63)	36.4 (29)	25.5 (9)

Note: Figures in parentheses are percentages of farmers in each farm size category existing in each year.
Source: IIMI/BSERT 1994 Pump Owners Survey in Bogra, Comilla, Faridpur, Hobiganj and Nilphamari Districts.

Table 6. Bank loans for purchasing irrigation equipment: Number of minor irrigation units purchased with bank loans in each farm size category.

Year	Farm size category			
	SF	MF	LF	Total
STW	4 (35)	17 (66)	7 (29)	28 (130)
DTW	4 (13)	8 (26)	1 (6)	13 (45)
LLP	0 (15)	0 (13)	3 (32)	3 (60)
Total	8 (63)	25 (105)	11 (67)	44 (235)

Note: Figures in parentheses are actual numbers of minor irrigation units owned in each farm size category for each technology
Source: IIMI/BSERT 1994 Pump Owners Survey in Bogra, Comilla, Faridpur, Hobiganj and Nilphamari Districts.

Table 7. Pump ownership sources of funds for buying irrigation equipment: Percent of farmers using sources.

Sources of funds (n)	Farm size category		
	SF (64)	MF (106)	LF (67)
Credit	19	41	21
Savings	69	56	75
Land sale	9	10	1
Land mortgage	19	11	10
Livestock sale	13	15	13
Other asset sale	17	8	10
Other	5	10	15

Source: IIMI/BSERT 1994 Pump Owners Survey in Bogra, Comilla, Faridpur, Hobiganj and Nilphamari Districts.

Table 8. Pump owners' sources of funds for meeting O&M costs: Percent of farmers using sources.

Sources of Funds (n)	Farm size category		
	SF (64)	MF (106)	LF (62)
Credit	31	30	19
Savings	78	75	84
Land sale	-	2	2
Land mortgage	6	9	13
Livestock sale	6	14	6
Other asset sale	20	18	31
Other sources	5	16	8

Source: IIMI/BSERT 1994 Pump Owners Survey in Bogra, Comilla, Faridpur, Hobiganj and Nilphamari Districts.

Table 9 Pump owners' opinions on the availability of equipment related support services in 1989 and 1994: Percent findings easily available.

Support services	Farm size category					
	SF		MF		LF	
	1989	1994	1989	1994	1989	1994
Machines	67	92	61	93	82	97
Spare parts	60	95	62	94	76	95
Mechanics	57	92	48	87	50	89
Drillers	51	65	49	73	42	74
Extension	7	6	15	9	12	11
Credit	9	10	24	13	20	18
Insurance	0	2	2	5	0	0
Diesel	86	98	86	99	85	94
Electricity	22	32	19	32	5	10
Fertilizer	91	98	90	96	94	99
Pesticide	96	95	89	94	84	93

Source: IIMI/BSERT 1994 Pump Owners Survey in Bogra, Comilla, Faridpur, Hobiganj and Nilphamari Districts.

Table 10. Farmers' opinion on water adequacy and timeliness: Percent of farmers reporting adequacy and timeliness.

Water adequacy and timeliness	Farm size category							
	SF		MF		LF		Total	
(n)	1989 (146)	1994 (220)	1989 (87)	1994 (100)	1989 (28)	1994 (30)	1989 (261)	1994 (350)
Water adequate in early season	95	89	91	95	100	93	94	91
Water adequate in late season	86	74	77	86	96	83	84	78
Timely water in early season	93	87	87	91	100	97	92	89
Timely water in late season	86	78	79	84	96	80	85	80

Source: IIMI/BSERT 1994 Pump Owners Survey in Bogra, Comilla, Faridpur, Hobiganj and Nilphamari Districts.

Figure 1. STW ownership by farm size: Percentage of owner categories in each year.

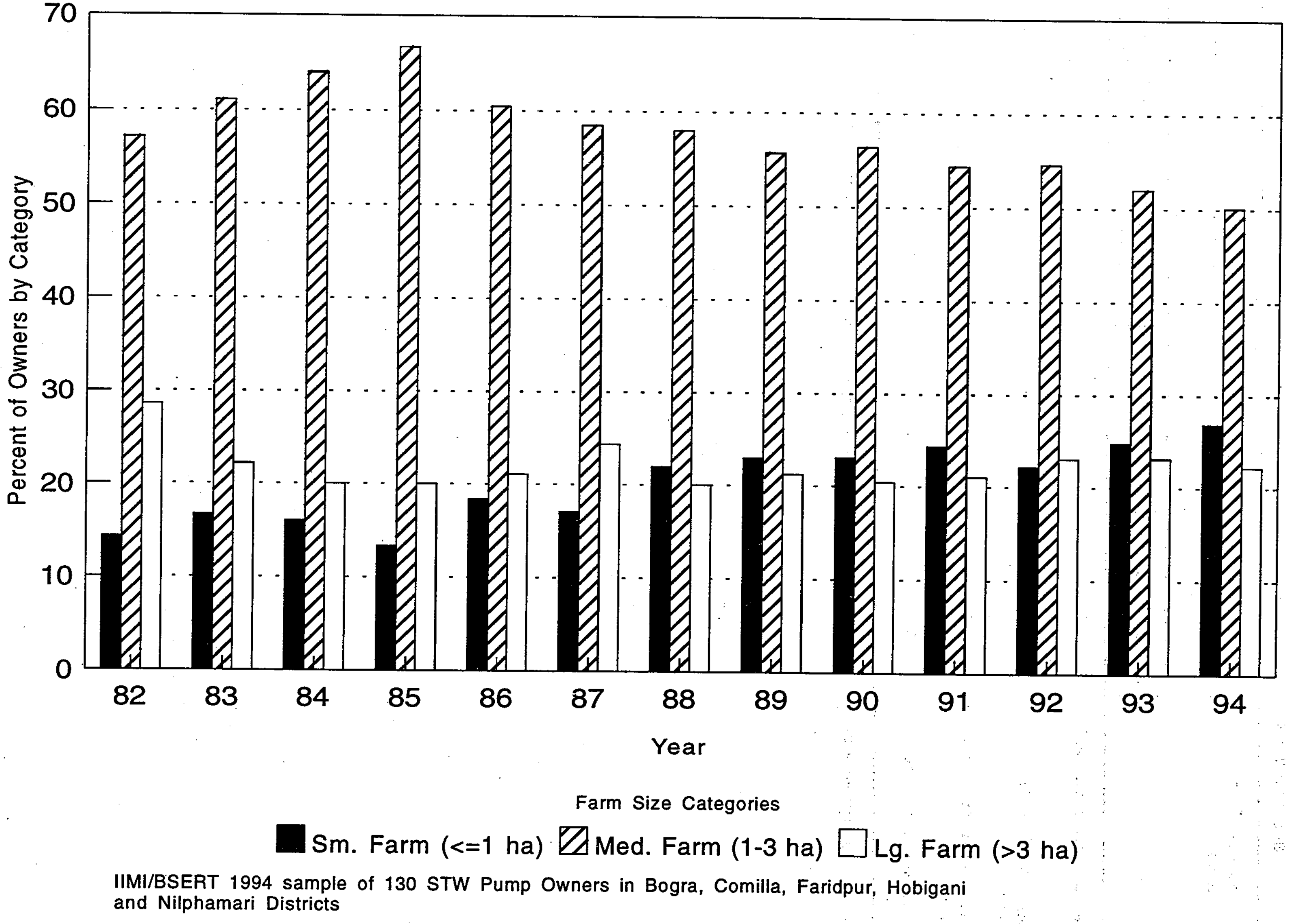
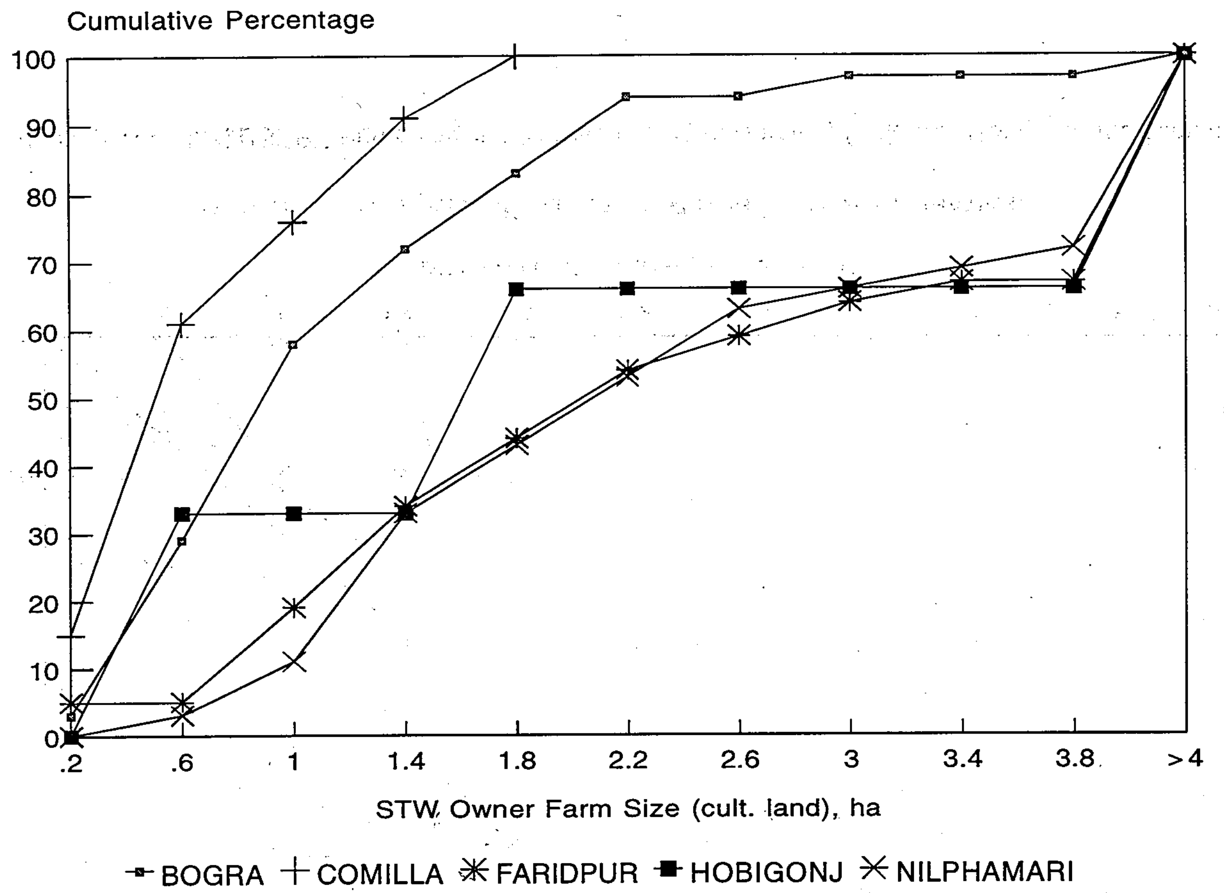
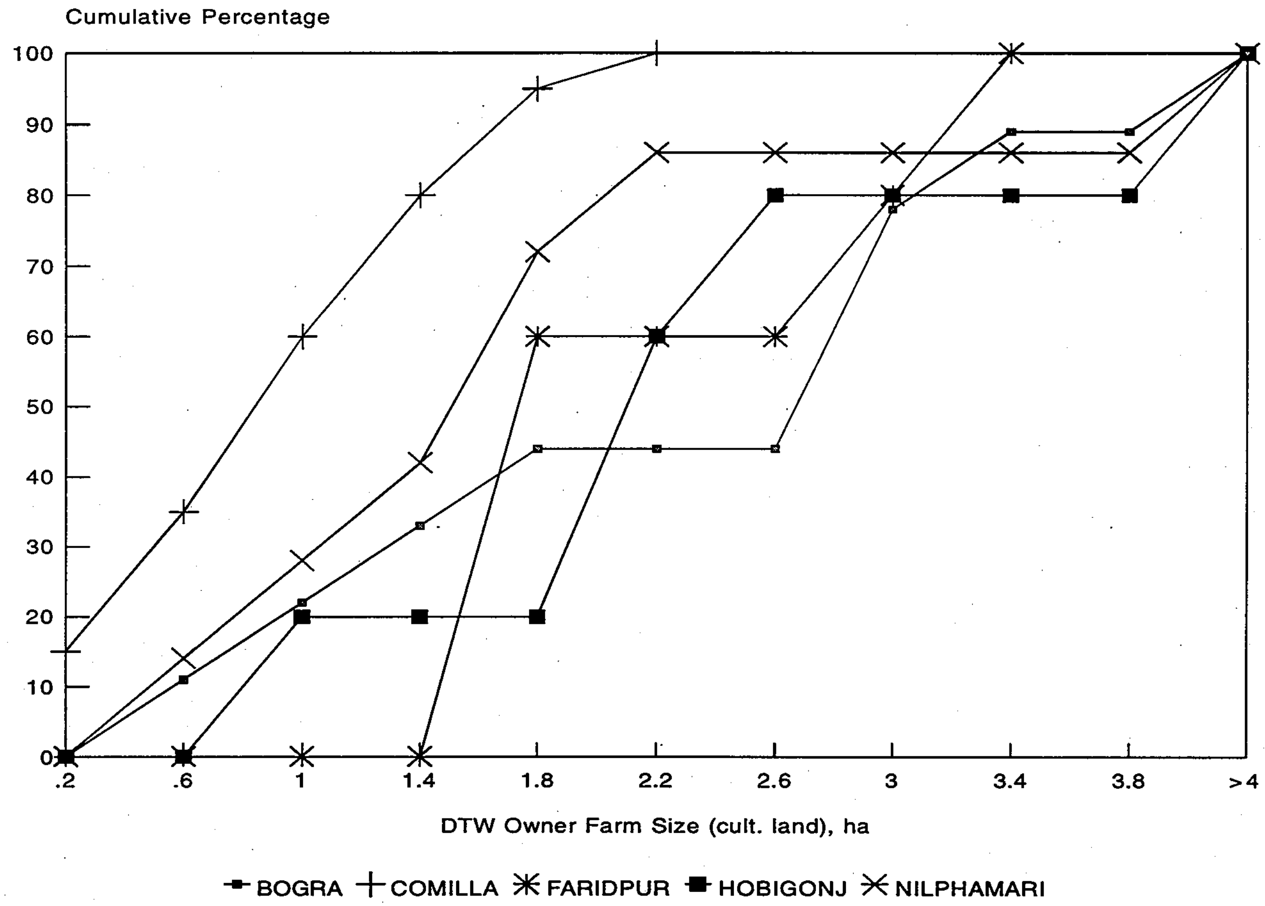


Figure 2. Land cultivated by shallow tubewell owners by size of farm (cumulative percentage).



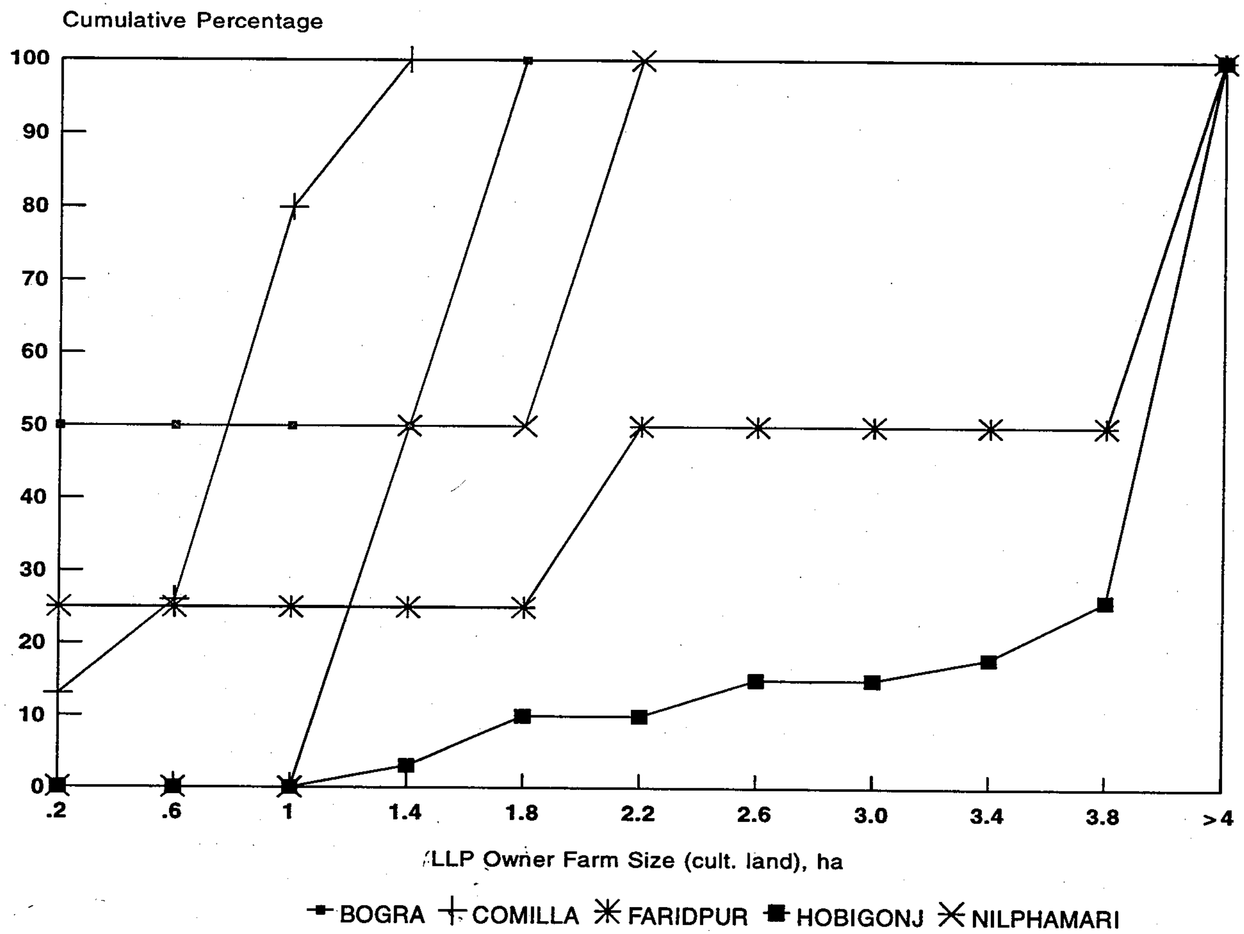
Source: 1994 IIMI/BSERT Pump Owners Survey in Bogra, Comilla, Faridpur, Hobigonj and Nilphamari districts.

Figure 3. Land cultivated by deep-tubewell owners by size of farm (cumulative percentage).



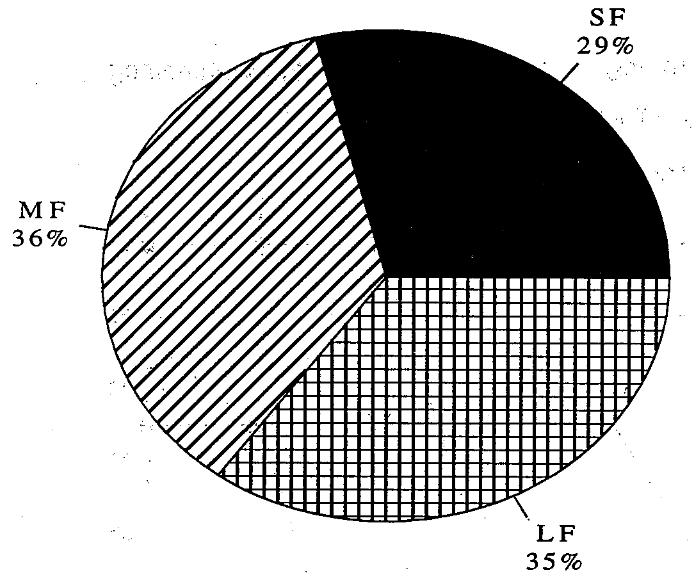
Source: 1994 IIMI/BSERT Pump Owners Survey in Bogra, Comilla, Faridpur, Hobigonj and Nilphamari districts.

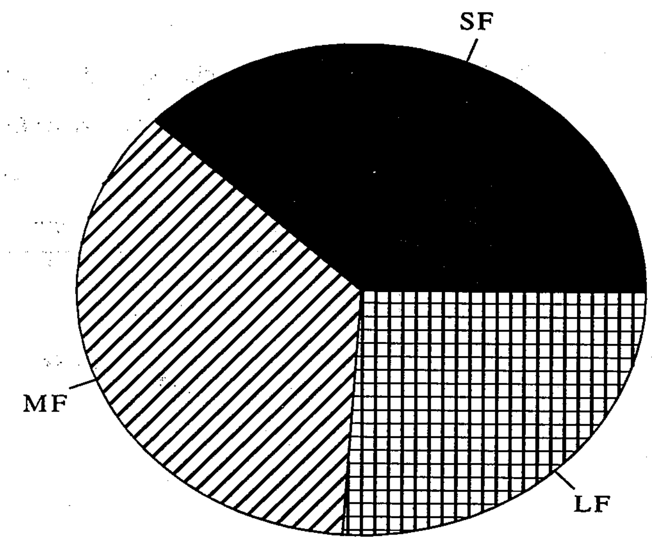
Figure 4. Land cultivated by low-lift-pump owners by size of farm (cumulative percentage).



Source:1994 IIMI/BSERT Pump Owners Survey in Bogra, Comilla, Faridpur, Hobigonj and Nilphamari districts.

Figure 5. Farmers' access to irrigated acreage: Share of farm category (percent).





SF - Small Farmers, MF - Medium Farmers, LF - Large Farmers

Source: IIMI/BSERT 1994 Pump owners Survey in Bogra, Comilla, Faridpur, Hobigonj and Nilphamari Districts.

Technical Aspects Affecting the Selection and Operation of Minor Irrigation Equipment[27]

1. INTRODUCTION

Irrigation equipment is, in general, imported in Bangladesh and farmers' choices were previously limited to a few brands of diesel engine such as Yanmar 70, Yanmar 105, Kubota 90 and Mitsubishi from Japan, Dongfeng from China, Dedong from Korea and Kirloskar from India. The removal of the importation ban on small engines in 1987, the elimination of import duties on irrigation equipment and the relaxation of engine standardization and tubewell siting regulations in 1988-89 have promoted the importation of STW and LLP engines of cheaper price and varying horse powers than before—primarily from China.

Following the liberalization policy, the cheaper and smaller engines from China have developed a large market in the country and are widely used in minor irrigation schemes. These engines have a relatively wide range of horse power and are gradually replacing the now aging Japanese ones. Farmers can now choose from a variety of engine capacities to suit their needs at prices which appear to be within the means of many more prospective owners. Although this new breed of inexpensive Chinese engines is reputed to be less durable and more vulnerable to frequent breakdowns (than those which were previously imported), their low price has been immediately popular amongst farmers. An evaluation of their technical performance in a field setting is in order, however.

An issue complicating such an evaluation, however, is that engines are found at times to be coupled with pumps of different sizes with varying capacities. In attempting to abstract groundwater from various depths (to a maximum total head of 9 m) through STWs or surface water at various lifts (to a maximum total head of 12.2 m) with LLPs, attention is often not paid to the water horse power requirement. For instance, STW pumps with a design discharge of 20 liters per second and capable of working against a head of 9 meters might be found coupled to engines of capacities as low as 3 and as high as 18 hp. Obviously, pumping plant efficiency in the field can be expected to vary widely under such conditions. The incidence and implications of such mismatches must be explored in an evaluation of the technical characteristics of minor irrigation equipment and of system management and strategy.

Specific objectives of this study are:

a) to examine the technical characteristics of the minor irrigation equipment;

b) to assess the implication of mismatches between engines and pumps in operating the irrigation systems.

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[27]This paper has been prepared as part of the Study on Minor Irrigation Privatization in Bangladesh conducted by IIMI (the International Irrigation Management Institute) in association with the Ministry of Agriculture with funding from the Asian Development Bank. Research for this paper has been done by IIMI and BSERT (the Bureau of Socioeconomic Research and Training of BAU, the Bangladesh Agricultural University) --- with S.C. Dutta, M.R. Biswas and A.T.M. Ziauddin having been particularly associated with its preparation (1995).

2. METHODOLOGY

Forty six DTWs, 131 STWs and 63 LLPs were selected from five districts for the study (Table 1.).[28] About 75 percent of these units were diesel operated while the others were powered by electricity—though five DTWs had provisions for both engines and motors in order to maintain uninterrupted irrigation water supply. A survey was carried out among these units to collect information on nominal brake horse power (BHP), nominal revolution per minute (RPM), and make and country of origin of the prime movers (engine and motors) and pumps. This information is usually inscribed on the name plates attached to the equipment.

The pump owners were interviewed through a prescribed questionnaire in order to gather additional information on the frequency and nature of breakdown and energy (diesel or electricity) consumption per hour (by the prime movers). For diesel engines specific fuel consumption was calculated by dividing diesel use per hour by nominal brake horse power.[29] Pump owners were also asked about their opinion on the quality of the equipment and on their preference between different brands.

Technical field measurements on water horse power requirements of the equipment and pumping plant efficiency (water horse power divided by nominal brake horse power) were made at a sub-sample of the study units. One thana from each of Comilla, Faridpur and Nilphamari districts and two thanas each of Bogra and Hobigonj were selected for sampling 50 units (10 DTWs, 28 STWs and 12 LLPs) taking 10 from each of the five districts (Table 2). Besides these 50 units, 15 potentially interacting STWs (6 from Bogra, 3 from Comilla, 4 from Faridpur and 2 from Nilphamari) were also included for taking field measurements.

Field measurements included static water level and pumping water level (both measured by avometer), surface water level, pump discharge (via cut-throat flume) and actual RPM of the pump (using a tachometer). These measurements were done twice in the irrigation season of 1994—the first being at the end of February when water ought to have been plentiful and the second one at the end-April when there would have been peak crop water demand. Analyses of these data were made in order to assess the technical performance of the irrigation equipment.

There were two main groupings of STW engines in the field. One group included engines imported since the 1988 liberalization of import and standardization restrictions (and was primarily from China). The other (predominantly from Japan) was made up of engines imported mostly before 1989 under the old restrictions. Many of these older engines were purchased second-hand by their present owners. Part of an examination of minor irrigation technical performance in the field today is to see how these older machines are holding up against the newer, cheaper imports (Table 3).

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[28]For sampling methodology see the paper in this volume on Study Background, Organization and General Methodology.

[29]Nominal BHP was used instead of actual BHP as measurement equipment necessary for measuring actual BHP was unavailable.

3. TECHNICAL CHARACTERISTICS OF MINOR IRRIGATION EQUIPMENT

3.1 Brake Horse Power

It is often asserted that, because of the import liberalization policy, engines and motors of different BHP are being imported—and that this equipment is being used by farmers without consideration to the actual power requirements under the prevailing field conditions. Among the irrigation units included in the study (and irrespective of DTW, STW or LLP technology), the brake horse power of the engines and motors did, in fact, vary a great deal. For engines the power ranged from 20 to 50 hp for DTWs, 2 to 18 hp for STWs and 2 to 30 hp for LLPs (Table 4). Similarly, electric motor power for these systems ranged from 20 to 40 hp (DTW), 4 to 12 hp (STW), and 8 to 18 hp (LLP) (Table 5). These ranges would indicate a somewhat indiscriminate approach to the choice of prime mover power.

3.2 Nominal RPM of Prime Movers

The speeds of the engines were particularly widely varied. The investigation revealed that the nominal RPM of the diesel engines ranged from 1500 to 2500 (DTWs), 1500 to 2600 (STWs), and 1500 to 2600 (LLPs)—and they varied greatly between countries of origin (Table 4).

The average nominal RPM of the DTWs and LLPs operated by electric motors, however, were 1478 and 1500, respectively with a small value of coefficient of variation. On the other hand, nominal RPM of the STW motors varied from 2500 to 2900, a range similar to that of the diesel engines.

3.3 Energy Consumption

When employed for the same purpose, the choice of engines of different horse powers would normally lead to different levels of fuel consumption. It is desirable to maintain low fuel consumption for efficient burning, optimal heat energy and keeping within a satisfactory range of specific fuel consumption (SFC) between 0.21 to 0.29 liter/bhp/hr (Michael and Khepar 1992).[30]

The average fuel consumption for different engines was estimated and the engines used in DTWs had average consumptions ranging from 3.348 liter/hr (an English make) to as high as 4.760 liter/hr (a Bangladeshi make). For STWs the range was from 0.568 (China brands) to 1.840 (Bangladesh)—and for LLPs from 0.550 (an unknown make) to 2.9 (China make) liter/hr (Table 4). Fuel consumption was fairly much in line with the power of the engines.

The specific fuel consumption of engines ranged in liters/BHP/hr from 0.08 to 0.15 with an average of 0.11 (for DTWs), 0.08 to 0.21 with an average of 0.13 (for STWs) and 0.09 to 0.29 with an average of 0.15 (LLPs). Engines maintaining SFC within the above-mentioned satisfactory range included two

[30]If the SFC is more than 0.29 l/bhp/hr it indicates lower thermal efficiency resulting in inefficient burning of fuel and low output horsepower. If this value is less than 0.21 l/bhp/hr it indicates that, in spite of efficient burning of fuel the engine is running at a speed lower than the design rpm --- producing low output horsepower. The functioning of the engine in either of these two cases is considered to be unsatisfactory.

STW engines (one Indian and another of unknown origin) and 13 LLP engines (5 Chinese, 7 Japanese and 1 Indian).[31]

Fuel consumption of Chinese and Japanese engines was, on average, 0.986 and 1.06 liter/hr, respectively—and the average specific fuel consumption was 0.124 liter/BHP/hr for the Chinese engines and 0.141 liter/BHP/hr for the Japanese ones. The Chinese engines' low or comparable fuel consumption, coupled with their much lower price, can be expected to induce farmers to purchase Chinese engines.

The electricity consumption of the DTWs varied from as low as 13 to as high as 20 kwh/hr with an average of 16.3 kwh/hr (Table 5). The high electricity consumption by the motors indicates high operation costs. The average electricity consumption of motor-driven STWs and LLPs was 6.0 and 10.6, respectively. The variation in electricity consumption for both STWs and LLPs was not remarkable. The Chinese electric motors, because of their smaller size, consumed a lower amount of electricity as compared to others.

3.4 Breakdown of the Engines

3.4.1 Frequency

The high frequency of minor irrigation engine breakdown is often asserted to cause damaging breaks in the supply of water in many minor irrigation systems. Cheaper (lower quality) or aged engines are generally seen to be to blame.

In Table 6, it can be seen that in the 1993-94 irrigation season:

> Twenty one out of 23 DTW engines had at least 1 breakdown—with the median being one and mean being 1.8 per machine. The occurrence of breakdown was most frequent in larger engines of the 30-40 hp group (mostly English made).
>
> One hundred and eight out of 120 STW engines had at least 1 breakdown. The median was 1 and the mean was 1.9. 37 percent of the newer Chinese engines, 62 percent of the more aged Japanese engines and 53 percent of all other STW engines had more breakdowns than the median.
>
> Thirty eight out of the 46 LLP engines had at least 1 breakdown. The mean was 1.7 and the median on the cusp between 1 and 2. 50 percent of the Chinese, 67 percent of the old Japanese and 33 percent of all other LLP engines had more than one breakdown.

For STWs and LLPs the aged Japanese engines seem to have broken down more frequently (2.24 average) than the cheaper (but newer) Chinese engines (1.64 average). T-test results indicate that the difference in mean frequency of breakdown between these two sources of engine (irrespective of BHP group) was statistically significant.

[31] The low specific fuel consumption of these engines was due to their low rpm (as seen later in Table 11).

3.4.2 Parts Broken

The breakdowns of engines were either major or minor depending on which part broke or malfunctioned. Failure of bearings or breakage of crankshaft and replacement of piston assemblies were the major ones and affected irrigation the most. Minor breakdowns such as replacement of oil seals, nozzles, plungers etc. were, however, frequent. The repair of major breakdowns were often delayed due to lack of availability of workshop facilities while delays, when they occurred, for the minor ones were mainly due to the flow of spares in the market.

Occurrence of breakdowns of various parts in DTW, STW, and LLP engines throughout the irrigation season of 1993-94 are summarized in Table 7. Major as well as minor parts breakdowns hit engines up to the third order in some of the DTWs, STWs, and LLPs. The breakdown of piston assembly was most common in all the engines irrespective of technologies. The most serious breakdown, the breakdown of crank shaft, occurred in 1 DTW (a Bangladeshi engine), 10 STWs (3 Japanese and 7 Chinese) and 1 LLP (Chinese). These breakdowns could not be easily repaired due to lack of workshop facilities in the rural areas. The minor breakdowns in DTW, STW and LLP engines were concentrated in the breaking of nozzles and plungers but they were easily repairable by the rural mechanic subject to availability of replacement parts.

3.4.3 Breakdown Duration

The average breakdown days at various orders (number of times during the season) of breakdown of the diesel engines of DTWs, STWs and LLPs are reported in Table 8.[32] When diesel DTWs broke down they were out of order for an average of 3.6 days per time (about 4% of the base period). Many had multiple breakdowns (though 6 had none) and the average for all the DTWs was 5.8 days out of operation (about 5% of the average base period between first and last irrigations) during the 1993-94 season. Four engines broke down four times and had a total of 15.7 days average out of operation—potentially causing water stress to the field crop. The breakdown days were particularly high for the English engines of 30-40 brake horse power.

For STW diesel engines the average breakdown per occurrence was 3.0 days (about 3% of the base period) and the average days lost during the whole season was 5.0 days. For the 16 units which broke down 4 times, they were out of operation a total of 11.4 days (average). Seasonal breakdown days were highest for the 4-8 BHP group.

Among LLP engines the average breakdown lasted 2.0 days and the average days lost during the whole season was 3.5 days. For the 5 units which broke down 5 times during the season, the total number of down days averaged 11.1 days.

In looking at the newer, cheaper Chinese engines and the more aged Japanese ones, it can be seen that for STWs the Chinese engines were out of order an average of 3.7 days for the season (2.8 days per occurrence) while the Japanese engines were idled 6.4 days over the same period (3.2 days per occurrence). The difference between seasonal days out of order was statistically significant. For LLPs, however, there was no difference in seasonal down days (4.4 days for Chinese engines vs 4.3 days for

[32]Electric motors broke down much less frequently than diesel engines and are not included in this breakdown discussion.

Japanese). For STWs, at least, age of engine seemed to be associated with more intransigent breakdowns than did cheapness.

3.5 Pump Owners' Opinion About Quality of Engines

Pump owners were asked their opinion about various quality indicators of their diesel engines (Table 9). Sixty five per cent of the responding diesel DTW owners were satisfied with their engine quality. Only 48 percent, however, reported that their machines had few breakdowns and 18 percent had a high number of breakdowns (with the remaining owners not mentioning breakdowns as a factor). 65 percent of the respondents reported that their engines had a high level of fuel consumption. Only a very few felt that spare parts were easily available or that their machines were easy to repair or were durable.

Eighty seven per cent of the STW owners were satisfied with the quality of their engines despite the fact that only 61 percent were satisfied with the breakdown record and 31 percent expressed dissatisfaction with breakdown frequency. A mere 26 per cent felt that they got good fuel consumption while 61 percent perceived that their fuel use was relatively high. While more than for DTWs, owners were generally not satisfied with repair ease, durability or availability of spare parts.

Eighty five per cent of the LLP owners were satisfied with the quality of their engines and 67 percent were content with the breakdown record while 17 felt that they had an abnormally high number of breakdowns. Views on fuel consumption, availability of spare parts, ease of repair and durability were comparable to that of STW owners.

Perceptions on quality, durability, etc. of Japanese engines seem to have been coloured by views of such engines when they were new rather than as they are in the field today (as old machines). For example, overall quality and acceptance of breakdown record were viewed fairly comparably by owners of Chinese and Japanese engines. These views exist despite the present breakdown records in which the older Japanese engines have shown a higher incidence of problems than have the newer Chinese ones. Japanese engines were seen as having a longer working life than Chinese machines. Spare parts were viewed as more available for Chinese engines. Few opinion distinctions can be made between LLP engines of these two countries of origin except that breakdown record was perceived as better for Japanese ones (despite, again, the opposite result that can be seen in some of the previous sections on incidence of repair and breakdown days).

3.6 Pump Owners' Preference for Engines

When asked what diesel engines they would prefer to have, a majority of the DTW owners mentioned English makes (see Table 10). This was especially true of the owners of English engines.

For STWs and LLPs there was an over-all preference for engines from Japan. This was almost uniformly true of those owning a Japanese engine—but was also true of half the owners of Chinese machines. Perceptions of durability and quality (stemming more from the days when the Japanese engines were newer, one suspects) seem to have remained, despite the more recent deterioration of the aging Japanese units. Despite these preferences, however, farmers are buying Chinese engines, not Japanese—mostly due to the much lower price of the former.

4. TECHNICAL PERFORMANCE OF THE PUMPING PLANT

4.1 RPM of the Prime Movers

The actual RPM of the pumps measured in end-February and end-April were much less than the designed one for almost all technologies except the electrically operated LLPs (Table 11). The low RPM of the pumps would be responsible, among other factors, for low discharge and poor specific fuel consumption (Michael and Khepar 1992). Pump speeds were much less than engine causing a mismatch between them.

4.2 Pumping Plant Efficiency

Pumping plant efficiencies of different irrigation technologies were examined. Irrigation systems with smaller engines offered the highest efficiency of about 35 per cent in the 20-30 hp DTWs and under-4 hp STW groups and of more than 42 percent in the under-4 hp LLP group—providing the best utilization of energy sources for these groups. The lowest efficiency was found to be about 18 percent for the over-40 hp DTWs,[33] 5 percent in the 12-18 hp STWs[34] and 12 percent for the 8-12 hp LLP group—indicating an excess use of power (Figure 1). For LLPs there were some larger engines (in the 12-18 hp group) which gave a higher efficiency of about 25 percent. The reasons were further scrutinized with water horse power (WHP). On average, the water horse power requirement was about 7.5 for DTW, 1.0 for STW and 2.0 for LLP (Figure 2) in order to abstract water under the prevailing situation in the study areas. These variations were not only due to the engine power alone, of course, as water levels at different locations influenced pump discharges and pumping plant efficiencies.

4.3 Water Levels

Pumping water levels stayed well within the pump level in both Comilla (10.0 to 12.0 m) and Bogra (9.8 to 11.2 m) indicating satisfactory functioning of the DTWs in those regions (Figure 3).

The static water level conditions in Faridpur, Hobigonj and Nilphamari districts were excellent for pumping by STWs (Figure 4). Static water levels were equal to or less than 6 meters in all five districts except in Bogra during end-April. In Bogra the pump discharge of 2 out 8 measured wells was only 7 to 8 LPs (which was only two thirds of the average discharge at that time).

The total water lifts (suction lift plus delivery head plus friction loss) for the LLPs varied with locations. The maximum was 8.4 meters in Comilla (Figure 5)—which was within the capacity of the units and expressing smooth functioning of the pumps (Figure 6). In Hobiganj it was reported that there

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[33]Mirjahan (1986) reported that the pumping plant efficiency of DTWs was much lower than the recommended value. The main reason for this was the low average discharge of the pumps.

[34]Dutta and Mandal (1985) found that the pumping plant efficiency of diesel engine driven STWs was even less than 15%—due to low rpm of the engines and low discharge of the pumps.

was less than normal surface water in end-February—but at the end of March there was rise of flood water and as a result no irrigation was done thereafter.

4.4 Pump Discharge

The average pump discharge of the DTWS was 43.34 LPs in end-February and 47.63 LPs in end-April (Figure 6). The pump discharge varied appreciably between end-February and end-April in some places, however. This variation was due to the fact that static water level rose in Comilla, Hobiganj and Faridpur because of early rains but dropped in Bogra and Nilphamari during this period (Figure 4).[35]

The average pump discharge of all the STWs was 12.58 LPs and 12.04 LPs in end-February and end-April, respectively. Taking discharges of all the shallow tubewells together it was found that there was no remarkable change in average pump discharge between these two periods. But in Bogra the pump discharge decreased considerably due to the fall in static water level by end-April.

The average pump discharge of the LLPs was 36.31 LPs in end-February and it increased significantly by end-April. This increase was due to the rise in surface water levels resulting from early rains and also to some extent for the increase in RPM of the pumps.

It should be noted that the pump discharges for STWs were significantly lower than the designed pump discharges (because of lower rpm of the pumps).[36] Nevertheless, there was no significant variation in actual pump discharge between end-February and end-April.

5 MATCHING OF ENGINES WITH PUMPS USED IN SHALLOW TUBEWELLS

Improper matching of engines with their pumps within the context of their aquifer conditions is normally associated with under-utilization of high-powered engines and with stress for low-powered engines. For example, assuming an average pumping plant efficiency of 20 percent and a water horse power requirement of one hp for a STW, the minimum brake horse power of the engine would be 5 hp. If an engine were to have bhp that was less than 5 hp and pumping plant efficiency that was less than 20 percent, the result would be low discharge. On the other hand, if this engine were be run at a much higher speed to get more discharge than the design RPM of the pump, there would be a strong possibility that the pump blades would break.

Only two pump blade breakages were reported among the sample STWs (indicating that the dangers of over-speeding the pumps may be fairly well known in the field)—but many of the systems can be seen to have under-utilized engines due to mismatching.

Among the sample STWs (irrespective of country of origin), pumping plant efficiencies were examined in two groups, one belonging to 4-8 BHP and the other to 8-18 BHP. The mean pumping plant

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[35]The specific capacity (discharge divided by drawdown) of the DTWs was more than 5 LPS per meter of drawdown indicating properly developed wells in a highly permeable aquifer (Garg 1993)

[36]This is similar to a finding by Dutta (1985) in a sample of 37 STWs run under various programs in Tangail that the average pump discharge was only 58% of the nominal discharge.

efficiency was 21 percent and 6.9 percent for the 4-8 and 8-18 hp groups, respectively. The t-test results revealed that the difference in efficiency between these two groups was significant at the 5 percent level. This indicated, then, that the matching of 4-8 hp engines with their pumps and aquifer conditions was better than that of the 8-18 hp engines. The larger engines were generally underutilized. This was true both for Japanese and Chinese engines. About 70 percent of the Japanese engines and 53 percent of the Chinese engines belonging to the 4-8 BHP group matched well with their pumps and conditions.

But what of the relationship, if any, between BHP and the command area and cost of cultivating boro (involving cost of diesel and mobil, and repair cost including spares and mechanical services)? The command area, cost of diesel and mobil, and repair cost (including spares and mechanics) for cultivating boro were correlated with the BHP of the engines of the STWs. BHP was not found to have a significant relationship with any of them.

The average command area and boro costs for diesel/mobil and repairs under the STWs having engines belonging to the 4-8 BHP and 8-18 BHP groups are presented in Table 12. The t-test results revealed that there was no significant difference in mean command area, or diesel and mobil cost, or the repair cost for these two groups.[37] This implies that STWs having high powered engines do not necessarily have higher command areas than those with smaller engines. Higher capacity engines are also not associated with different repair or fuel costs—but do involve higher initial investment costs. Unless the high powered engines are utilized for other purposes (boat plying, use with LLP, etc.), they are wastefully mismatched with the pump and the system.

6. STW TECHNICAL PERFORMANCE COMPARISON

To examine the difference in performance between the two predominant types of STW systems now in the field (using the newer and cheaper Chinese engines vs the aged more expensive Japanese ones) various measures were used. These included the discharge from the wells, water horse power and pumping plant efficiency.

6.1 Discharge and Total Head

Discharge of the STWs with Chinese and Japanese engines at different total head may have different levels of performance depending on technical characteristics. The pump discharge and total head for the STWs were examined and are presented in Figure 7. The mean pump discharge was 14.21 and 12.49 liter per second for a mean total head of 5.28 and 6.76 meters, respectively for Chinese and Japanese diesel engine operated STWs. The t-test results showed that there was no significant difference in pump discharge or total head between these two groups of STWs.

[37] For STWs operated by both 4-8 and 8-18 hp engines the average Boro command area is likely to be less than the potential command area which is mainly calculated on the basis of technical characteristics (e.g. pump capacity, crop, soil, etc.). Such a potential command area calculation ignores the financial, managerial and socioeconomic aspects of command area utilization (e.g., pump owners' cash constraints, transaction costs, competition for command area plots, rivalry, approach to risk, etc.).

6.2 Pumping Plant Efficiency

As standardization and engine capacity regulations differed between the periods of importation of the Japanese and Chinese engines, power utilization can be expected to vary between these two sources. Water horse power and pumping plant efficiencies of these engines are therefore examined.

The water horsepower and pumping plant efficiency for the individual STWs are shown in Figure 8. The mean water horse power was 1.014 hp and its standard deviation was 0.39 for the Chinese groups—whereas it was 1.098 hp with a standard deviation of 0.40 for the Japanese groups. The t-test results showed that there was no significant difference in water horse power between them.

STW pumping plant efficiency ranged from as low as 4 per cent for 14 hp Chinese engines to as high as 35 per cent for 3.3 hp engines from the same source. The mean value was found to be 15 per cent with a standard deviation of 0.09. On the other hand, this efficiency varied from as low as 9 percent to as high as 29 per cent within the 6 hp group alone of Japanese engine operated STWs. The mean efficiency was 17 per cent with a standard deviation of 0.08. No significant variation in mean pumping plant efficiency between Chinese and Japanese diesel operated STWs was observed.

6.3 Comparison overview

Both the inexpensive and comparatively new Chinese STW engines and the more aged Japanese ones were found to have a wide range of nominal brake horse power and rpm leading to diverse levels of fuel consumption. Although the fuel consumption by the Chinese engines was, on average, lower than the older Japanese ones, the specific fuel consumption was not very satisfactory in either case.

The frequency of breakdown and the number of breakdown days were significantly higher for the now aged Japanese STW engines than for the cheaper but newer Chinese ones. It was reported by pump owners that it was very difficult to get Japanese spare parts for their engines and repairs were not very easy. On the other hand, spare parts for the Chinese engines were cheap and readily available and repairs could be done easily by local mechanics.

Whatever may be the technical characteristics of the Chinese and Japanese STW engines, the field measurements revealed that there was no significant difference in pump discharge, water horse power and pumping plant efficiency between the two.

Pump owners, remembering the durability and repair characteristics of the Japanese engines when they were new, did have a (price neutral) preference for engines of Japanese origin. Today, however, pump owners buy Chinese engines—because of their much lower price. The Chinese engines have also been shown, when compared to the now aging Japanese ones, to have better fuel consumption, less occurrence of breakdown, fewer breakdown days in a season easier availability of inexpensive spare parts and repair.

7. SUMMARY AND RECOMMENDATIONS

Findings are summarized below:

a. Engines or motors belonging to wide ranges of power were found in use in minor irrigation schemes. Smaller engines were found to be more popular in terms of capacity utilization.

b. Engine BHP used in minor irrigation schemes is usually higher than required indicating wastage of power and energy.

c. The nominal RPM of many engines were much higher than the designed RPM of the pumps and the farmers had therefore to reduce the engine speed considerably. As a result, the engines could not run with a full load—resulting in poor specific fuel consumption and lower discharge.

d. Overall pumping plant efficiencies for the irrigation systems with smaller engines were found to be higher while the systems with larger engines yielded lower efficiencies. The latter indicates a mismatch between engines and field conditions (well or lifting system).

e. The command area of the STWs does not depend on the BHP of the engines. As a result, cheaper and smaller engines were favoured and, as such, Chinese engines have taken control of the markets and replaced the more expensive engines (from Japan).

f. Fuel consumption for smaller engines, whether of Japanese and Chinese origins, was reasonably satisfactory indicating good performance of the engines with their pumps.

g. Although high breakdown rates (in an absolute if not relative sense) were found in cheaper STW and LLP engines, spares and repairs were readily available and the farmers' choice was in favour of them. Larger units may have had better breakdown records but availability of spares and ease of maintenance were perceived to be greater problems. As a result, farmers wanted to get rid of larger irrigation units.

h. Considering pump discharge, water horse power and pumping plant efficiency, both the newer Chinese engine operated STWs and the more aged Japanese engine operated STWs did not show any remarkable difference. But the pump discharge and the pumping plant efficiency were not very satisfactory for either.

The following recommendations are made to improve the quality of minor irrigation in Bangladesh:

1. Since there was frequently a mismatch between engines and their pumps and systems, there should be an effort to remove it. Skill on matching engines with pumps and systems is important—and there is scope for providing training and technical information for equipment traders, drillers, and mechanics in regards to the selection of the right size of engine and pump

and interpreting the physical system. This provision would help farmers minimize their costs of irrigation.

2. Although Japanese STW and LLP engines and English DTW engines were preferred by pump owners (if price were not considered), equipment purchasers have gone for cheaper engines —even with a perceived lower level of durability and a higher rate of breakdowns (though those perceptions seemed at variance with the actual incidence of breakdown and days out of operation as reported by the pump owners). The engines now being bought have ready availability of spares and quick repair service (as well as, of course, lower price). Therefore, the liberalized importation of smaller and cheaper engines should be continued. As engine price is so important, if the Government wishes to encourage the local manufacture of this equipment, it should **not** be done through raising the costs to farmers of imported units (through duties or restrictions, etc.).

3. There were frequent occurrences of major breakdowns of engines and the farmers often had to wait for a long time for the completion of repairs, particularly for DTWS and (older) Japanese engine operated STWs. This was a real problem in critical periods of crop growth. The increase and improvement of local workshop facilities could relax this problem to some extent. Bank loans on easy terms could be made available to establish rural workshops so that they can take up major repairs.

4. To keep the irrigation units functioning smoothly, amongst other factors the mechanical service could be improved. For this purpose, training programs for local mechanics could be implemented.

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Table 1. Distribution of deep tubewells (DTW), shallow tubewells (STW) and low-lift pumps (LLP) by district and source of power.

District	DTW			STW		LLP		
	Diesel	Elect.	Both diesel and elect.	Diesel	Elect.	Diesel	Elect.	Total
Bogra	1	4	4	37	-	2	-	48
Comilla	7	12	1	10	3	10	5	48
Faridpur	4	1	-	32	7	1	3	48
Hobigonj	2	3	-	3	-	31	9	48
Nilphamari	4	3	-	38	1	2	-	48
All	18	23	5	120	11	46	17	240

Source: 1994 IIMI/BSERT Pump Owners' Survey in Bogra, Comilla, Faridpur, Hobigonj and Nilphamari districts.

Table 2. Distribution of DTWs, STWs and LLPs for pump discharge measurement.

Thana	DTW	STW	LLP	Total
Bogra:				
Dhunat	0	4	0	4
Kahaloo	2	4	0	6
Subtotal	2	8	0	10
Comilla:				
Laksham	4	3	3	10
Faridpur:				
Faridpur Sadar	1	8	1	10
Hobigonj:				
Hobigonj Sadar	1	1	3	5
Nobigonj	0	0	5	5
Subtotal	1	1	8	10
Nilphamari				
Nilphamari Sadar	2	8	0	10
Grand total	10	28	12	50

Source: 1994 IIMI/BSERT Field Measurements in Bogra, Comilla, Faridpur, Hobigonj and Nilphamari districts.

Table 3. Condition of Japanese and Chinese engines at the time of purchase and purchasing period.

Horse power	% Chinese engines				% Japanese engines			
	Condition		Purchasing year		Condition		Purchasing year	
	New	Old	Up to 1988	After 1988	New	Old	Up to 1988	After 1988
Up to 4	100 (13)	Nil	-	100 (13)	Nil	Nil	Nil	Nil
4-8	75 (12)	25 (4)	6 (1)	94 (15)	60 (9)	40 (6)	73 (11)	27 (4)
8-12	87 (7)	13 (1)	13 (1)	87 (7)	50 (3)	50 (3)	67 (4)	33 (2)
12-18	94 (17)	6 (1)	-	100 (18)	Nil	Nil	Nil	Nil
All	89 (49)	11 (6)	4 (2)	96 (53)	57 (12)	43 (9)	71 (15)	29 (6)

Note: Figures in parentheses indicate number of observations.
Source: 1994 IIMI/BSERT Pump Owners' Survey in Bogra, Comilla, Faridpur, Hobigonj and Nilphamari districts.

Table 4. Nominal brake horse power (BHP), revolutions per minute (RPM), and fuel used by diesel engine operated DTWs, STWs and LLPs.

Technology	BHP range (hp)	Country of origin	Average nominal RPM	Average fuel consumption (liter/hr)	Specific fuel consumption (liter/BHP/hr)
DTW (23)*	20 - 30 (6)	England (5)	1650	3.348	0.1337
		Japan (1)	2500	-	-
	30 - 40 (10)	Bangladesh (2)	2250	4.760	0.1535
		China (1)	-	-	-
		England (4)	2062	3.000	0.0952
		India (1)	2250	3.770	0.1077
		Italy (2)	2240	3.285	0.1043
	40 - 50 (4)	Bangladesh (1)	2250	3.500	0.0833
		England (1)	1500	4.000	0.0952
		Italy (2)	2250	4.500	0.1023
	Unknown (3)	Italy (1)	2200	3.570	-
		Unknown (2)	-	3.410	-
STW (120)	2 - 4 (14)	China (13)	2600	0.568	0.1550
		Unknown (1)	-	0.770	0.1925
	4 - 8 (35)	China (17)	2041	0.871	0.1401
		India (3)	1500	1.117	0.2058
		Japan (15)	1864	0.934	0.1536
	8 - 12 (17)	China (8)	2100	1.134	0.1095
		Japan (6)	1940	1.187	0.1096
		Korea (2)	2200	1.155	0.1050
		Unknown (1)	2200	1.000	0.0833
	12 - 18 (19)	Bangladesh (1)	1500	1.840	0.1022
		China (18)	2088	1.344	0.0934
	Unknown (34)	China (3)	-	0.923	-
		India (3)	-	1.130	-
		Japan (21)	-	1.004	-
		Unknown (8)	1733	0.903	-
LLP (46)	2 - 4 (9)	China (5)	2600	0.750	0.2153
		Japan (3)	1733	1.167	0.2917
		Unknown (1)	2600	0.550	0.1375
	4 - 8 (6)	China (1)	2000	0.570	0.0950
		India (1)	1500	1.000	0.2000
		Japan (4)	1675	1.188	0.2018
	8 - 12 (9)	China (4)	2150	1.290	0.1075
		England (1)	1500	1.500	0.1705
		Japan (2)	2200	1.140	0.0972
		Korea (1)	2200	1.500	0.1364
		Pakistan (1)	2200	1.500	0.1250
	12 - 18 (14)	China (11)	2180	1.628	0.1065
		England (2)	1500	2.250	0.1271
		Japan (1)	2200	1.800	0.1000
	18 - 30 (2)	China (1)	2000	2.900	0.1000
		Japan (1)	2200	2.000	0.0935
	Unknown (6)	India (1)	1500	1.000	-
		Japan (1)	-	0.700	-
		Korea (1)	2200	1.120	-
		Unknown (3)	-	1.500	-

Note: Figures in parenthesis indicate number of cases. 5 DTWs had both engines and motors.
Source: 1994 IIMI/BSERT Pump Owners' Survey in Bogra, Comilla, Faridpur, Hobigonj and Nilphamari districts.

Table 5. Nominal brake horse power (BHP), revolutions per minute (RPM), and electricity used by electrically operated DTWs, STWs and LLPs.

Technology	BHP range (hp)		Country of origin		Average nominal RPM	Average elect. consumed (kwh/hr)
DTW (28)*	20 - 30	(16)	China	(9)	1475	15.93
			India	(1)	1450	20.00
			Korea	(1)	1465	20.00
			Pakistan	(2)	1457	20.00
			Unknown	(3)	1417	16.00
	30 - 40	(1)	China	(1)	1500	16.00
	Unknown	(11)	India	(1)	1760	-
			Pakistan	(1)	-	20.00
			Russia	(1)	-	13.00
			Unknown	(8)	-	17.00
STW (11)	4 - 8	(3)	China	(3)	1426	8.00
	8 - 12	(6)	China	(4)	1448	5.12
			Japan	(1)	2500	6.00
			Unknown	(1)	1500	7.00
	Unknown	(3)	Italy	(1)	2900	-
			Japan	(1)	-	3.00
LLP (17)	8 - 12	(2)	China	(1)	1500	6.00
			Unknown	(1)	1450	-
	12 - 18	(9)	China	(2)	1460	11.00
			Japan	(5)	1468	9.52
			Unknown	(2)	1500	11.00
	Unknown	(6)	Unknown	(6)	-	12.13

* 5 DTWS had both engines and motors.

Note: Figures in parenthesis indicate number of cases.

Source: 1994 IIMI/BSERT Pump Owners' Survey in Bogra, Comilla, Faridpur, Hobigonj and Nilphamari districts.

Table 6. Frequency of breakdown of the diesel operated DTWs, STWs, and LLPs.

Technology	BHP range (hp)	Country of origin	No. of units having different breakdowns					
			0	Only 1	Only 2	Only 3	Only 4	Only 5
DTW (23)	20 - 30 (6)	England (5)	-	2	3	-	-	-
		Japan (1)	-	-	1	-	-	-
	30 - 40 (10)	Bangladesh (2)	-	1	-	-	1	-
		China (1)	-	1	-	-	-	-
		England (4)	-	-	2	1	1	-
		India (1)	1	-	-	-	-	-
		Italy (2)	-	-	1	1	-	-
	40 - 50 (4)	Bangladesh (1)	-	1	-	-	-	-
		England (1)	-	-	-	1	-	-
		Italy (2)	-	2	-	-	-	-
	Unknown (3)	Italy (1)	-	1	-	-	-	-
		Unknown (2)	1	-	-	1	-	-
	All DTWs		2	8	7	4	2	-
STW (120)	2 - 4 (14)	China (13)	2	3	4	2	2	-
		Unknown (1)	1	-	-	-	-	-
	4 - 8 (35)	China (17)	2	10	2	1	2	-
		India (3)	-	-	-	2	-	1
		Japan (15)	2	6	3	1	3	-
	8 - 12 (17)	China (8)	1	7	-	-	-	-
		Japan (6)	-	-	1	2	2	1
		Korea (2)	-	1	1	-	-	-
		Unknown (1)	-	1	-	-	-	-
	12 - 18 (19)	Bangladesh (1)	-	-	-	1	-	-
		China (18)	2	8	6	-	2	-
	Unknown (34)	China (3)	-	2	-	-	1	-
		India (3)	-	1	1	-	1	-
		Japan (21)	-	8	4	5	3	1
		Unknown (8)	2	3	1	2	-	-
	All STWs		12	50	23	16	16	3
LLP (46)	2 - 4 (9)	China (5)	2	1	1	1	-	-
		Japan (3)	1	-	1	1	-	-
		Unknown (1)	-	-	1	-	-	-
	4 - 8 (6)	China (1)	-	-	-	-	1	-
		India (1)	-	1	-	-	-	-
		Japan (4)	-	2	-	1	1	-
	8 - 12 (9)	China (4)	-	-	3	-	-	1
		England (1)	-	1	-	-	-	-
		Japan (2)	-	-	2	-	-	-
		Korea (1)	-	-	-	1	-	-
		Pakistan (1)	-	-	1	-	-	-
	12 - 18 (14)	China (11)	3	5	2	1	-	-
		England (2)	-	2	-	-	-	-
		Japan (1)	-	-	1	-	-	-
	18 - 30 (2)	China (1)	-	-	-	-	-	1
		Japan (1)	-	1	-	-	-	-
	Unknown (6)	India (1)	-	-	1	-	-	-
		Japan (1)	-	-	-	-	1	-
		Korea (1)	-	1	-	-	-	-
		Unknown (3)	2	1	-	-	-	-
	All LLPs		8	15	13	5	3	2

Note: Figures in parenthesis indicate number of cases.
Source: 1994 IIMI/BSERT Pump Owners' Survey in Bogra, Comilla, Faridpur, Hobigonj and Nilphamari districts.

Table 7. Percent score of most frequently broken parts of diesel operated DTWs, STWs and LLPs.

Tech.	Order of breakdown	Per cent score of breakdown							
		Liner	Piston	Ring	Nozzle	Plunger	Bearing	Crank shaft	Head-set
DTW (23)	1st time	9	17	22	13	22	13	-	-
	2nd time	4	13	13	13	13	-	-	-
	3rd time	-	4	4	4	7	4	4	-
	4th time	-	4	4	-	-	-	-	-
STW (120)	1st time	25	22	31	22	18	20	1	3
	2nd time	8	9	6	9	6	7	2	1
	3rd time	3	3	3	3	3	5	4	-
	4th time	-	-	-	3	3	2	1	3
	5th time	1	1	1	-	-	-	-	1
LLP (46)	1st time	10	17	22	35	15	9	-	-
	2nd time	7	7	2	13	15	2	-	2
	3rd time	2	9	2	4	-	7	2	-
	4th time	2	2	2	4	2	-	-	2
	5th time	2	-	-	2	-	-	-	2

Note: Figures in parenthesis indicate number of cases.

Source: 1994 IIMI/BSERT Pump Owners' Survey in Bogra, Comilla, Faridpur, Hobigonj and Nilphamari districts.

Table 8. *Average breakdown days of the diesel operated DTWs, STWs, and LLPs.*

Technology	BHP range (hp)	Country of origin	Average breakdown days with number of units out of operation									
			1st time		2nd time		3rd time		4th time		5th time	
			No.	Days	No.	Days	No.	Days	No.	Days	No.	Days
DTW (23)	20 - 30 (6)	England	4	4.50	1	1.00	-	-	-	-	-	-
		Japan	1	2.00	1	2.00	-	-	-	-	-	-
	30 - 40 (10)	Bangladesh	1	1.00	1	1.00	1	10.00	-	-	-	-
		China	1	1.00	-	-	-	-	-	-	-	-
		England	4	3.75	4	2.00	1	1.00	1	3.00	-	-
		India	-	-	-	-	-	-	-	-	-	-
		Italy	1	5.00	2	3.50	1	14.00	1	1.00	-	-
	40 - 50 (4)	Bangladesh	1	2.00	-	-	-	-	-	-	-	-
		England	1	8.00	1	6.00	1	3.00	1	5.00	-	-
		Italy	2	1.00	-	-	-	-	-	-	-	-
	Unknown (3)	Italy	1	9.00	-	-	-	-	-	-	-	-
		Unknown	-	-	1	2.00	1	2.00	1	5.00	-	-
	All DTWs		17	3.71	11	2.45	5	6.00	4	3.50	-	-
STW (120)	2 - 4 (14)	China	9	4.33	6	2.00	4	2.00	2	2.50	-	-
		Unknown	-	-	-	-	-	-	-	-	-	-
	4 - 8 (35)	China	13	2.31	4	3.00	3	2.67	1	2.00	-	-
		India	2	2.50	2	2.00	2	1.50	2	1.50		
		Japan	12	3.83	6	2.67	3	1.67	-	-	-	-
	8 - 12 (17)	China	6	2.17	-	-	-	-	-	-	-	-
		Japan	6	4.83	5	5.40	3	2.33	2	3.50	-	-
		Korea	2	1.50	1	1.00	-	-	-	-	-	-
		Unknown	1	2.00	-	-	-	-	-	-	-	-
	12 - 18 (19)	Bangladesh	1	4.00	1	1.00	1	2.00	1	1.00	-	-
		China	16	3.56	8	2.38	2	4.00	-	-		
	Unknown (34)	China	3	1.33	1	1.00	1	1.00	-	-	-	-
		India	3	3.67	2	5.50	1	2.00	-	-	-	-
		Japan	20	3.50	12	2.75	8	1.88	6	1.67	1	3.00
		Unknown	5	4.20	3	4.00	2	6.00	-	-	-	-
	All STWs		99	3.37	51	2.92	30	2.37	16	2.75	1	3.00

(Continued.)

Table 8 (Continued). Average breakdown days of the diesel operated DTWs, STWs, and LLPs.

Technology	BHP range (hp)		Country of origin	Average breakdown days with number of units out of operation									
				1st time		2nd time		3rd time		4th time		5th time	
				No.	Days	No.	Days	No.	Days	No.	Days	No.	Days
LLP (46)	2 - 4	(9)	China	2	8.00	2	8.00	1	2.00	1	4.00	1	1.00
			Japan	1	3.00	1	1.00	1	1.00	1	1.00	1	1.00
			Unknown	1	1.00	1	2.00	-	-	-	-	-	-
	4 - 8	(6)	China	1	8.00	1	1.00	1	1.00	1	3.00	-	-
			India	1	2.00	-	-	-	-	-	-	-	-
			Japan	4	1.00	2	1.00	2	4.00	2	3.00	1	4.00
	8 - 12	(9)	China	4	1.75	4	1.50	1	1.00	-	-	-	-
			England	1	2.00	-	-	-	-	-	-	-	-
			Japan	2	1.50	2	5.50	-	-	-	-	-	-
			Korea	1	1.00	1	3.00	1	3.00	1	2.00	1	2.00
			Pakistan	1	4.00	1	1.00	-	-	-	-	-	-
	12 - 18	(14)	China	8	1.88	3	1.33	1	3.00	1	3.00	1	1.00
			England	2	1.50	-	-	-	-	-	-	-	-
			Japan	1	1.00	1	1.00	-	-	-	-	-	-
	18 - 30	(2)	China	1	1.00	1	1.00	1	2.00	-	-	-	-
			Japan	1	1.00	-	-	-	-	-	-	-	-
	Unknown	(6)	India	1	1.00	1	1.00	-	-	-	-	-	-
			Japan	1	1.00	1	1.00	1	1.00	1	1.00	-	-
			Korea	1	7.00	-	-	-	-		-	-	-
			Unknown	-	-	-	-	-	-	-	-	-	-
	All LLPs			35	2.31	22	2.32	10	2.20	8	2.50	5	1.80

Note: Figures in parenthesis indicate number of cases.
Source: 1994 IIMI/BSERT Pump Owners' Survey in Bogra, Comilla, Faridpur, Hobigonj and Nilphamari districts.

Table 9. Pump owners' opinion about the quality of the engines that are presently being used (score in percent).

Technology	Country of origin		Good quality	Less breakdown	Less fuel consumption	Easy avail. of spares	Easy to repair	More durable
DTW (23)	Bangladesh	(3)	33	100	-	-	-	-
	China	(1)	100	100	-	-	-	-
	England	(10)	60	40	-	10	10	20
	India	(1)	100	100	-	-	-	100
	Italy	(5)	80	80	-	20	-	-
	Japan	(1)	100	-	-	100	-	-
	Unknown	(2)	50	50	-	-	-	-
	All DTWs		65	48	-	13	4	9
STW (120)	Bangladesh	(1)	-	-	-	-	-	-
	China	(59)	92	61	31	41	14	8
	India	(6)	50	50	-	17	17	17
	Japan	(42)	88	62	24	24	10	33
	Korea	(2)	100	100	50	-	-	50
	Unknown	(10)	80	60	20	40	20	-
	All STWs		87	61	26	33	13	18
LLP (46)	China	(22)	86	55	18	41	23	27
	England	(3)	100	100	-	33	-	67
	India	(2)	100	100	-	50	-	-
	Japan	(12)	75	75	17	42	17	25
	Korea	(2)	50	50	50	-	-	-
	Pakistan	(1)	100	100	-	-	-	100
	Unknown	(4)	100	75	25	25	-	25
	All LLPs		85	67	17	37	15	28

Note: Figures in parenthesis indicate number of cases.
Source: 1994 IIMI/BSERT Pump Owners' Survey in Bogra, Comilla, Faridpur, Hobigonj and Nilphamari districts.

Table 10. Engines of DTWs, STWs and LLPs used by the pump owners and their preference.

Technology	Country of origin	Number of pump owners preferring machines of different countries							
		Bangladesh	China	England	India	Italy	Japan	Korea	Unknown
DTW (23)	Bangladesh (3)	1	-	2	-	-	-	-	-
	China (1)	-	-	1	-	-	-	-	-
	England (10)	1	-	7	-	1	1	-	-
	India (1)	-	-	-	1	-	-	-	-
	Italy (5)	1	-	2	-	1	-	-	1
	Japan (1)	1	-	-	-	-	-	-	-
	Unknown (2)	1	-	1	-	-	-	-	-
	All DTWs	5	-	13	1	2	1	-	1
STW (120)	Bangladesh (1)	-	-	-	-	-	1	-	-
	China (59)	-	27	-	-	-	26	1	5
	India (6)	-	2	-	-	-	3	-	1
	Japan (42)	-	2	-	-	-	39	1	-
	Korea (2)	-	-	-	-	-	1	1	-
	Unknown (10)	-	1	-	-	-	8	-	1
	All STWs	-	32	-	-	-	78	3	7
LLP (46)	China (22)	-	11	1	-	-	10	-	-
	England (3)	-	-	3	-	-	-	-	-
	India (2)	-	-	-	-	-	1	-	1
	Japan (12)	-	3	-	-	-	9	-	-
	Korea (2)	-	-	-	-	-	-	2	-
	Pakistan (1)	-	-	1	-	-	-	-	-
	Unknown (4)	-	-	-	-	-	3	-	1
	All LLPs	-	14	5	-	-	23	2	2

Note: Figures in parenthesis indicate number of cases.

Source: 1994 IIMI/BSERT Pump Owners' Survey in Bogra, Comilla, Faridpur, Hobigonj and Nilphamari districts.

Table 11. Revolutions per minute of prime movers and pumps of DTWs, STWs and LLPs.

Technology	Power source	Average BHP	Nominal RPM		Actual pump RPM	
			Engine/Motor	Pump	1st round	2nd round
DTW	Diesel	30.3 (7.70)	2071 (400)	1725 (392)	1396 (134)	1356 (433)
	Electricity	29.9	1475	na	1418	1451
STW	Diesel	9.0 (3.90)	2026 (314)	1733 (350)	1116 (481)	1050 (372)
	Electricity	na	2900	2200	1380	1456
LLP	Diesel	11.8 (5.59)	1700 (341)	1900 (374)	1513 (275)	na
	Electricity	14.9	1460	1450	1433	1398

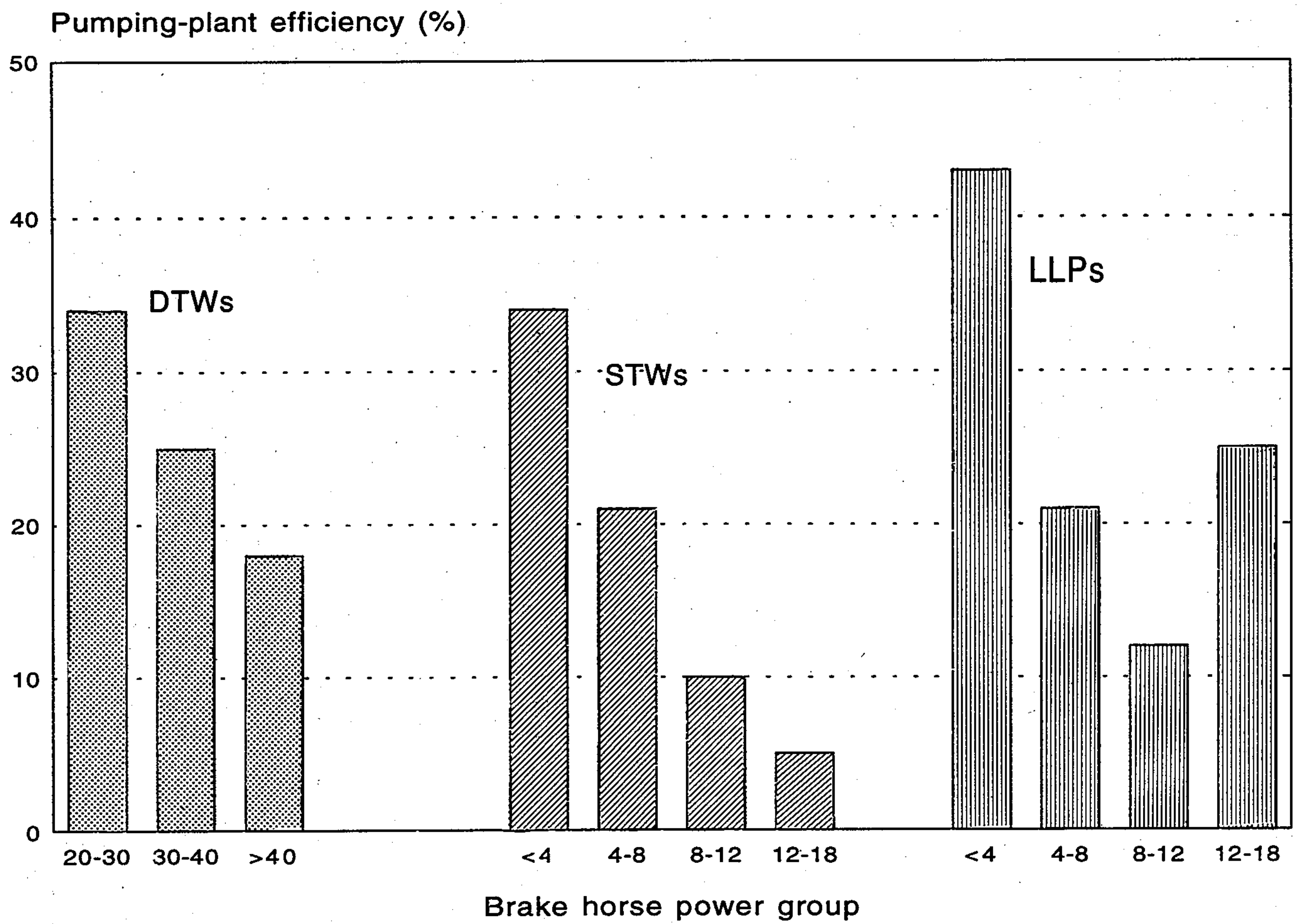
Notes: Figures in parenthesis indicate standard deviation.
First round measurement was taken in end-February and the second round was taken in end-April.
Source: 1994 IIMI/BSERT Field Measurements in Bogra, Comilla, Faridpur, Hobigonj and Nilphamari districts.
na = Not available.

Table 12. Command area, cost of diesel and mobil, and repair cost for growing boro paddy by diesel operated STWs.

BHP range	No. of cases	Boro command are (ha)	Cost of diesel and mobil (Tk)	Repair cost (Tk)
4-8	35	1.92 (1.78)	4349 (4058)	680 (787)
8-18	36	2.56 (2.27)	4288 (5210)	749 (805)

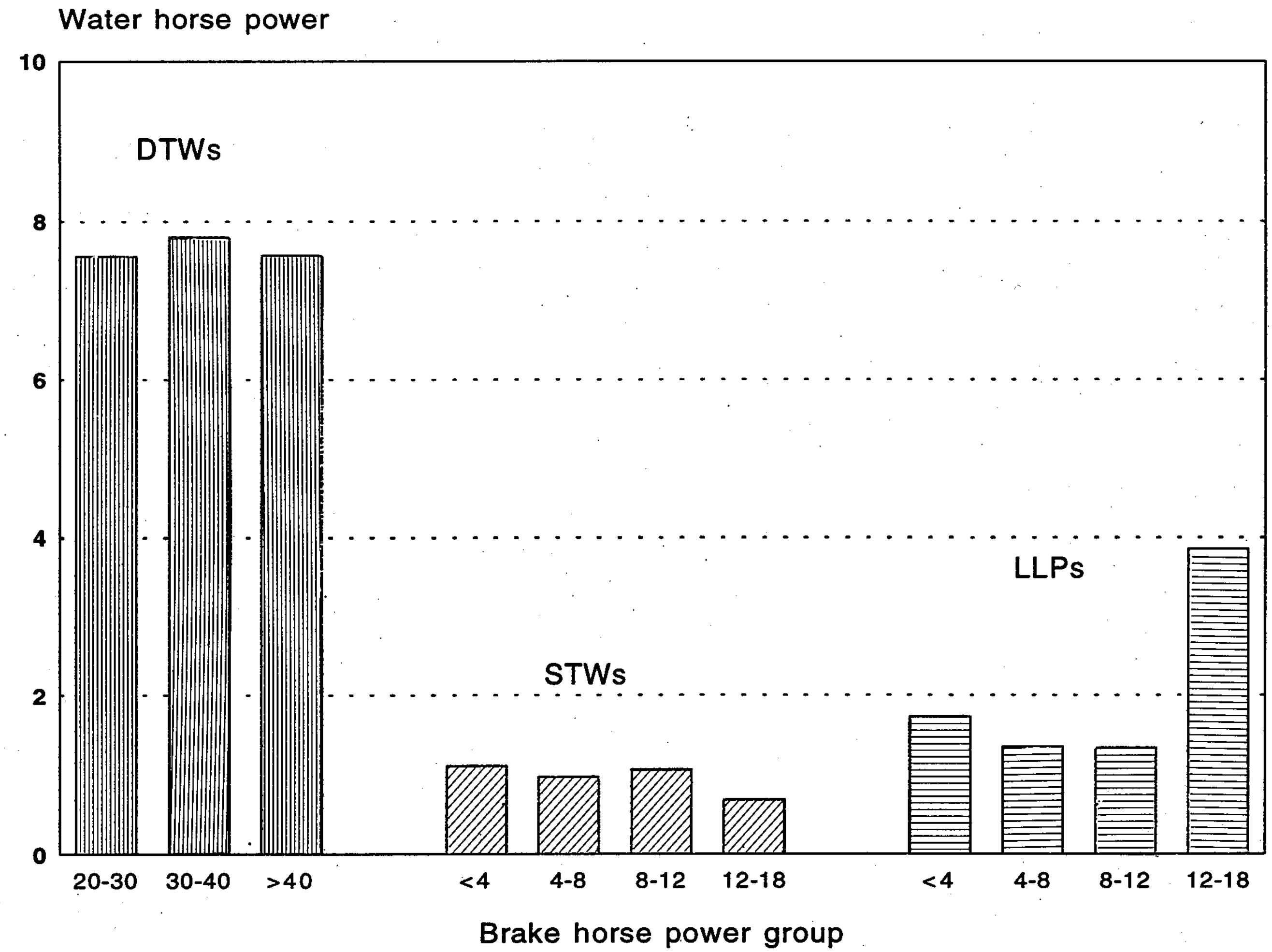
Note: Figure in parentheses indicate standard deviation.
Source: 1994 IIMI/BSERT Pump Owners' Survey in Bogra, Comilla, Faridpur, Hobigonj and Nilphamari districts.

Figure 1. Pumping plant efficiency of DTWs, STWs and LLPs in the study areas.



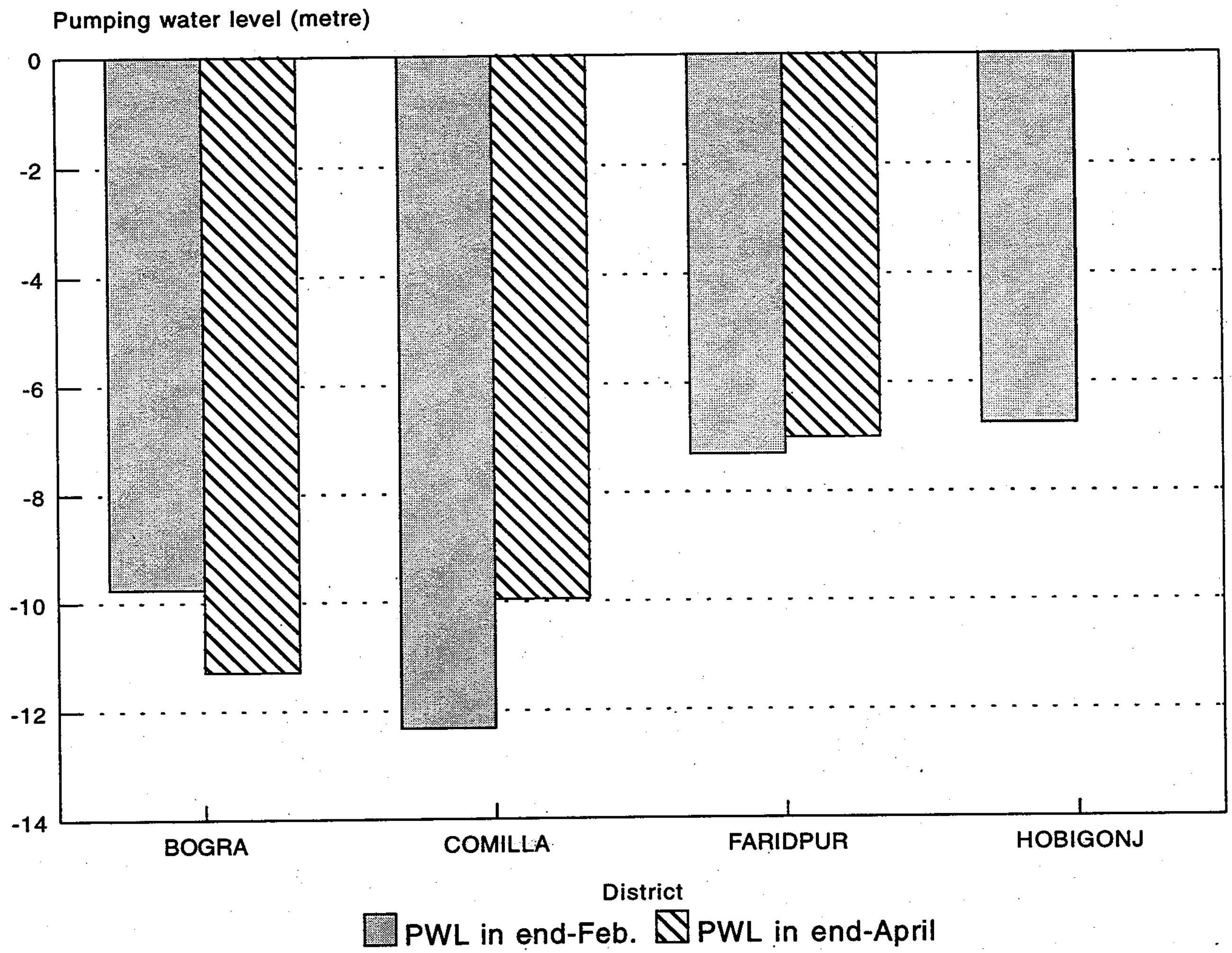
Source: 1994 IIMI/BSERT Field Measurements in Bogra, Comilla, Faridpur, Hobigonj and Nilphamari districts

Figure 2. Water horse power for the DTWs, STWs and LLPs in the study areas.



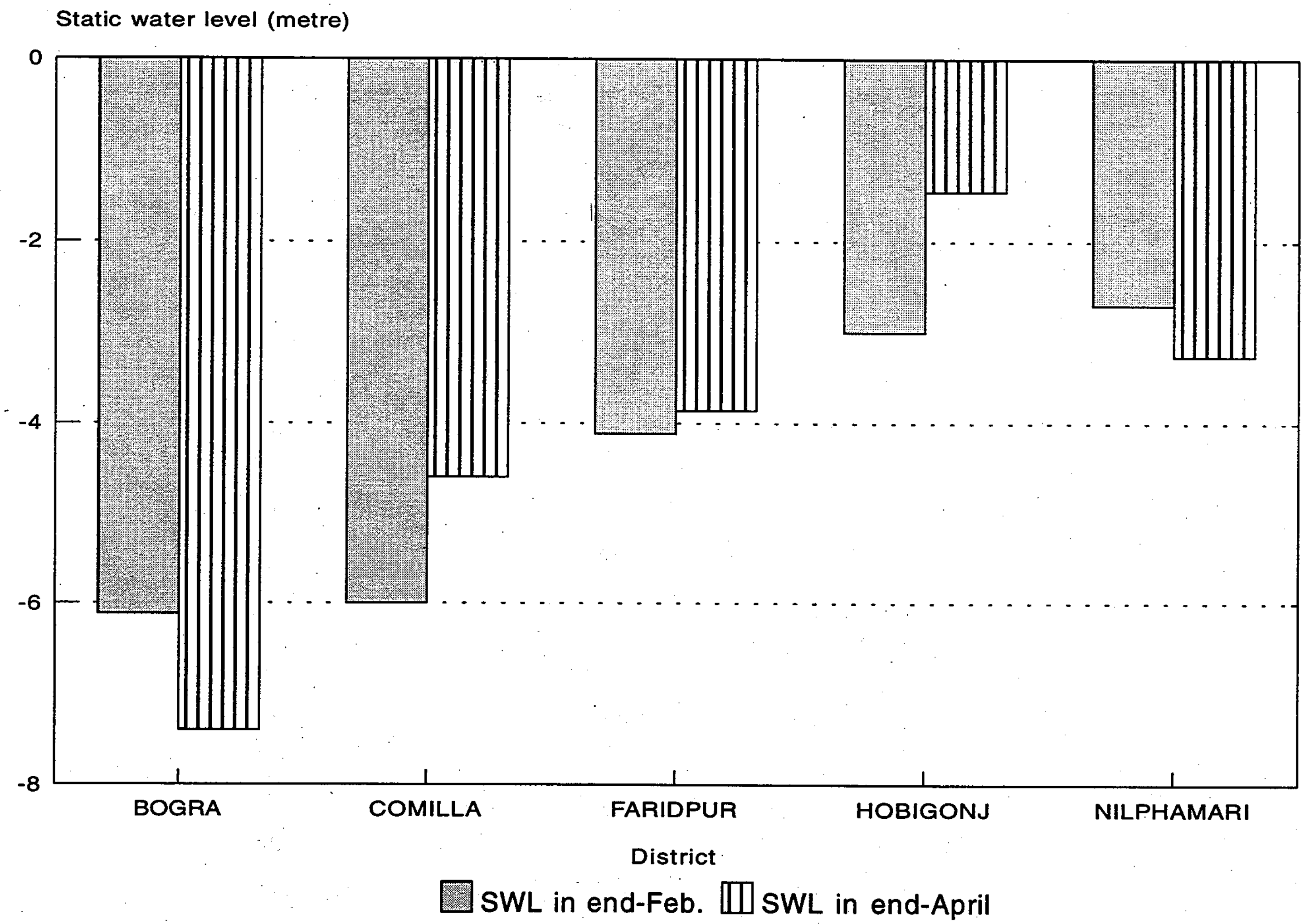
Source: 1994 IIMI/BSERT Field Measurements in Bogra, Comilla, Faridpur, Hobigonj and Nilphamari districts.

Figure 3. Pumping water level (PWL) at end of February and end of April in the study areas.



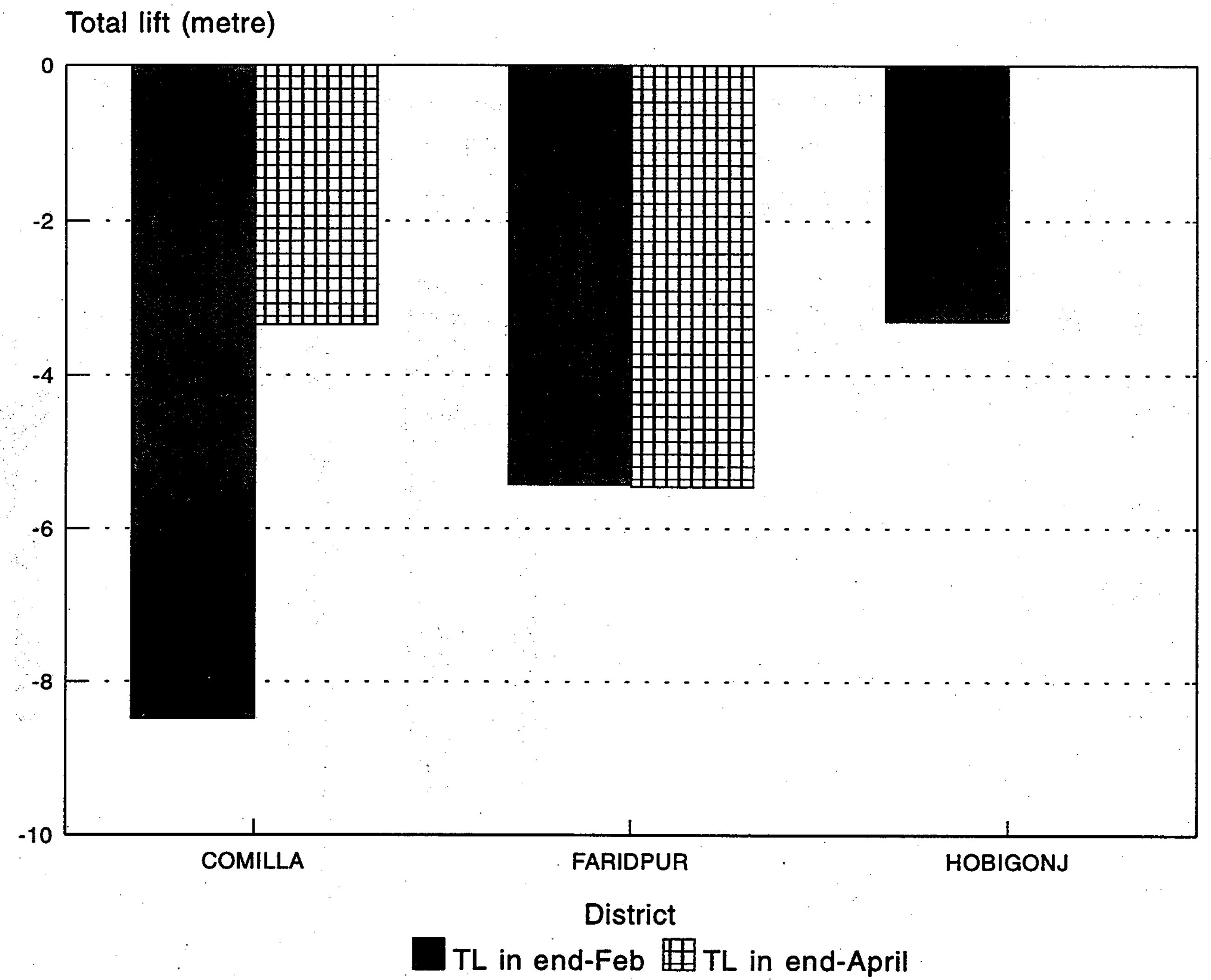
Source: 1994 IIMI/BSERT Field Measurements in Bogra, Comilla, Faridpur, Hobigonj and Nilphamari districts.

Figure 4. *Static water level (SWL) at end of February and end of April in the study areas.*



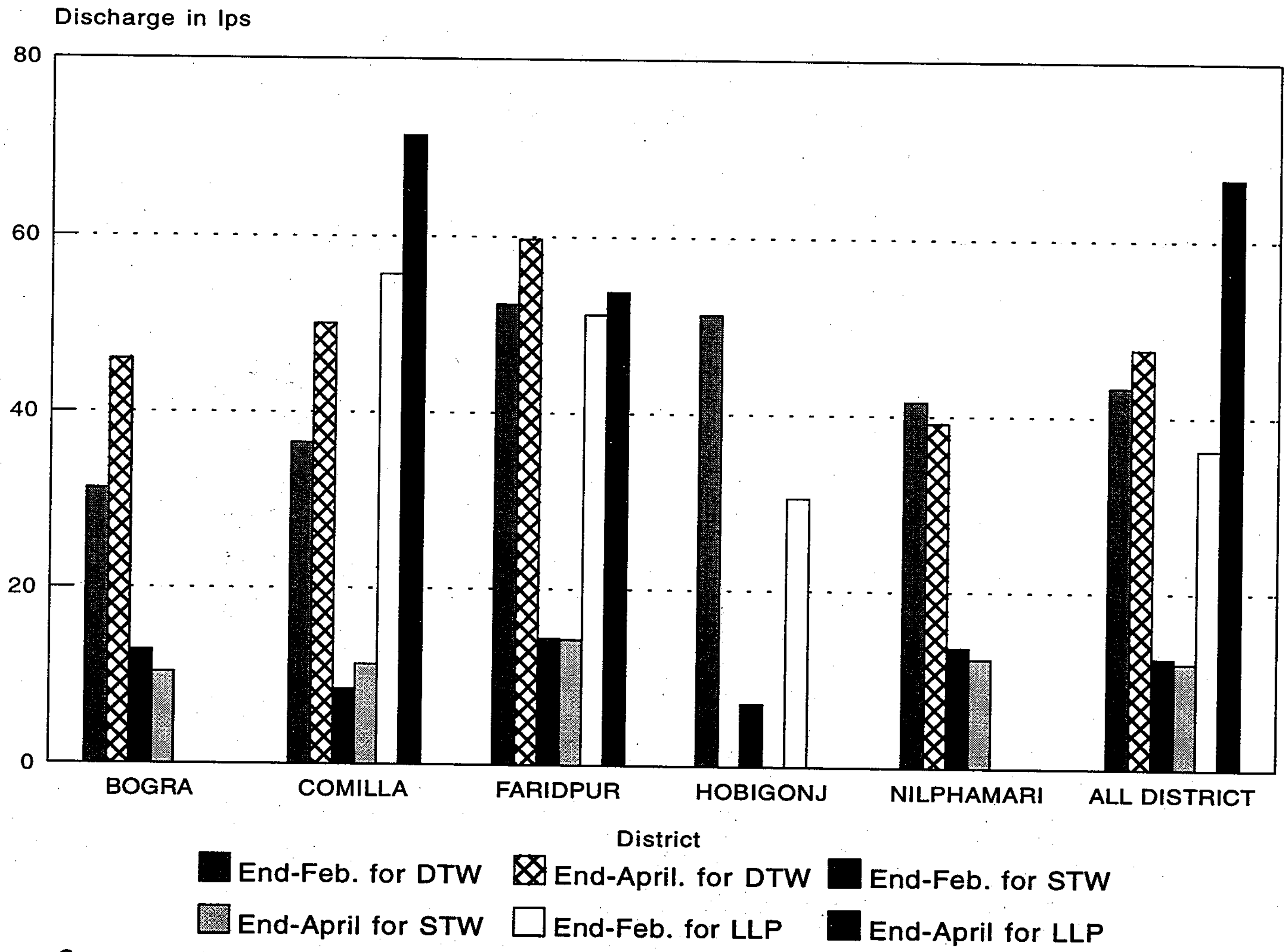
Source: 1994 IIMI/BSERT Field Measurements in Bogra, Comilla Faridpur, Hobigonj and Nilphamari districts.

Figure 5. Total lift (TL) of LLPs at end of February and end of April in the study areas.



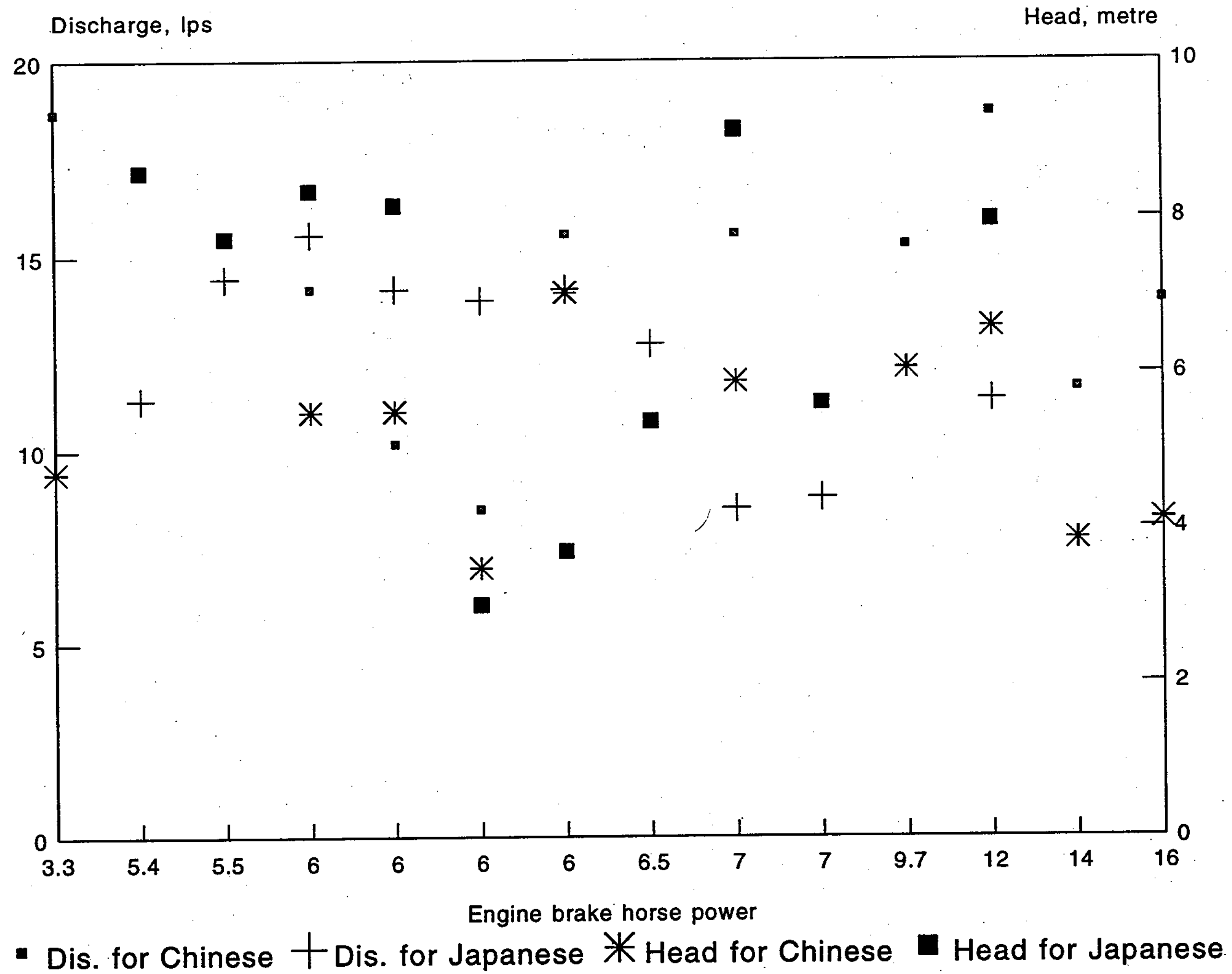
Source: 1994 IIMI/BSERT Field Measurements in Bogra, Comilla, Faridpur, Hobigonj and Nilphamari districts.

Figure 6. Pump discharge of DTWs, STWs and LLPs at the end of February and at the end of April in the study areas.



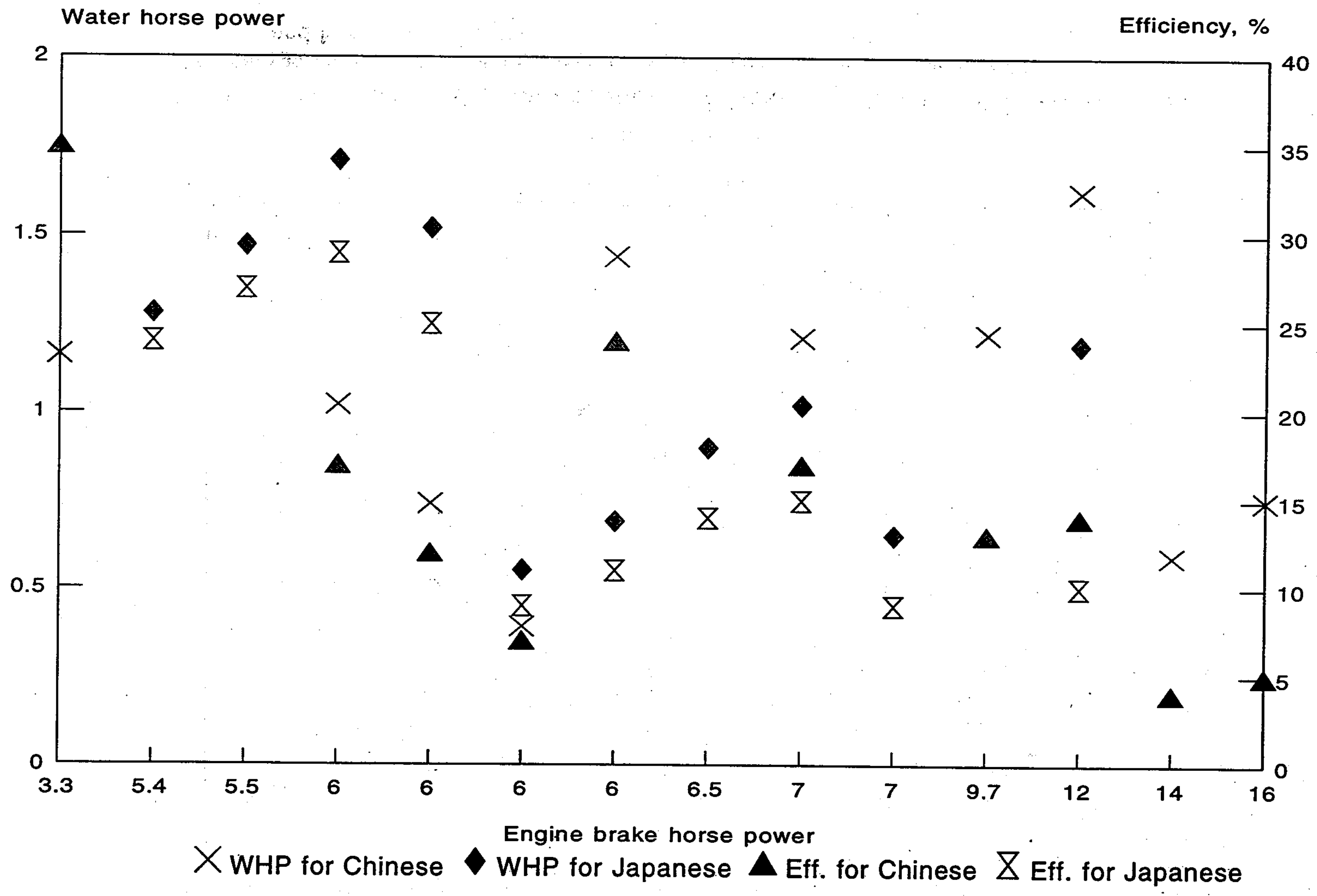
Source: 1994 IIMI/BSERT Field Measurements in Bogra, Comilla, Faridpur, Hobigonj and Nilphamari districts.

Figure 7. Dispersion of discharge and total head of Chinese and Japanese engine operated STWs.



Source: 1994 IIMI/BSERT Field Measurements in Bogra, Comilla, Faridpur, Hobigonj and Nilphamari districts.

Figure 8. *Dispersion of WHP and pumping plant efficiency for Chinese and Japanese engine-operated STWs.*



*Source:*1994 IIMI/BSERT Field Measurements in Bogra, Comilla, Faridpur, Hobigonj and Nilphamari districts.

Water Adequacy Issues[38]

I. INTRODUCTION

With the growth of minor irrigation in Bangladesh there has been increasing attention paid to the availability of water for agricultural and domestic uses. Most areas of the country seem to have groundwater resources which (with a few exceptions in some years) appear to receive a full aquifer recharge during the monsoon season (Pitman 1993). The extraction of water for irrigation, however, can be expected to naturally hasten the normal drawdown of water levels during the dry months. Concerns about this environmental issue can be separated into a number of related topics:

a. The depth to which water levels drop during the irrigation season: Are there areas (and are they growing in size and/or frequency) where pumps are unable to cover their command areas at the peak of the dry season, causing crop damage?[39]

   I. In some areas is the number of pumps reaching a level at which such irrigation problems are becoming critical?

   ii. Are pumps in some places being placed so close together that they cause an environmental externality and actively interfere with each other's operation—and is this interference (as distinct from the general seasonal decline of the water level, whether or not hastened by irrigation) affecting those pumps' ability to cover their command areas at the dry season peak?

b. The ability to pump owners and farmers to adapt and cope with water availability problems when they occur: How do these water users deal with water shortages, both within a given dry season as well as between seasons?

c. The completeness of annual aquifer recharge in all regions: Are incomplete recharges becoming more frequent in some areas? How is minor irrigation being affected by this environmental phenomenon if and when it occurs?

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[38]This paper has been prepared as part of the Study on Minor Irrigation Privatization in Bangladesh conducted by IIMI (the International Irrigation Management Institute) in association with the Ministry of Agriculture with funding from the Asian Development Bank. Research for the paper has been done by IIMI and BSERT (the Bureau of Socioeconomic Research and Training of BAU, the Bangladesh Agricultural University) --- with D.E. Parker, M.R. Biswas, S.C. Dutta and M.U. Salam having been particularly associated with its preparation.

[39]See the Task Forces...(1991) for one discussion of this concern.

The present study of privatization of minor irrigation, while not intended or designed as an aquifer study (or as a full-fledged environmental investigation), can provide a certain amount of information pertinent to some of these environmental issues (parts of points 'a' and 'b' above) for the sections of the five districts which were examined. This information provides a picture of the water environment context in which the other aspects of the study exist. The field research for this study included 1994 water measurements at sample pumps as well as questions posed to sample pump owners and farmers as to their water adequacy problems and coping mechanisms. These questions pertained primarily to their 1994 experience but also, to some extent, to the previous five years. The question of annual recharge and its effects (issue 'c'), however, would entail multi-year research and is beyond the scope of this study.

II. METHODOLOGY

As described elsewhere, this minor irrigation privatization study was designed to focus on a few selected districts—some of which were relatively advanced in minor irrigation development (Bogra and Comilla), and others which have been later starters in that development (Hobiganj, Nilphamari and Faridpur). Within three thanas of each district a sample of 48 pumps was chosen, with each of the main technologies (DTW, STW, and LLP) selected in proportion to the amount of land they covered in a given district. There were 46 DTWs, 131 STWs and 63 LLPs in the over-all sample of 240 minor irrigation systems. Pump owners were interviewed in March and June of 1994 and again in late February of 1995. A sample of 350 irrigating farmers (70 in each district) was chosen from a sub-sample of 50 of the pump systems (10 in each district) and these farmers were also interviewed in March and June of 1994. Engineering measurements (on pump spacing and on discharge and static water levels at both the end of February and the end of April 1994) were taken for the same sub-sample of 50 pump systems from which the farmer irrigators were drawn. Measurements were also taken at a number of non-sample wells which were located so close to sample wells as to make interference a real possibility.

III. WATER AVAILABILITY EXPERIENCE

The annual monsoon rains, as noted earlier, generally fully recharge both groundwater aquifers and surface ponds and rivers. In the dry season, from mid-October to late May, there is naturally a gradual decline in these water levels—even in the absence of irrigation. Occasional dry season rains sometimes give a degree of relief to this decline. While aquifer characteristics do vary between regions, the aquifers in most areas are uncontained and there is a good deal of underground lateral movement of water. The levels of neighboring shallow aquifers, ponds and rivers in a given area are, then, interrelated and all decline to some degree during the dry season.

Minor irrigation takes water from these sources and places it on fields—typically ponded in boro paddy plots. While some of this water does percolate back to the aquifer, a great deal of moisture is used in evapotranspiration which would not have taken place without the irrigation. As a result, the

seasonal decline in surface and groundwater levels in rural areas is hastened during the irrigation season. In some places this increased decline may possibly even provide some level of monsoon flood protection benefit as the soil can accept more recharge through seepage before it is saturated. During the dry season, however, a combination or these natural and irrigation-related water-table declines also raises the possibility of temporary area-specific water shortages for irrigation and domestic use.

What, then, has been the experience of water availability in the districts examined under the present study? The primary areas of focus of this privatization research have been on markets and support services, etc., and not on the technical aspects of aquifer change. Never-the-less, some measurements were taken at a number of pump sites. For additional information there has had to be a reliance on pump-owner and farmer perceptions of water availability. These perceptions have provided some insight—but have also raised a few problems of interpretation in that one person's concept of a drawdown problem or of the adequacy of water supply may differ from that of another person'.

Discharge Measurements

Static water level and discharge measurements were taken from a sub-sample of pumps in each study district. Within each district this sub-sample was concentrated in a single thana (Laksham in Comilla district, Nilphamari Sadar in Nilphamari district and Faridpur Sadar in Faridpur district) with the exception of Hobiganj and Bogra districts. In Hobiganj, Nobigonj was selected as a hoar thana and Hobiganj Sadar as a non-hoar area. In Bogra, Dhunat was chosen as a flood-plain area and Kahalu as a barind-type region. Measurements were taken at additional non-sample wells if they were particularly close to sample units. It was intended that measurements would be taken in late February (the beginning of the boro season) and in late April (when water demand is often at its peak and the water table is expected to be at its lowest). In 1994, however, some of the regions had stopped irrigating after heavy April rains. As a result, a second measurement was not possible for some of the units for which measurements had been taken in February. In Hobiganj this was true for all of the sub-sample units.

The change in static water level between measurements for sampled units in the four remaining districts is presented in Figure 1. It can be seen that the April rains were sufficiently heavy that the static water table actually increased between late February and late April at the Comilla pumps and some of the Faridpur units. For the Bogra STWs, however, there was a decline which varied between pumps but which averaged about one and a quarter meters. Likewise, in Nilphamari the STW water level decrease was about half a meter. None of these declines were exceptional nor could they be expected to cause much trouble for pumps which were not already at their suction limits (in terms of depth of water level) at the beginning of the season.

That the 1994 decline in static water level was not much of a problem for the sub-set of measured pump units can be seen in Figure 2. Some units in Comilla and Faridpur actually had an increase in discharge. For those with a decline the decrease averaged only three liters per second (LPS)—little more than a fifth of the normal discharge capacity of a STW. There were a small number of STWs for which the decline was as high as 4 or 5 LPS (about a third of their February discharge), indicating that they may have been approaching their suction limits.

Pump Owner Reported Drawdown

1994: The 240 sample pump owners located in all 15 thanas of the study districts were asked about the incidence during the last few years of their units' drawdown problems (for DTWs and STWs) and water shortage and drying up (for LLPs). In Table 1 the response for 1994 can be checked against the water measurements noted above—in those thanas where there were both early and late season measurements. Pump owners in Dhunat and Kahalu thanas in Bogra district, Faridpur Sadar in Faridpur district, and Nilphamari Sadar in Nilphamari district reported little problem with drawdown, as expected. In Laksham thana, however, the picture was somewhat different from the measurement data. While the DTW owners had no problem, 3 out of the 4 STW and 4 out of the 5 LLP owners reported difficulties. These difficulties had evidently come about before the April rains which happened to precede the measurements at these units.

Among the thanas in which water measurements were not taken (or which did not have a second measurement), there were four which reported little or no drawdown or water shortage problems in 1994—Kishoregonj (in Nilphamari district), Comilla Sadar in Comilla district and Boalmari and Madhukhali (both in Faridpur district). On the other hand, in Sherpur (of Bogra district) 11 out of 16 STWs had reported drawdown problems. Likewise, 6 of 11 STWs in Saidpur (Nilphamari district) had difficulties. Also, somewhat less than half of the many Hobiganj LLPs (in all three thanas) and all of the Langolkot LLPs (in Comilla district) had water shortage problems before the April rains.

But what did the study districts' reported incidents of drawdown and water shortage mean? After all, some degree of drawdown is natural and minor irrigation equipment is normally expected to be able to accommodate some decline in water level during the season. The meaning of the pump owner reports, then, is imprecise. However, it can be noted (as discussed further in the next section on pump owner water adequacy reports) that none of the STW and DTW owners reported periods in 1994 when they did not have at least a few hours of pumping each day. In other words, it would appear that, at least in 1994, the amount of drawdown did not drop the water level below that at which these pumps can operate to some degree.

1989 to 1993: In some thanas the 1994 reporting of drawdown problems was not isolated. Sherpur and Saidpur (for STWs) and Laksham, Langolkot, Baniachong, Nobiganj and Hobiganj Sadar (for LLPs) all have had multiple reports by owners of drawdown difficulties over the last few years. Are minor irrigation operators in these areas facing a growing problem—and if a growing problem does exist, is it due to more irrigation in the area or to failure of the monsoon rains to fully recharge the aquifer? Of those owners with an opinion, recent drawdown problems are ascribed partly to increased irrigation competition (42% of 41 LLP owners and 70% of 50 STW owners). A variety of other causes (i.e. poor rainfall, natural drying up, poor installation, upstream obstructions, etc.) were also cited by a majority of respondents, however. A more definitive answer to this question of the severity and causes of recent growth in drawdown problems in some areas must await research more directly focussed on aquifer issues, however.

Pump Owner Reported Water Availability Status

In addition to their drawdown perceptions, pump owners were also asked to characterize their pumps' water availability in each dry season month according to a scale ranging from "more than adequate" through "adequate" and "less than adequate" to "dried up". Table 2 presents average scales for DTWs, STWs and LLPs from mid-December to mid-May of 1994. In checking owners' responses against the measurement data, where available, it can be seen (as was the case with drawdown perceptions) that water availability was not really a problem throughout the dry season in Faridpur Sadar in Faridpur district and Nilphamari Sadar in Nilphamari district. Also as before, pump owners in Laksham thana in Comilla district reported poor water availability for all three technologies prior to the April rains which affected the pump measurements. In Dhunat and Kahalu thanas in Bogra district the pump owners reported poor availability—in contrast to both their wells' measurements and their own drawdown perceptions.

In the thanas without water measurements but for which owners had reported no drawdown problems there were, in contrast, moderate levels of water inadequacy reported in Kishoregonj, Madhukhali and Boalmari (all for STWs)—and more severe problems in Comilla Sadar (for both DTWs and STWs). Not surprisingly, the thanas with reported drawdown problems all also reported water availability concerns. This was true for LLPs in Hobiganj Sadar, Nobiganj and Baniachong as well as for STWs in Saidpur and Sherpur (where the concern was particularly heavy).

The degree to which reports of drawdown and water availability differed in some districts again raises the issue of interpretation of these opinion measures. As can be seen in Table 3 (and mentioned briefly in the previous section in regards to drawdown) all pumps were reported to be pumping at least a few hours a day—even during months when water was characterized as "inadequate" or even "dried up". The pumps seemed to be operating, even if at a lower level than desired. The few reported instances of pump stoppage would appear to have been quite temporary.

Irrigating Farmer Reports on Water Supply

As noted earlier, a sample of 350 irrigating farmers was drawn from the same pump units (10 per district) chosen for water measurements. These units were located in Dhunat and Kahalu thanas in Bogra district, Hobiganj Sadar and Nobiganj thanas in Hobiganj district, Faridpur Sadar in Faridpur, Laksham in Comilla district and Nilphamari Sadar in Nilphamari. The sample farmers were asked about the water supply status of the largest plot they each irrigated within their (sample) pumps' command areas.[40] They were asked separately about both water adequacy and timeliness—at an early stage in the irrigation season and at a later, flowering stage. Their experience in both 1994 and five years before was requested.

In Table 4 a summary of their answers can be found. A comparison can be made between these farmer responses and the measurement and pump owner information discussed above:

[40]Statistical tests between plots identified as being at "head," "middle" and "tail" locations showed no difference in reported water adequacy and timeliness due to location.

Faridpur and Nilphamari

Both Faridpur Sadar and Nilphamari Sadar, it may be recalled, had displayed little in the way of 1994 problems in the water measurements or in the pump owner reports of drawdown and water availability. Among the irrigator farmers of the same units in these thanas it can be seen that water adequacy and timeliness was also generally good. In Faridpur there was a moderate drop between early and late in the season.

Bogra

The farmers of Dhunat and Kahalu thanas displayed almost an identical early/late season pattern as Faridpur. These two thanas had not shown problems in the measurements or pump owner reported drawdown, but pump owners had indicated a water availability problem late in the season. The owners' water availability concern, evidently, was not translated into problems for the irrigating farmers.

Hobiganj

The irrigating farmer respondents in Nobiganj and Hobiganj Sadar reported almost no drop in water supply between early and late in the season. This is in marked contrast to the frequent negative reports given by the owners of LLPs (the dominant irrigation technology in these thanas).

Comilla

Laksham farmers had an early/late season drop in water adequacy which appears to be less than that in Faridpur, Nilphamari and Bogra—despite the problems reported by pump owners in the period before the April rains.

Over-all there seems to have been less in the way of water supply problems noted by irrigator farmers than was reported by their pump owners. Early season water adequacy and timeliness were the norm in all areas. A small to moderate drop between early and late season water supply generally took place. The magnitude of this drop, however, generally seems to have been smaller than that noted by pump owners and unrelated to inter-thana differences in pump-owner reports of drawdown and water adequacy.

Between 1989 and 1994 there were few changes of note. Irrigators' reported water supply generally stayed the same in Bogra, showed marginal improvements in Faridpur and Nilphamari and a moderate decline in Hobigonj. In Comilla (Laksham) the decline was somewhat more pronounced. However, when the experience of those Comilla farmers who irrigated in **both** years is isolated, it can be seen that for these farmers there was no change between the two periods. In general, while there were some differences between study thanas, there does not appear to have been any marked decline in water availability to farmers over time.

Domestic Water Supply

Ninety-five percent of the sample irrigator farmers used hand tubewells for their domestic water supply. This domestic water source, then, taps the same aquifer as the local STWs and DTWs. Asked if they had a problem with their hand tubewells at the height of the dry season, however, the replies of farmers in Laksham (Comilla), Faridpur Sadar Hobiganj Sadar and Nobiganj (Hobiganj) indicated that very few had difficulties (Table 5). Only in Dhunat and Kahalu (both of Bogra district) and Nilphamari Sadar were there more substantial domestic water problems (and these were reportedly more acute in 1994 than in 1989). This experience in the two Bogra thanas might be seen as generally fitting the water adequacy views of their local pump owners. The result is more surprising in Nilphamari, however, where pump owners as well as irrigators had no problem with groundwater supplies for irrigation.

IV. TUBEWELL INTERFERENCE

As noted earlier, one of the concerns regarding the rapid growth of minor irrigation has been with the possibility that some tubewells are being placed so close together as to cause an environmental externality and actively interfere with each other. Each tubewell, when operating, extracts water from a range or space shaped like an inverted cone—with the pump in the middle where the cone is deepest. The steepness of the sides of such cones differ by soil and aquifer characteristics. If two tubewells are placed sufficiently close together, their cones may intersect and the wells end up competing for the available water within their common ranges. They will each, then, have less accessible water within their respective ranges than they would have if they had not had intersecting cones. This problem is distinct from the issue of general aquifer decline (whether or not hastened by irrigation development) which might happen even if all tubewells were spaced so as not to have intersecting cones of extraction.

To examine the effects of such interference it is necessary to have static water level and discharge measurement for a number of interfering and non-interfering wells. Pump measurements in this privatization study included 28 STWs which might be compared. 16 of these STWs were located closer than the recommended spacing allowance (230 meters from other STWs and 480 meters from the nearest DTW). In Table 6 the late season static water levels and discharges of these 16 "potentially interfering" wells are presented along with comparable figures for the 12 STWs which were spaced well away from other wells (i.e.: assumed to be "not potentially interfering"). Among the "potentially interfering" wells there is no significant relationship between well distance and static water level. While the static water tables of these two groups do seem to differ (with "potentially interfering" wells having a deeper static water level than the other group) this difference may well be partly due (as with the distance non-relationship) to the fact that the sample is drawn from widely different regions. Discharges for the two groups, however, are almost the same. In other words, whether not the "potentially interfering" group has wells which are affecting each other, the extent of that effect has not reached a damaging level.

In order to control for the differences between regions, 8 of the "potentially interfering" wells in the Dhunat and Kahalu thanas of Bogra district were selected for closer examination. These wells were paired with their neighboring non-sample "potentially interfering" STWs. Static water level and discharge measurements were taken both early and late in the dry season and the differences in drawdown and

discharge between periods were regressed against the distance between the paired wells. In Figure 3 it can be seen that the decline in static water levels between these two periods was significantly related to the distance between the wells. The closer the two wells, the greater the seasonal decline (though beyond 150 meters the decline was very small). When looking at the change in discharge (Figure 4), however, there is no discernable relationship with distance. As with the more regionally diffuse sample above, the amount of interference between wells has not reached the level of significantly affecting discharge. The static water levels, though affected by neighboring wells, have not dropped out of the effective pumping ranges of the sample STWs.

V. COPING WITH WATER SUPPLY PROBLEMS

As has been seen above, a number of the sample minor irrigation systems have faced some degree of water shortage or drawdown. It is useful to look at the experience of the owners of these units to see what kind of responses and coping mechanisms were used in the face of water supply problems. Such responses (to be found in Table 7) might be categorized as:

a) taking place within the season of the water supply problem—as pump owners attempt to service the command area for which they are under contract.

b) taking place the next year of operation—when command area might be adjusted or technology up-graded.

c) choosing not to operate the following year—i.e., dropping out of the irrigation enterprise.

Within the Season of Drawdown

There were 54 sample well owners (9 DTW and 45 STW) who reported drawdown problems in one or more of the last few years. Among these owner/operators the most common (78% of DTWs and 56% of STWs) reported within-season response was to increase their daily pumping hours. On this issue a cross-check can be made with Table 3 in which pumping hours in each month are differentiated by water adequacy ratings. For DTWs pumping hours do appear to be higher for wells reported to have "inadequate" water in a given month than for those with reported "adequate" water. For STWs the picture is less consistent—as a number of "dried up" wells during Chaitra had more pumping hours than wells with "adequate" or merely "inadequate" water during the same month but wells with an "inadequate" supply in Fulgoon and Chaitra seemed actually to pump fewer hours than those with "adequate" water.[41] It is possible that some STWs were sufficiently close to their pumping limit depths and could

[41]The relationship between water adequacy perceptions and pumping hours is not statistically significant for either DTWs or STWs in any month.

not, therefore increase pumping hours as much as their owners would have liked. DTWs would not have faced this problem.

For STWs another common coping method was to deep-set the pump.[42] 38 percent of those with drawdown problems reported using this technique which entails digging a pit (which must be lined for support if it is very deep) into which the engine and pump can temporarily be placed. This method enables the STW suction pumps to gain access to lower levels of water, but it is more expensive to operate. As can be seen in Figure 5, some sample deep-set machines have been lowered a second time. In the Sherpur area (which had, perhaps, the most serious drawdown problems among the study areas) the deep-setting averaged 2.7 meters while in Laksham it was 1.8 meters.

Other strategies for dealing with drawdown problems within the season included supplying less water to all plots under irrigation or to supplement supply with water from a nearby pump. The latter might seldom be possible given that all pumps in a given area are likely to be suffering from drawdown when it occurs. Finally, there were a few pumps which were reported to have stopped operating. This stoppage would appear to have been temporary given that all of these wells reported daily hours of pump operation throughout the relevant months during the season.

Changes in the Next Year of Operation

Those owners who had drawdown problems in years before the survey in 1994 were able to report their next year position. There were 9 DTWs and 32 STWs in this situation. The year after facing drawdown and water supply problems a number of these pump owners reported the defection of some of their irrigator clients. Five (56%) of the DTWs and 9 (28%) of the STWs appear to have suffered this loss. The average decrease of command area was, respectively, 15.4 acres and 5.9 acres for DTWs and STWs. Some irrigators simply chose not to irrigate at all while others took the opportunity of shifting their business to other nearby pumps. Given the location of their plots, this latter option is likely to be open to only a sub-set of irrigators.

Perhaps to avoid such a loss of command area, some STW owners chose to invest in a more powerful engine/pump by the year following their reported drawdown problems. This was true for 4 (13%) of the STW owners.

Ceasing to Operate the Next Year

Some pump owners simply chose to get out of the irrigation business when faced with drawdown problems which made their operations either unprofitable or too difficult. As the study sample of pump owners were all (by definition) still operating in 1994 it was not possible to gauge the frequency of this response for prior years. In February of 1995, however, there was a reinterview with pump owners—and those sample owners who had dropped out since 1994 were sought out and questioned. Two sample STW owners in Sherpur and one DTW owner in Laksham claimed drawdown as one of their reasons

[42]Deep-setting as an expected coping mechanism is discussed in UNDP (1989), among other places.

for dropping out. The Sherpur owners had, in fact, mentioned drawdown as a problem during their 1994 interview (and had even temporarily stopped pumping during that season). This was not true of the particular DTW owner in Laksham, for which there may have been other contributing reasons for dropping out.

Coping Response Overview

Over-all the pump owners facing drawdown and water availability problems found a number of ways in which to cope or react to their situation. This coping behavior, in almost all affected areas of the study districts, was able to sufficiently solve the problem so that irrigation could continue and crops were not damaged. In most of the thanas the most common response was to increase pumping hours. On the other hand in Sherpur, where water availability may have been worse than in most of the other areas, the various owners seemed to have tried (between them) almost all the identified strategies discussed above. The relative severity of their situation would appear to have justified the used of the more expensive options such as deep-setting and the purchase of higher capacity pumps/engines.

It should be noted that there are areas of response to water scarcity problems which were not investigated in this study given its individual pump-owner market focus. One such area is that of community response. Village communities do have the interest, and often the ability, to deal with issues of resource over-use. To what extent do village leaders attempt to arbitrate issues of pump number and location on the land in their area? Are pump owners willing to submit to community pressures on these issues? Given the great difficulty (and likely damage to the spread of irrigated agriculture in areas not seriously affected by drawdown) of effectively implementing more central regulatory controls on the several hundred thousand minor irrigation units in the country, more information on local community responses to water scarcity problems may well be very useful.

VI. CONCLUSIONS AND RECOMMENDATIONS

This study of minor irrigation privatization, as noted earlier, was neither intended nor designed as an in-depth examination of aquifer issues. Never-the-less, there is a fair amount of insight to be gained about some aspects of water availability/scarcity and of the way pump owners cope with their water environment and its occasional adequacy problems in the districts included in the study. Some points that could be made include:

a) In most of the thanas included in the study the level of reported drawdown or water inadequacy would appear to have been fairly moderate during the 1994 dry season. In these areas water was within the reach of the pumps throughout the irrigating season. Pump discharge, as a result, seems to have been little affected.

b) There were one or two concentrated areas (such as Sherpur) plus some scattered individual pumps which suffered in 1994 from some degree of reported water scarcity. Even in these areas

there does not seem to have been an actual cessation of pumping so crops continued to get at least some water.

c) In those areas where some level of drawdown and water availability problem was reported the pump owners seemed quite adept at coping with the situation. Increasing pump operating hours, spreading the available water a little thinner or even deep-setting a STW pump were common responses. With these actions the pumps seem to have been able to complete the irrigations needed by the standing crops in their command areas.

d) Between dry seasons some further adjustments have been made by a number of pump owners and irrigating farmers who have faced water adequacy problems. Some pump owners have up-graded their equipment so as to be better able to cope with possible future water scarcity situations. On the other hand, some command areas have been adjusted downwards to a smaller size as a few irrigating farmers have defected and chosen not to irrigate plots served by a pump. This shrinking may make the command area more appropriately sized for the expected water availability situation—though the financial viability of the smaller enterprise might be in doubt.

e) As with any market enterprise, there have been a few pump owners who have chosen to drop out of the irrigation business—for a variety of reasons. In the study areas, for example, there have been two STW owners who have opted not to operate in 1995 due to water drawdown problems in 1994 (and possibly earlier). This decline in the local number of wells served by an aquifer is again a response to water scarcity which helps adjust the total water use to the capacity of the resource (a resource which is generally fully replenished during each monsoon). Such trial and error adjustments in number of wells are likely where there is inadequate scientific knowledge (made accessible to pump owners and potential pump owners) about the properties of local aquifers including their ability to accommodate tubewells.

f) For a few STWs within parts of the study districts there was a real possibility of pump interference from other pumps that were located within recommended siting distances. Measurements taken at these wells indicated that there was some mutual decline in static water level for such potentially interacting pumps. However, in none of these cases was there much of a resulting decline in discharge—as these particular pumps were still operating within their pumping depth limits. Pumps placed "too close" together, then, do not automatically create a severe water scarcity problem for themselves. Spacing, of course, becomes more important where the general local aquifer level is already close to STW pumping limits.

An over-all view of the study areas, then, is that there was not a particularly large or wide-spread water availability problem in 1994. In those cases where some water difficulties have been faced, the pump owners and farmers have made responses which have generally been adequate to preventing severe damage to existing crops and/or which have helped adjust future water use to the apparent carrying capacity of the water resource. It would be of use to further examine such pump-owner/farmer responses—as well as village community reactions—to water scarcity situations in areas where water

availability is frequently a more severe problem than it has been in the areas that happened to be included in this study. Individual pump-owner/farmers and their communities could also use better information about the capacity of their local aquifers. A program to ascertain and disseminate such information could help pump investors make better decisions about whether or not to install additional pumps in an area.

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Table 1. (part 1). *Drawdown perceptions, 1989-1994: Incidence of DTW and STW owner recall of drawdown problems and LLP owner perception of water shortage and drying up.*

Thana	1989			1990			1991		
(n in 1994)	DTW	STW	LLP	DTW	STW	LLP	DTW	STW	LLP
Bogra									
Dhunat (dtw-0,stw-16,llp-0)	-	0	-	-	0	-	-	0	-
Kahalu (dtw-9,stw -7,llp -0)	0	0	-	0	0	-	0	1	-
Sherpur (dtw-0,stw -14,llp -2)	-	1	1	-	1	0	-	2	1
Comilla									
Comilla Sadar (dtw -7,stw-4,llp -5)	2	0	0	1	0	0	3	0	0
Laksham (dtw -7,stw-4,llp -5)	0	0	0	0	0	4	1	0	0
Langolkot (dtw -6,stw-5,llp -5)	0	0	0	0	0	0	0	0	0
Faridpur									
Boalmari (dtw -1,stw-13,llp -2)	0	0	0	0	0	0	0	1	0
Faridpur Sadar (dtw -3,stw-12,llp -1)	0	0	0	0	0	0	0	1	1
Madhukhali (dtw -1,stw-14,llp -1)	0	0	0	0	0	0	0	0	1
Hobiganj									
Baniachong (dtw -2,stw-0,llp -14)	0	-	0	0	-	2	0	-	0
Hobiganj Sadar (dtw -2,stw-3,llp -11)	0	0	1	0	0	2	0	0	2
Nobiganj (dtw -1,stw-0,llp -15)	0	-	0	0	-	0	0	-	1
Nilphamari									
Kishoregonj (dtw-0,stw-16,llp-0)	-	0	-	-	0	-	-	0	-
Nilphamari Sadar (dtw -4,stw-12,llp -0)	0	0	-	0	0	-	0	0	-
Saidpur (dtw -3,stw-11,llp -2)	2	0	0	0	0	0	0	0	0

Source: IIMI/BSERT 1994 Pump Owner Survey in Bogra, Comilla, Faridpur, Hobiganj and Nilphamari districts

Table 1 (part 2): *Drawdown perceptions, 1989-1994: Incidence of DTW and STW owner recall of drawdown problems and LLP owner perception of water shortage and drying up.*

Thana	1992			1993			1994		
(n in 1994)	DTW	STW	LLP	DTW	STW	LLP	DTW	STW	LLP
Bogra									
Dhunat	-	0	-		-	0	-		-
0	-								
(dtw-0,stw-16,llp-0)									
Kahalu	0	1	-	0	0	-	0	1	-
(dtw-9,stw -7,llp -0)									
Sherpur	-	9	1	-	9	1	-	11	1
(dtw-0,stw -14,llp -2)									
Comilla									
Comilla Sadar 3	1	0	2	1	3	1	0	0	
(dtw -7,stw-4,llp -5)									
Laksham	1	0	4	0	0	5	0	3	4
(dtw -7,stw-4,llp -5)									
Langolkot	0	0	5	0	0	5	0	0	5
(dtw -6,stw-5,llp -5)									
Faridpur									
Boalmari	0	0	0	0	0	0	0	0	0
(dtw -1,stw-13,llp -2)									
Faridpur Sadar	0	1	0	0	0	1	0	0	0
(dtw -3,stw-12,llp -1)									
Madhukhali	0	0	0	0	0	0	0	0	0
(dtw -1,stw-14,llp -1)									
Hobiganj									
Baniachong	1	-	6	1	-	2	0	-	3
(dtw -2,stw-0,llp -14)									
Hobiganj Sadar	0	0	4	0	0	4	0	0	5
(dtw -2,stw-3,llp -11)									
Nobiganj	0	-	6	0	-	5	0	-	6
(dtw -1,stw-0,llp -15)									
Nilphamari									
Kishoregonj	-	0	-	-	0	-	-	0	-
(dtw-0,stw-16,llp-0)									
Nilphamari Sadar	0	0	-	0	0	-	0	0	-
(dtw -4,stw-12,llp -0)									
Saidpur	2	1	0	1	4	0	0	6	0
(dtw -3,stw-11,llp -2)									

Source: IIMI/BSERT 1994 Pump Owner Survey in Bogra, Comilla, Faridpur, Hobiganj and Nilphamari districts.

Table 2. *Water availability perceptions by thana: Average scores of pump owners' opinions of monthly water adequacy during the 1994 dry season.*

(1 = more than adequate; 2 = adequate; 3 = inadequate; 4 = dried up)

Thana	Tech.	Poush		Magh		Fulgoon		Chaitra		Baishak	
		(Dec/Jan)		(Jan/Feb)		(Feb/Mar)		(Mar/Apr)		(Apr/May)	
		Ave.	(n)	Ave.	(n)	(Ave.	(n)	Ave.	(n)	Ave.	(n)
Dhunat	STW	2.0	(16)	2.0	(16)	2.1	(16)	2.7	(16)	2.5	(16)
Kahalu	DTW	2.0	(7)	2.0	(9)	2.0	(9)	2.8	(9)	3.0	(9)
	STW	2.0	(6)	2.0	(7)	2.0	(7)	3.0	(7)	3.0	(7)
Sherpur	STW	1.2	(5)	1.9	(14)	2.9	(14)	3.5	(14)	2.6	(14)
	LLP	1.5	(2)	2.0	(2)	3.0	(2)	3.5	(2)	3.5	(2)
Comilla S.	DTW	1.6	(7)	1.7	(7)	2.3	(7)	3.0	(7)	2.3	(3)
	STW	1.5	(2)	1.7	(3)	1.8	(4)	2.5	(4)	2.5	(2)
	LLP	1.0	(2)	1.0	(5)	1.0	(5)	1.0	(5)	1.0	(3)
Laksham	DTW	2.0	(7)	2.0	(7)	2.3	(7)	2.6	(7)	1.7	(3)
	STW	2.0	(4)	2.0	(4)	2.8	(4)	2.8	(4)	1.3	(3)
	LLP	2.0	(5)	2.4	(5)	3.0	(5)	4.0	(5)	2.4	(5)
Langolkot	DTW	2.0	(4)	2.0	(6)	2.5	(6)	2.8	(6)	2.5	(2)
	STW	1.0	(3)	1.6	(5)	2.0	(5)	2.8	(5)	2.5	(2)
	LLP	1.0	(5)	1.2	(5)	4.0	(5)	4.0	(5)	-	
Boalmari	DTW	2.0	(1)	2.0	(1)	2.0	(1)	2.0	(1)	2.0	(1)
	STW	1.9	(10)	1.9	(13)	2.2	(13)	2.4	(12)	2.2	(9)
	LLP	2.0	(2)	2.0	(2)	2.0	(2)	2.0	(2)	2.0	(2)
Faridpur S.	DTW	1.7	(3)	1.7	(3)	2.3	(3)	2.3	(3)	2.0	(3)
	STW	1.7	(12)	1.8	(12)	2.1	(12)	2.4	(12)	2.3	(12)
	LLP	1.0	(1)	1.0	(1)	2.0	(1)	2.0	(1)	2.0	(1)
Madhukhali	DTW	2.0	(1)	2.0	(1)	2.0	(1)	2.0	(1)	2.0	(1)
	STW	1.9	(14)	2.0	(14)	2.6	(14)	2.6	(14)	2.0	(13)
	LLP	2.0	(1)	3.0	(1)	3.0	(1)	3.0	(1)	-	
Baniachong	DTW	2.0	(2)	2.0	(2)	2.0	(2)	2.0	(2)	-	
	LLP	1.4	(14)	1.9	(14)	2.3	(14)	2.0	(14)	-	
Hobiganj S.	DTW	2.0	(2)	2.0	(2)	2.0	(2)	2.0	(2)	-	
	STW	2.0	(3)	2.0	(3)	2.0	(3)	2.0	(3)	-	
	LLP	2.1	(11)	2.2	(11)	2.8	(11)	2.5	(11)	2.5	(2)
Nobiganj	DTW	2.0	(1)	2.0	(1)	2.0	(1)	3.0	(1)	-	
	LLP	1.3	(15)	2.0	(15)	2.7	(15)	2.7	(15)	-	
Kishoregonj	STW	1.2	(14)	1.3	(15)	2.1	(16)	2.6	(16)	1.9	(14)
Nilphamari	DTW	2.0	(4)	2.0	(4)	2.0	(4)	2.0	(4)	2.0	(4)
	STW	2.0	(11)	2.0	(12)	2.0	(12)	2.0	(12)	2.0	(12)
Saidpur	DTW	1.0	(1)	1.7	(3)	1.7	(3)	2.3	(3)	2.3	(3)
	STW	1.4	(9)	1.9	(10)	2.4	(11)	2.7	(11)	2.4	(11)
	LLP	1.0	(2)	1.0	(2)	2.0	(2)	2.0	(2)	1.5	(2)

Source: IIMI/BSERT 1994 Pump Owner Survey in Bogra, Comilla, Faridpur, Hobiganj and Nilphamari Districts.

Table 3. *Water availability perceptions and reported pump operating hours: Pump owners' opinions of monthly water adequacy and reports of daily pumping hours during the 1994 dry season.*

Tech.	Months	More than adequate		Adequate		Inadequate		Dried up	
		No.	Daily Hrs.	No.	Daily Hrs.	No.	Daily Hrs.	No.	Daily Hrs.
DTW (46)	**Poush** (Dec/Jan)	5	6.8	31	6.3	-	-	-	-
	Magh (Jan/Feb)	5	6.8	37	6.2	1	8.0	-	-
	Fulgoon (Feb/Mar)	3	5.3	31	6.3	10	7.2	-	-
	Chaitra (Mar/Apr)	1	5.0	18	4.7	25	6.1	-	-
	Baishak (Apr/May)	1	2.0	12	3.0	13	4.1	-	-
STW (131)	**Poush** (Dec/Jan)	28	4.5	75	4.1	1	1.0	-	-
	Magh (Jan/Feb)	21	3.6	103	3.7	3	3.2	-	-
	Fulgoon (Feb/Mar)	7	4.6	83	4.3	40	3.9	-	-
	Chaitra (Mar/Apr)	1	9.0	50	3.8	70	3.7	7	4.1
	Baishak (Apr/May)	4	1.5	69	2.2	35	2.3	1	1.0
LLP (63)	**Poush** (Dec/Jan)	23	7.3	28	7.6	1	8.0	-	-
	Magh (Jan/Feb)	13	6.2	40	6.3	6	6.3	-	-
	Fulgoon (Feb/Mar)	5	5.0	24	6.1	20	5.3	4	4.7
	Chaitra (Mar/Apr)	5	3.3	27	3.7	6	3.3	9	2.1
	Baishak (Apr/May)	4	2.4	5	2.0	1	1.0	1	2.0

Source: IIMI/BSERT 1994 Pump Owner Survey in Bogra, Comilla, Faridpur, Hobiganj and Nilphamari Districts.

Table 4. Irrigating farmers' reported water adequacy and timeliness in the 1989 and 1994 boro seasons (percent).

	Bogra		Comilla		Faridpur		Hobiganj		Nilphamari		Total	
	1989	1994	1989	1994	1989	1994	1989	1994	1989	1994	1989	1994
n	61	70	22 *	70 *	61	70	59	70	58	70	261	350
Water adequate in early season	97	100	96 *	79 *	85	93	98	86	95	99	94	91
Water Adequate in late season	75	73	91 *	66 *	71	73	93	83	95	97	84	78
Timely Water in early season	95	96	91 *	74 *	84	96	97	79	93	99	92	89
Timely Water in late season	74	73	91 *	74 *	74	76	95	77	95	99	85	80

* *Note:* The 22 Comilla sample farmers who had irrigated in 1989 represented less than a third of those who were interviewed in 1994 (a much smaller proportion than in the other districts). These 22 farmers stated that their water adequacy and timeliness (both early and late in the Boro season) had either not changed or had improved between 1989 and 1994. The apparent decrease in the water delivery measures in Comilla, then, is due solely to the 1994 opinion of those irrigators who had **not** also irrigated in 1989. The other districts did not display such a discrepancy between the opinions of new (1994 only) and old (both 1989 and 1994) irrigators.

Source: IIMI/BSERT Irrigating Farmer Surveys: 1994 in Bogra, Comilla, Faridpur, Hobiganj and Nilphamari.

Table 5. Sample farmers' reports of domestic water supply shortage at the peak of the 1994 dry season.

	Domestic water problem, 1994 (n)	Of those with a 1994 problem considered more acute than 1989 (n)
Bogra	21 (70)	21 (21)
Comilla	8 (70)	6 (8)
Faridpur	5 (70)	5 (5)
Hobiganj	8 (68)	7 (8)
Nilphamari	36 (70)	29 (36)
All areas	78 (348)	68 (78)

Source: Irrigator Farmer Survey: 1994 in Bogra, Comilla, Faridpur, Hobiganj and Nilphamari.

Table 6. Static water levels and pump discharges for 16 "potentially interfering" and 12 "not potentially interfering" STWs.

Pump serial (No)	"Potentially interfering" STWs			"Not potentially interfering" STWs	
	Distance to nearest STW or DTW (m)	Static water level (m)	Discharge (LPs)	Static water level (m)	Discharge (LPs)
01	60.96	4.05	14.16	4.57	7.08
02	44.80	3.96	15.57	5.49	17.84
03	15.24	5.94	15.57	4.57	12.17
04	30.48	5.94	14.16	3.20	7.08
05	121.91	6.40	11.32	2.68	13.59
06	30.48	6.55	11.32	3.14	13.87
07	213.35	7.16	7.08	2.59	8.49
08	152.39	7.77	8.49	2.44	11.61
09	60.96	4.57	6.79	2.83	15.85
10	182.87	4.24	8.78	2.99	13.59
11	175.25	3.87	15.29	2.74	14.16
12	213.35	4.21	10.19	2.13	17.27
13	213.35	5.00	18.68	-	-
14	213.35	3.75	12.74	-	-
15	205.73	3.81	9.91	-	-
16	449.56	4.27	15.29	-	-
Mean (sd)	149.00 (111)	5.09 (1.33)	12.21 (3.50)	3.28 (1.03)	12.72 (3.63)

**Note:* "Potentially interfering" STWs are within 230 meters of other STWs or 480 meters of a DTW. "Not potentially interfering" STWs are outside of these ranges.

Source: IIMI/BSERT 1994 Field Measurements in Bogra, Comilla, Faridpur, Hobiganj and Nilphamari districts.

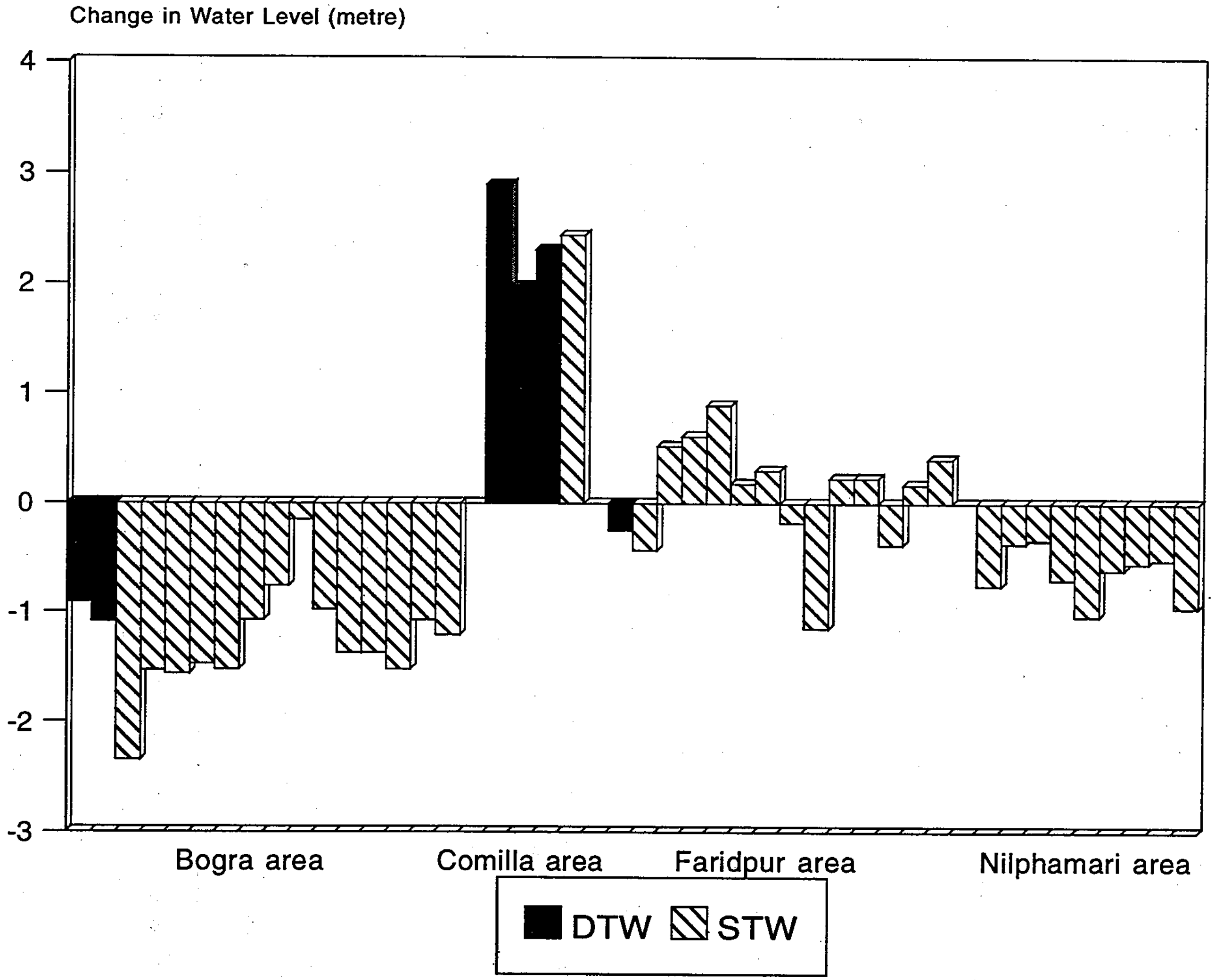
Table 7. *Pump owner actions in response to drawdown problems in any year(s) between 1989 and 1994.*

	DTW		STW		
Within the Season of Drawdown	n=9		n=45		
Increased pumping hours per day	7	(78%)	25	(56%)	
Deepset pump	-		17	(38%)	
Used water from adjacent pump	1	(11%)	-		
Supplied less water to all plots	2	(22%)	4	(9%)	
Temporarily stopped pumping	-		5	(11%)	**
Other actions	1	(11%)	9	(20%)	
In Year Subsequent to the Season of Drawdown (but still operating)	n=9		n=32		
Some farmers either stopped irrigating or switched to other pumps	5	(56%)	9	(28%)	
Average command area lost to such drop-outs	15.4 acres		5.9 acres		
Changed to higher capacity engine/pump	-		4	(13%)	
Other actions	4	(44%)	20	(63%)	
1994 pump owner/operators who chose to not operate in 1995 due, in part, to drawdown problems	1		2		

Note: Of the 5 STWs which were reported to have stopped, 4 of the occurrences were in 1994. All of these wells reported daily hours of pump operation throughout the relevant months during the season. Well stoppage is assumed, therefore, to have been a temporary phenomenon in these cases.

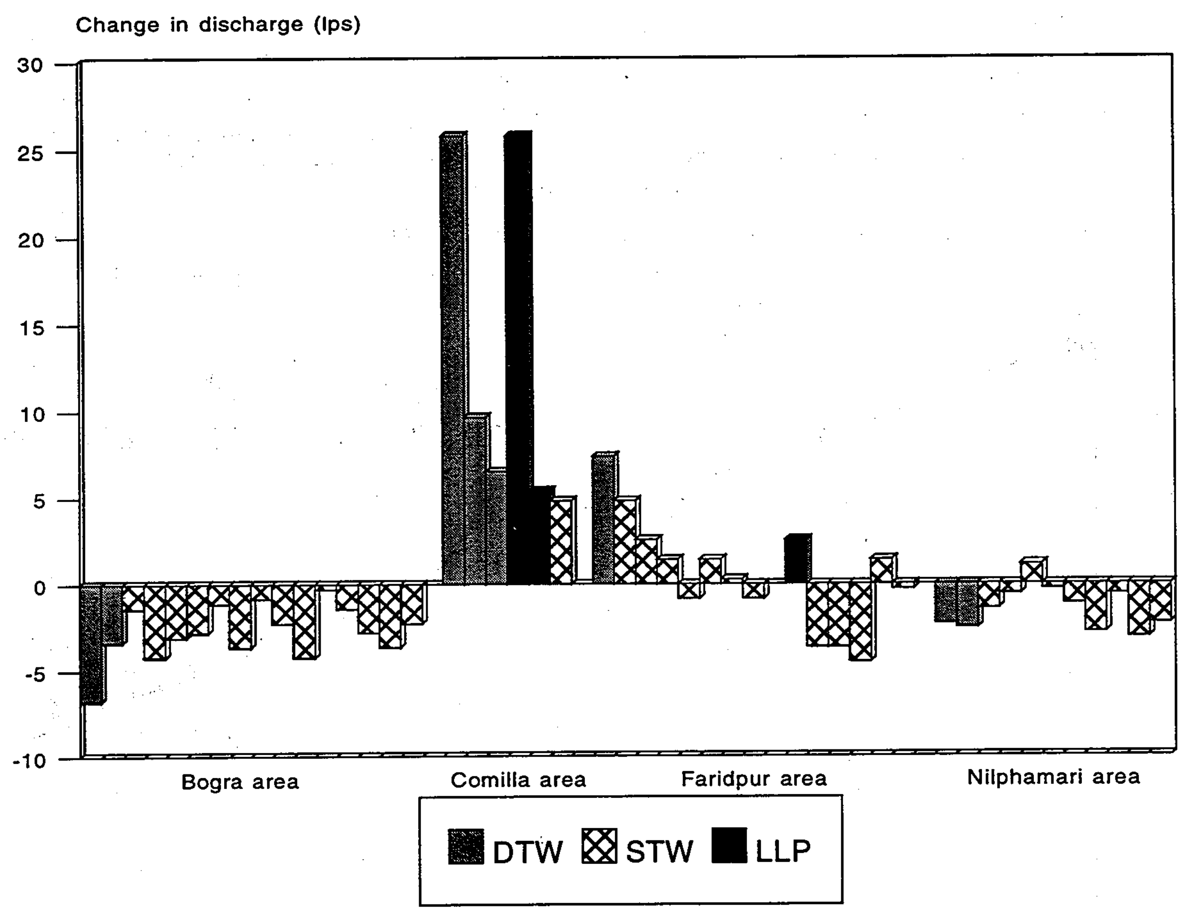
Source: 1994 IIMI/BSERT Pump Owner Sample in Bogra, Comilla, Faridpur, Hobiganj and Nilphamari districts.

Figure 1. Change in static water level during early and late boro seasons in 1994.



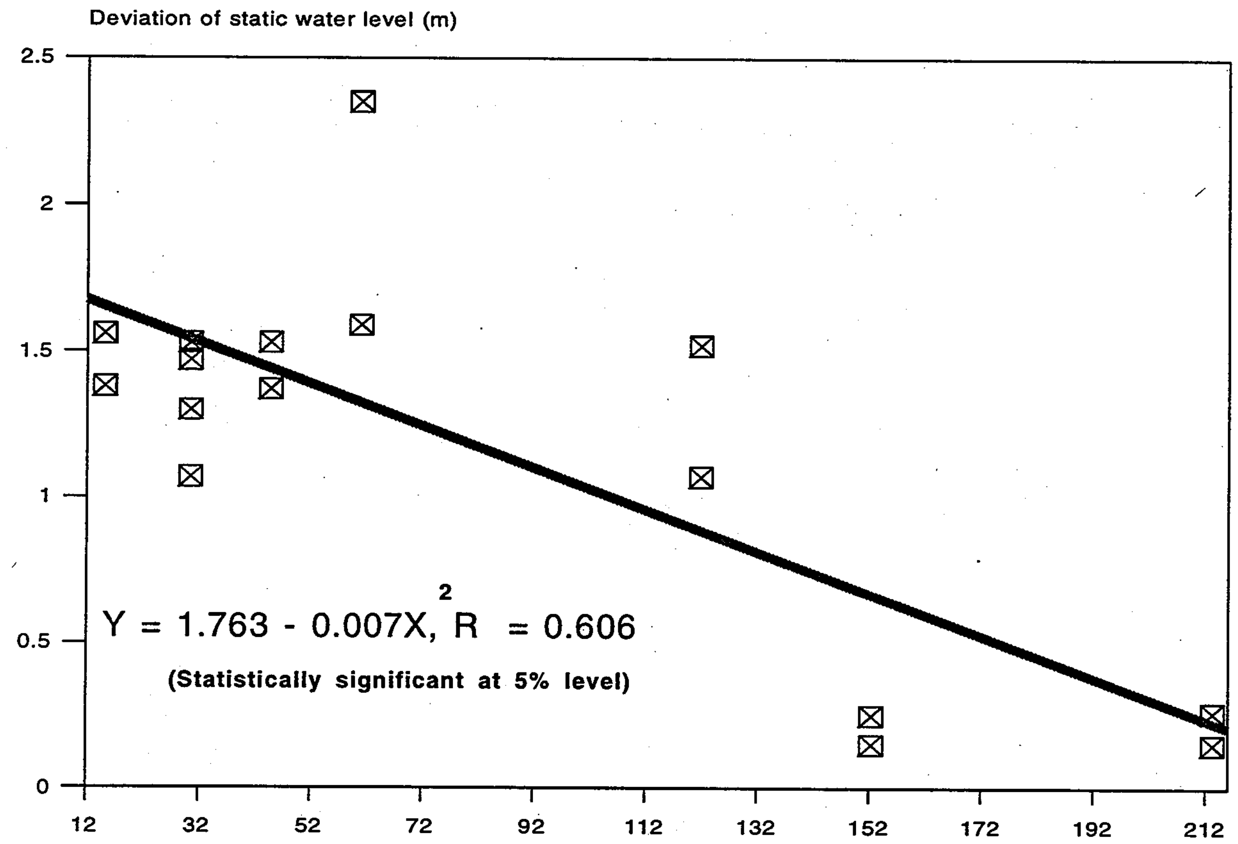
Source: 1994 IIMI/BSERT Field Measurements in Bogra, Comilla, Faridpur, Hobigonj and Nilphamari districts.

Figure 2. Change in pump discharge (lps) during early and late boro seasons in 1994.



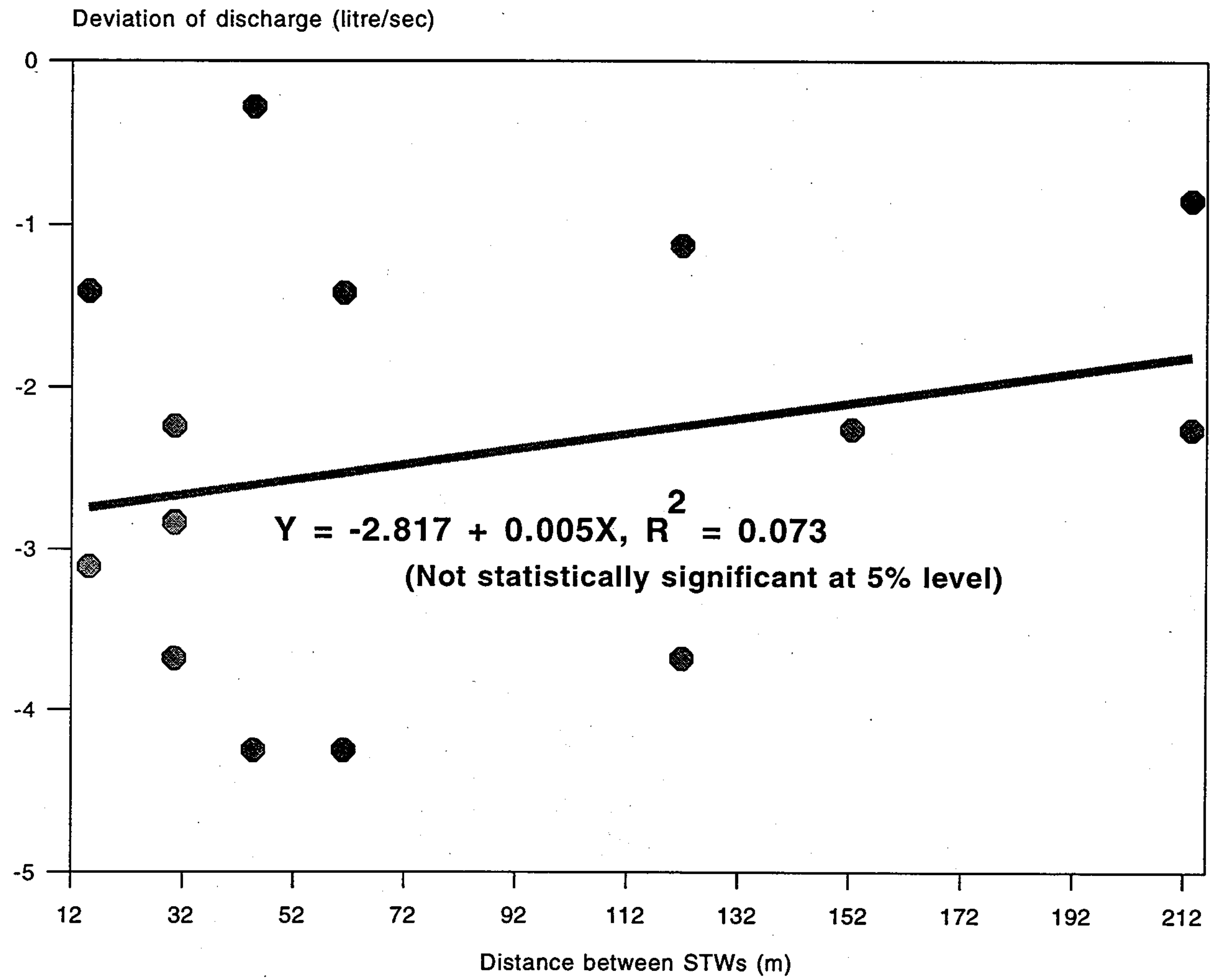
*Source:*1994 IIMI/BSERT Field Measurements in Bogra, Comilla, Faridpur,Hobigonj and Nilphamari districts.

Figure 3. *Distance between irrigation units and deviations in static water levels between early and late boro seasons in 1994 for 8 Bogra district pairs of closely-set STWs.*



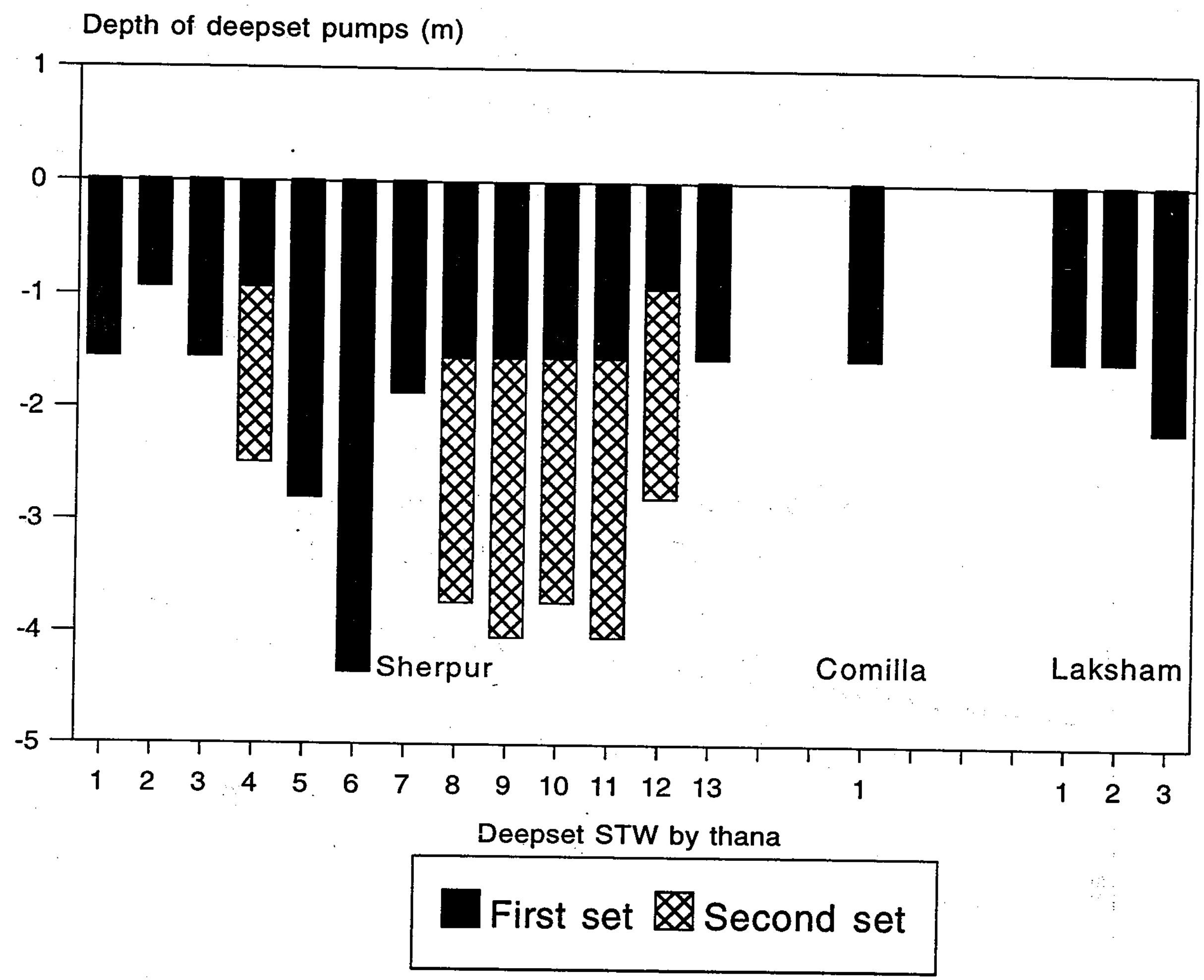
Source: 1994 IIMI/BSERT Field Measurements in Bogra, Comilla, Faridpur, Hobigonj Hobigonj and Nilphamari districts.

Figure 4. *Distance between irrigation units and deviations in discharge between early and late boro seasons in 1994 for 8 Bogra pairs of closely-set STWs.*



Source: 1994 IIMI/BSERT Field Measurements in Bogra, Comilla, Faridpur, Hobigonj and Nilphamari districts.

Figure 5. Depth of deep-set pumps in 1994 study areas.



*Source:*1994 IIMI/BSERT Field Measurements in Bogra, Comilla, Faridpur, Hobigonj and Nilphamari districts.

District- and Local-Level Markets for Minor Irrigation Equipment[43]

I. INTRODUCTION

The early growth of minor irrigation in Bangladesh involved a great deal of public agency action and support. Both the Bangladesh Water Development Board (BWDB) and the Bangladesh Agricultural Development Corporation (BADC) were major actors in this area. Their involvement (particularly that of BADC) was especially pronounced in the areas of equipment procurement, importation and distribution. With Government policy shifts towards a more privatized minor irrigation sector. The marketing activities has been transferred to the private sector. The major part of this move took place between 1979 and 1990. Private traders started dealing first with shallow tubewell (STW) and later low-lift pump (LLP). The Government dropped its equipment standardization rules for imports of allowing a wider range of engine sizes and qualities. Equipment importation restrictions were greatly eased. It can now be asked how the emerging privatized market is doing, what role prior policy shifts played in the market's development, what problems/constraint the market faces and what recommendations might be made towards the better functioning of the market.

II. Objectives

This paper will attempt to examine the minor irrigation equipment market that has emerged through the privatization policy shifts in the last fifteen to twenty years. The emphasis here will be on the domestic market at district and local levels.

Part of the intent is to ask how the market is now functioning—what are its strengths and problems? How well (in adequacy, timely availability, cost, quality/brand choice, etc.) is that market delivering minor irrigation equipment and spare parts? How competitive is the market and how well linked or integrated has it become in the context of the broader market for other agricultural inputs and products?

Another objective is to examine the growth of the minor irrigation equipment market at the district/local level and try to measure the impact of privatization policies on the development of that market. Here a note of caution should be appended. While the growth of market activities in the irrigation equipment distribution field has generally been ascribed to privatization, it is not always possible to associate each element of market development to particular privatization policy shift. The several relevant privatization policy decisions occurred over a number of years and each could be expected to have a lagged (and perhaps interacting) effect.

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[43]This paper has been prepared as part of the Study on Minor Irrigation Privatization in Bangladesh conducted by IIMI (the International Irrigation Management Institute) in association with the Ministry of Agriculture with funding from the Asian Development Bank. Research for the paper has been done by IIMI and BSERT (the Bureau of Socioeconomic Research and Training of BAU, the Bangladesh Agricultural University)—with D.E. Parker and S.K. Raha having been particularly associated with its preparation.

III. METHODOLOGY

The emphasis of this paper is on the experience of district and local level traders of minor irrigation equipment. A sample of traders was chosen from parts of the five districts that have been included in the broader study of minor irrigation privatization.[44] Of those districts, two (Bogra and Comilla) are relatively advanced in the development of their minor irrigation sectors and others (Nilphamari and Hobiganj) are comparatively late-comers to the minor irrigation scene. A fifth district, Faridpur, falls between these two groups in its minor irrigation development. In total there were 187 sample traders—63 in Bogra district, 34 in Comilla, 38 in Faridpur, 23 in Hobiganj and 29 in Nilphamari. Interviews using a set questionnaire were conducted in the month of May 1994, with a follow-up in February 1995. In addition some case study interviews were done in May and June of 1994.

The first interview enabled us to understand the traders' experience in 1993/94. As there was no baseline survey at the time of particular privatization we had to follow the recall method where we asked the respondents about the state of equipment business five years ago". Five years back i.e., 1988/89 when the market could not yet have the chance to fully respond to the 1987/88 policy changes affecting equipment standardization and import restrictions. To get some sense of changes that might, in part, be ascribed to the effects of privatization policies, respondents were asked various questions about the state of their business "five years ago."

IV. GROWTH AND TRENDS IN THE IRRIGATION EQUIPMENT MARKET

The recent growth pattern of minor irrigation equipment coverage in Bangladesh has been presented in Table 1. Among the different equipment STW recorded a sharp increase since 1987 (Table 1). It is but quite slow in LLP and almost stagnant in DTWs. This appears to be facilitated by the increase in the number of shops at district level where every year new shops numbering around 20 were established in the last six years (Table 2). Of the sampled equipment shops, two thirds started trading in irrigation materials from 1988 or later. The sharp jump in number of shops since 1988 is an outcome of policy changes to only import liberalization in 1987/88 particularly with respect to chinese engines. These engines were much cheaper (though often less durable) than what had previously been permitted for import and thus STWs and LLPs became affordable to a much larger number of farmers. The district and local market appear to respond quite favourably to the new opportunities for business.

The growth in the number traders has been noted in all sample districts and particularly so in the districts previously less developed in minor irrigation. In Figure 1 the yearwise establishment of shop in the study can be seen. Almost all existing shops in Hobiganj and Nilphamari were started after 1987. The historically more advanced (in minor irrigation) districts already had a minimum traders support prior to 1988—though these districts also recorded a surge of businesses after the liberalization of import and standardization restrictions. The change in Government policy seems to have been a major catalyst in expanding minor irrigation in the country.

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[44] For details about sampling methodology see the paper from this study on Study Background, Organization and General Methodology.

A note should be made regarding deep tubewell (DTW) equipment. Virtually all the growth in the equipment market has been in relation to trade in STW, LLP and manually operated machines and supplies and not at all due to deep tubewells (DTWs). DTWs installed after 1988 were highly subsidized and were still distributed by the BADC's. While BADC stopped distributing DTWs there has not been a move by the private market. The job is actually expected to be performed by the Ministry of Agriculture through its agency called National Minor Irrigation Development Project (NMIDP) which however did not succeed in its venture. As DTW equipment is no longer subsidized it appears that farmers are least interest in such an investment at this traders do not have incentives in its market.

4.1 Changes in Supply Sources and Delivery

With the privatization, private market for irrigation equipment has rapidly developed specially after 1988 when wholesales started gathering at the district level. Their functioning improved more from the survey year when wholesalers as distinct from importers supplied 25 percent of the engines and motors to traders (compared to 54% of spare parts (vs 50%). past), 57% of Accompanying this modest shift improvement in the accessibility or proximity of traders' suppliers has also been noted. Roughly half of the sample traders opinioned that their suppliers became more accessible than five years before. The other half reported no change. The traders received their ordered engines/motors within two days (compared to 3 days five years). Supplies for pipe orders in quickened although pump and spare parts seemed to have remained almost unchanged.

Of the traders interviewed in early 1995, fifty (a quarter) had changed their suppliers since 1994. The moves were generally to take advantage of competitive conditions such as better prices. Furthermore, traders choices for suitable increased as revealed from the changed in the suppliers increased as revealed from the changes in the suppliers. These changes were mainly due to better price (40 cases), credit offers (20) and closer proximity (8) although distrust of the old supplier (17) also played a part. Those who stayed with their old suppliers did so primarily because of their satisfactory relationship with the supplier and the availability of credit. This possibility towards changes of suppliers indicate more competition in the equipment market.

4.2 Changes in the Equipment Supplies

Equipment dealers reported few problems in the availability of supplies of irrigation equipment or market information (Table 4). Availability of engines, motors and pumps, and supplies of pipes, filters and spare parts improved at present (with the exception of 6" pumps). Improvements have also been indicated by an increase in the number of brands sold. Among shops selling engines there was an increase in the number of engine brands rising from a medium of 3 in 1988/89 to 5 in 1993/94. Traders were also of the opinion that supplies of various kinds of equipment increased in recent years.

In the post privatization period low capacity engines and motors become more popular as clearly visible from their increased sales. Small engines (up to 3 HP) grew from 10 percent in 88/89 to 27 percent in 93/94 i.e. about three times mostly at the cost of the share of 8-12 HP engines. Similarly small

5-7.5 HP electric motors for irrigation grew from 26 percent in 88/89 to 44 percent in 93/94 i.e., about double (with large motors above 15 HP showing a decline). And for pumps, the small 3" models grew from 22 percent of the market to 36 percent (Table 5).

Despite such changes in the scaled equipment sales there seems to have been little changes among sample traders in the equipment mix sold by their shops. Further examination of the equipment mix in the shops finds little change. The proportion of shops offering (variously) engines, motors, pumps, pipes, filters, spare parts, etc. remain almost same in both the period of 1988/89 and 1993/94 although overtime absolute number of shops increased considerably. The direct customers to whom the traders sold their goods also remained stable. The farmer customers accounted for an average increase of 75 to 80 percent. Sales price was slightly higher (4%) to farmers than to other traders. In both the periods roughly half of the transactions were with the locals coming from the same thana one third from other thanas in the same district and the remainders from outside. This suggests that the district shops are serving more to the nearby localities.

V. PRESENT MARKET STATUS

5.1 Background of Traders

A snapshot of sample trader characteristics shows that 90 percent had at least a secondary school education (Class VI to SSC Passed) and 50 percent reached higher secondary school and above (Table 6). Roughly half had some sort of prior business experiences some in irrigation equipment as well. The equipment shops are largely owned by a single person (90%). Roughly half of them were retail dealers while the other half had both retail and wholesale business. A few case study interviews are presented below in order to convey a better sense of the development and prospects of equipment traders:

5.2 Evolution of an Engine Trader--Bogra District

M. opened the shop in 1989, after having managed a drug store for thirty years. When he first opened the medicine shop there was only one other shop in town. However, at the end the of the eighties there were many more shops and everyone is doing reasonably well. He considered that, with the increase in minor irrigation in the Bogra region investment in retailing irrigation equipment would give him a better prospect. Nobody helped him to set up the business. He started on his own on the basis of discussion held with the retailers and equipment importers in Dhaka.

He started doing business with two Dhaka importers/wholesalers and bought a number of Chinese engines from them. He decided to sell Chinese engines because the Japanese engines are much more expensive. M. still works with these two importers and has developed a good relationship with them. Some of the machines he buys from them can be paid on credit (109-20%), the rest is paid in cash.

M. sold 50-60 engines in the first year of the business. This year (1994) he sold 150 engines, while the total number of engines sold over the last 5 years is about 800-900. His business is expanding without any motivational work or publicity. This is due to both the expansion of irrigation coverage in the

Bogra area, and the goodwill he has created among his customers. At present there are two shops even in his thana town that sell engines. Each has approximately 50 percent of the market. In addition, there are 10 shops that sell spare parts and 2 workshops that sell second-hand irrigation engines.

At the same time when M. started to sell the engines, he also started selling CI sheets, which are used for roofing. The demand for irrigation equipment is very seasonal, so CI sheets guarantee him an income beyond the irrigation season. He recently started selling power tillers, but doesn't want to sell spare parts because these are small items and they need careful handling and personal attention.

At the moment he markets 5 different Chinese makes, as well as different models (HP: 6-8-12 and 16) of each of these makes. He does not want to increase the number of brands, because he has the main brands the farmers demand. Farmers know what they want as they hear from their neighbors about their experiences with the different makes and models. There is actually very little difference between the different makes of the similar HP, both in terms of quality and price (100-200 Tk).

Engine price is determined by the purchase price, the transport costs from Dhaka to his town and some profit (200-300 Tk per engine). He sometimes discounts as farmers try to buy the engine at the cheapest price. Some farmers even go to Bogra to compare prices. M. doesn't discriminate among the farmers. All are eligible to some price and discount.

In every village in the Bogra region there are a large number of engines. M. reports that after a few years these engines need to be replaced, so in the future there will be a demand for new engines. The only constraint to further development of his business is access to credit. He cannot obtain the required amount of loan as there are always additional costs. Bankers don't ask for bribes directly, but without such payment credit processing takes a long time. Except for facilitating access to credit, he doesn't see any further role for the government in the expansion of minor irrigation development.

5.3 Growth of a Spare Parts cum Grocery Shop

The interview was with Mr. Z, the owner of a small grocery shop reveals that he also sells spare parts, pipes and mobil. The shop is a family business that started about half a century ago. Two years ago they started selling spare parts. Some of their regular customers suggested that they sell spare parts as otherwise they had to go to Sayedpur if they needed a part. Following this suggestion they decided to stop selling pulses and opened the spare part business. They were quite glad that they had found an alternative to selling pulses because the market for pulses is very competitive, and they always had to sell the pulses on credit, which causes a problem with readily available cash. Although the spare parts business is also competitive, its advantage is that most customers will pay for them by cash.

In the first year they purchased their spare parts from wholesalers/retailers in Sayedpur, but some customers informed him that spare parts are cheaper in Bogra and that he should purchase then from there. From his customers he obtained the names of a few wholesalers in Bogra. At present he purchases most of his parts from Bogra. Occasionally, in times of acute shortage, he buys them from Sayedpur. He only buys non-local parts (non-Bogra) as these are demanded by his customers. When he started selling spare parts he had very little knowledge about the technical aspects of irrigation equipment, but his customers suggested him what they needed.

Of the total value of parts he sells, 85 percent to 90 percent are sold for cash, the rest are sold on credit. Last year he sold spare parts worth Tk 40,000. Among his customers there are three big pump owners who own three engines each. They buy mobil from him.

The family business is a grocery business, and they want to continue with it, implying that they are not interested in any form of specialization. An expansion of the spare parts business is possible to the extent it does not affect the grocery. Still, there is scope for further expansion of the spare parts business because there is sufficient demand. But they require credit support from the wholesalers and in the case of such support they may sell small engines, as well. He is not interested in taking bank loan, which according to him makes him 'bonded' to the bank.

5.4 Establishment of an Engines and Spare Parts Shop

Md is still a student studying MA at Dhaka University and also operating his own engine and spare parts store. He started his shop three years ago. He owns the shop himself, but had financial help from one of his brothers who is in the brick manufacturing business.

The initial capital was Tk 1,000,000, of which 50 percent was used to buy spare parts and 50 percent to buy engines. He was able to obtain a Tk 5 lakh loan from the bank, using land collateral in the name of his father. His brother supported him with the remaining 5 lakhs. He has not increased the amount of the loan, but it has become a kind of rolling loan. Occasionally he has difficulties in paying his installment, but that has not affected his relationship with the bank.

Md buys all his engines from importers in Dhaka, which is easy as he is studying in Dhaka. Moreover, the prices of engine are cheaper in Dhaka. Normally he buys from two different importers and always pays. In most cases he places orders by telephone and pay the importers by telegraphic money transfers. Md buys his spare parts from five different shops in Dhaka.

The first year he sold about 300 engines and in the following two years it decreased 200. The declines is due to larger competition among the dealers in the area. He does not use a sales agent; the farmers come directly to his shop. Md employs a mechanic who also works independently in sometimes that he cannot offer the mechanic sufficient work. Usually a farmer who buys an engine from his shop uses his mechanic's services.

He believes that within a few years the engine business will go down because of the saturation of engines in the area. Within a few years every household will have its own engine. But still, there will always be a market for spare parts and for replacement of every 3 years. However, he has confidence in his future as engines are becoming cheaper which creates new market.

5.5 Scale of Business

The dealer operating in a district had a fairly modest size of trade in minor irrigation hardware. Table 7 shows the number of engines, motors and pumps sold per shop in each study district in 1993/94. As expected given the district's reputation as a regional growth center for minor irrigation, Bogra did a good deal of business. Of the latecomer districts, Hobiganj still shows a very small level of sales per shop but

Nilphamari traders are now generally on a par with those in Comilla and Faridpur. In the case of motors the progressive districts (Bogra and Comilla) are doing better.

In the reinterview with traders in February 1995 it was found that business for most traders was much better in 1994/95 than in 1993/94. In the year 1994 total sales of engines increased by about 150 percent to 22,501 engines. This increased was despite an average price rise of 38 percent. Motors increased from 264 to 1,063 and pumps grew from 12,444 in 1993/94 to 34,781 i.e. about three time in 1994/95. Much of this growth was concentrated in Bogra, Faridpur and Nilphamari districts rather than in Comilla and Hobiganj.

5.6 Degree of Competition

One of the main concerns of privatization of the minor irrigation equipment market is that the markets for equipment may overtime become monopolistic and thus prices may rise abnormally. The evidence is quite contrary. The number of shops increased quite rapidly in all districts specially in Habiganj and Nilphamari where irrigation started later (Figure 1). But the size of business is not large except Bogra. Annual transaction in all the districts except Bogra is low, the average being 240 pieces i.e. less than one in one working day. The number of shops in each district has been found to have grown dramatically specially in Habiganj and Nilphamari since 1988 (Figure 1). The typical shop is, itself, not very large in the amount of business it does (Table 7). These two factors could be expected to enhance competitive behaviour.

The indepth examination of the sales of engines and pump dealers, shows that the market share of the top three shops (for each of the items) in each district was quite high in 1993/94 (Table 8). Even in the established districts of Bogra and Comilla the concentration ratio (market share of the top three traders) is above 0.40—and the ratio ranges up close to 0.90 in Hobiganj and also in Faridpur for motors which was due to a fewer number of traders functioning these. Such a high concentration ratio would in some types of industry indicates the scope for oligopolistic pricing if not out-right monopolistic behavior.

That oligopolistic potential, however, would appear to be negated by the openness of the boundaries around the district minor irrigation markets. Traders are aware that potential engine/motor/pump customers often check the market prices in Dhaka or in regional centers such as Bogra. Some farmers make their engine purchases from these distant markets if they find them at a lower price. As a result, district and local level traders are to compete in a much wider market than their own districts. The large district traders are relatively small actors when examined in the context of this larger regional or national market. In this larger market the district traders are competitors, with very little scope for oligopolistic or monopolistic pricing.

The degree as the level of competition can be seen in the sales margin of engine traders. The traders' sales margin in 1993/94 (markup percentage of sales price over purchase price and transport cost) in all districts was very low for a piece of capital equipment such as an engine (Table 9). The average margin to an engine trader in peak demand periods (just before the beginning of boro season) was 4.9 percent and it declined to 3.8 percent in slack period such a pattern does not follow uniformly in all the districts. For example, Hobiganj, which had the highest concentration ratio for traders, recorded a margin of 15.4 percent sales by engine trader in peak time and a 12.3 percent margin in non-peak

times.[45] Higher margin appears to be due to its isolated locatio and poor communication system. In the following year of 1994/95 the sales margin remained almost on the same level. At Hobigang it however, declined. The estimated margin of about 4 percent appears to be quite reasonable. Most of the traders understandably are using a system of frequent ordering and quick inventory. During the main four month sales period for irrigation equipment (November through February) the average engine trader was able to turn over supply orders so frequently so as to make a return of 40 percent on inventory funds. Given that some traders deal in much higher volumes than other the average return per taka of inventory funds was 52 percent. Such returns are upto expected level despite the competitive nature of pricing and margins.

In February 1995 traders were again asked information from which margins could be calculated were also asked about the frequency of their supply orders and the turnover of their capital. In 1994/95 the margins had still been in the same range as the year before though Hobiganj no longer had a higher figure than the other districts. These margins of roughly 3 percent do seem to be small.

5.7 Market Linkages

One indicator of a product market's maturity is the extent to which it linked to related products. Are the same or connected marketing channels used to distribute the related products? Are marketing channels for complementary products growing at the same pace or is lack of development in the distribution of one product holding back the market for another product?

Among the 1987 sample irrigation equipment traders, 15 percent also sold power tillers, 19 percent sold other agricultural machinery and 3 percent sold fertilizer all these are complementary inputs to irrigated agriculture. In addition there are two fifths of traders who sold non-agricultural goods. The relationship between various forms of agricultural machinery (and even the mechanical portion of the non-agricultural goods) is a natural one based on the expertise of the traders and their sources of supply. Diesel (which was not sold in any of the irrigation equipment shops) and fertilizer, on the other hand, depend on very different supply channels even though their use in irrigated agriculture is closely related to irrigation equipment.[46] Among equipment traders, however, 44 percent of the respondents identified an increase in sales of complementary agricultural inputs that could help expansion of their own business.

5.8 Customer Services

Ninety percent of the sample traders sold their irrigation equipment on credit at least partially. Of the traders' total sales, however, only 23 percent was on credit and 77 percent in cash. In case of credit

[45]The difference between Hobiganj's margins per trader and those of all the other sample districts was statistically significant at the .05 level during non-peak periods. The difference was significant between Hobiganj and only Bogra, Comilla and Faridpur during peak times.

[46]A discussion of complementary input traders dealing in diesel/mobil and fertilizers/pesticides is included in the paper in this volume on Support Services for Minor Irrigation.

sales traders charged marginally higher price of about 2 percent over the case sales. Sales through commission agents were very rare.

Warranties were offered by only 27 percent of engine/motor dealers and less than one quarter of those warranties were in writing. Of the warranties offered, 18 percent covered replacement of engine/motor while 82 percent were for repairs if needed. A small number of customers made use of these warranties (an average of 8 per warranty-offering trader over the past two years). These traders are in general agreement with those derived from sample pump owners. Of 131 sample STW owners in the five study districts only 11 (or 8%) had a written warranty while 48 (37%) had a verbal one (1). Ten or one-sixth claimed that they had made use of the warranty conditions, and they were reported satisfied that the warranty conditions were fulfilled by the traders.

Thirty seven or one-fifth of engine/motor traders claimed to extend after sales service. One third of those making such an offer provided mechanical service and two thirds ensured spare parts for the specific engine sold. Among 131 sample STW owners, however, only 21 (16%) reported that their traders had promised after sales service which largely include mechanical services and sale of spare parts. About half of the promise bound offered after sales service and a few alleged that they had to pay for such services.

To increase the size of business the most common measure taken by minor irrigation equipment dealers was discounting sales price. Price discounts were, at times, offered by 61 percent of the sample traders but it rose to 82 percent in Hobiganj and Nilphamari. It is unclear whether this distinction is due to growing competition in these two districts or are due to wider sales margin claimed by the traders earlier.

5.9 Investment in Shop and Inventory

The average investment in current inventory equipment traders was 353,000 Taka though the median was only 125,000 and the range was from 1,000 to 7 lakhs Taka (Table 10). Two thirds of the invested sum was self financed and the remaining was on credit either from equipment suppliers or from banks. According to our estimate suppliers credit supports amount to 16 percent of the current investment and 13 percent from banks (Table 11).

Traders' initial forms of investment in shop and equipment at the time of starting their business was somewhat different. The average initial investment was 229,000 Taka in inventory (median of 60,000 Tk) and 102,000 Tk in the shop (30,000 Tk median).[47] At that time over 72 percent was from own funds (primarily from savings but partly by property mortgage), 8 percent from suppliers, 9 percent from banks and 8 percent from non-institutional sources of credit. As expected, it appears that established credit sources (banks and suppliers) are somewhat willing more to extend credit once a shop is well established. They are but more hesitant to help a starting business.

Credit from non-institutional sources (at least if it was from non-relatives) was expensive; averaging an interest of 25-27 percent for those sample farmers using it. Credit from banks costs 15 or 16 percent in interest. The traders, interviewed through informal case studies however noted the prevalence of extra

[47]Given their various dates of establishment, their different product mixes and the different rates of price change which would apply to those products, it is difficult to say how much current inventory has changed from initial inventory levels in real terms.

costs for bank credit.[48] The amount of bureaucratic hassle and various non-official charges are often attached to the loan. These costs raise the effective interest rate of bank credit to the range existing range for non-institutional credit (from non-relatives). Of the non-borrowers of the bank loan owing to lack of collateral but quite a large number mentioned of its complex formalities (78%).

5.10 Constraints to Expansion and the Need for Support Services

To report the major constraints to expansion traders mentioned of a. lack of fund and b. inadequate bank support. In fact, survey results indicate that these are considered more important that all other problems. The overwhelming number of traders (87%) identified shortage of capital as a principal constraint and it remains so for most of the aspirants. Business expansion is also limited by credit constraint.

Another major area of concern by traders is inadequate workshop and repair facilities. This is a particularly so to the new comers in the districts of Hobiganj and Nilphamari where roughly two thirds in of trader respondents mentioned of this constraint. By contrast, traders in the more irrigation-developed districts of Bogra and Comilla did not report such a problem.

Technical information and the related advice about irrigation equipment was also a highly desired service as identified by about half of the traders. This expected service was considerably higher in Faridpur (74%) and Nilphamari (69%), the low developed areas in irrigation.

Transport and communications difficulties considered to be important only in Hobiganj where all of them reported it as a major problem. The lack of infrastructure in Hobiganj would appear to be seen as a major inhibitor of growth in minor irrigation and the traders' business.

5.11 Looking to the Future

To understand the future market of the equipment traders were asked about their views. Almost all the respondents were optimistic, expecting that market will expand at least moderately. This has been revealed from informal case studies conducted among a number of traders. This is based on: a) a perception of further expansion of minor irrigation; b) a growing demand for replacement of old engines and the use of spare parts; and c) an increasing use of engines for non-irrigation purposes (such as rice husking, country boats, power tillers, etc.). Traders also felt that other (non-irrigation) forms of agricultural mechanization will also enhance their business.

In some areas, however, there was concern about the general profitability of irrigated agriculture particularly relating to rice. The price of rice in recent years has been quite low compared to prices of various modern agricultural inputs. A continued price fall of rice may cause a decrease in demand for irrigation equipment.

[48]See the credit section in the paper in this volume on Support Services for Minor Irrigation.

VI. CONCLUSIONS AND RECOMMENDATIONS

The market for irrigation equipment at the district and below seems to be fairly healthy. This market has shown a great deal of vitality starting with the liberalization of Government restrictions relating to standardization and imports. The privatization policy in the equipment market appears to be paying off with a large growth in the number of shops, improvements in supply channels and an enhancing capacity of marketing to cater to the needs of a variety of equipment (pertaining to scale). This market development has taken place in a rather competitive way. The number and size of the shops and the low level of their sales margins tend to suggest that monopolistic behavior is almost absent in the district and local equipment markets. The market linkages in both agricultural input and outputs is being established.

The favourably market development however, does not mean that there are no problems or constraints. Inaccessibility to credit would appear to be one such problem. In the districts which are relatively late-comers in minor irrigation there seem also to have a shortage of repair and workshop facilities. Many traders specially non engineers emphasize the need for more and better technical information about equipment. After-sales service for customers (via the use of warranties, etc.) is underdeveloped. So far traders have not attempted to sell DTWs may be there is little scope for sales of this expensive technology without subsidy.

The observed development of the minor irrigation equipment market since 1987/88 has been mainly due to liberalization of imports and standardization restrictions followed earlier. Future growth of this market in the country is country is however dependent on a continuation if the existing Government's privatization policy. There are, however, some areas where policy changes may facilitate efficient functioning of equipment markets. They are:

a. Traders access to institutional credit should be improved;

b. Programs to facilitate the extension of mechanical services to areas which have not a long history of minor irrigation will be useful. Training of mechanics can also help especially in DTW repairs and the workshops facilitates dealings in larger engines and submersible pumps.

c. Information network especially pertaining to technical aspects of irrigation equipment, would be useful to traders. Such services are unlikely to be rapidly developed in the private market without states.

d. As the use of minor irrigation equipment continues newer problems may crop up in the future. Information about local aquifers, possible installation of deep-set STWs, etc. is likely to become more and more useful to traders and pump owners.

Table 1. Total area irrigated by different irrigation technologies from 1982-83 to 1992-93 in Bangladesh.

Years	Area Irrigated ('000 ha)					
	STW	DTW	LLP	TRADITIONAL	CANAL	TOTAL
1982-83	371.5	234.3	337.1	405.5	160.3	1508.7
1983-84	480.0	263.2	342.0	372.3	136.4	1593.8
1984-85	586.4	286.9	351.3	384.1	147.3	1756.0
1984-86	586.4	303.9	356.1	314.0	163.1	1723.5
1986-87	639.4	317.7	385.7	326.2	155.4	1824.4
1987-88	753.1	344.8	401.8	433.4	114.9	2048.0
1988-89	941.3	380.4	482.4	391.3	169.6	2365.0
1989-90	1037.2	384.1	484.0	477.9	176.4	2559.6
1990-91	1078.5	365.4	513.1	498.2	172.8	2628.0
1991-92	1233.9	433.8	500.2	316.5	172.8	2657.2
1992-93	1392.1	436.7	496.2	322.9	172.8	2820.7

Note: These calculations are based on assumed average command areas of 4 ha per STW, 17 ha per DTW and 9.5 ha per LLP. This assumption may be somewhat unrealistic in that the average command areas per unit of equipment are very likely to have declined over the years due to: a) competition (or encroachment) for irrigable plots between units; and b) the introduction of smaller engines for use with both STWs and LLPs in recent years.

Source: David, W. 1994. Minor Irrigation Development in Bangladesh. Background Paper No. 4. Paper presented at the DAE/ATIA workshop on Research to Promote Intensive Irrigated Agriculture. Khamarbari, Dhaka.

Table 2. Year of establishment of sample irrigation equipment shops.

	Districts				
	Bogra	Comilla	Faridpur	Habiganj	Nilphamari
1965					
1971					
1972					
1974					
1975					
1976					
1977					
1978					
1979					
1980					
1981					
1982					
1983					
1984					
1985					
1986					
1987					
1988					
1989					
1990					
1991					
1992					
1993					
1994					

Source: IIMI/BSERT 1994 survey of traders in Bogra, Comilla, Faridpur, Hobiganj and Nilphamari districts.

Table 3. *Growth in shops dealing in different types of minor irrigation equipment: 1988/89 to 1993/94.*

	Number of shops 1988/89	Number of shops 1993/94	Increase in 1993/94 (%)
Engines/motors	35	69	197
Pumps	36	65	180
Pipes	37	84	227
Filters	36	75	208
Hand tubewells	26	55	212
Treadle pumps	13	38	292
Spare parts	69	139	201

Source: IIMI/BSERT 1994 survey of traders in Bogra, Comilla, Faridpur, Hobiganj and Nilphamari districts.

Table 4. *Availability of irrigation equipment supply and market information: Percentage of trader responses.*

	Easily available	Not easily available	More available than 5 years ago	Same availability as 5 years ago	Less available than 5 years ago
Engines:					
3HP	97	3	76	13	11
4-6HP	95	5	73	18	9
8-12HP	97	3	68	21	11
12+HP	89	11	74	21	5
Motors:					
5-7.5HP	92	7	7	27	0
10-15HP	86	14	75	25	0
15+HP	69	31	58	34	8
Pumps:					
3"	97	3	75	18	7
4"	95	5	74	21	5
5"	91	9	70	25	5
6" or more	41	56	33	24	43
Pipe/filter	98	2	71	11	18
Spare Parts	97	3	82	15	3
Market Information	97	3	42	51	7

Source: IIMI/BSERT 1994 survey of traders in Bogra, Comilla, Faridpur, Hobiganj and Nilphamari districts.

Table 5. Equipment scale as a percentage of equipment sold: Sample traders in 1988/89 and 1993/94.

	1988/89	1993/94	Percent change in 1993/94
Engines:			
3HP or less	10	27	270
4-6HP	36	32	89
8-12HP	37	26	70
More than 12HP	17	15	88
Motors:			
5-7.5HP	26	44	169
10-15HP	32	31	97
More than 15HP	42	25	60
Pumps:			
3"	22	36	64
4"	55	41	74
5"	20	22	110
6" or more	3	1	33

Source: IIMI/BSERT 1994 survey of traders in Bogra, Comilla, Faridpur, Hobiganj and Nilphamari districts.

Table 6. Basic characteristics of traders.

Education Level	
Illiterate	2
Primary	8
Secondary	40
Higher Secondary	23
Graduate and above	
Prior Occupation	10
Agriculture	18
Service	12
Same type business but	8
different shop	28
Same shop but different	4
business	2
Mechanic	18
Employee of a machinery shop	
Others	
Shop Ownership	
Single	90
Partnership	10
Number of Shops Owned	96
One	3
Two	1
Four	
Type of Trader	
Retail only	46
Retail and some wholesale	53
Wholesale only	1

Source: IIMI/BSERT 1994 survey of traders in Bogra, Comilla, Faridpur, Hobiganj and Nilphamari districts.

Table 7. Scale of business in 1993/94 for traders of engines, motors or pumps.

	Median	Mean	Min.	Max	N
Number of engines sold (if any)					
Bogra	235	388	24	1,150	24
Comilla	53	88	8	400	8
Faridpur	37	69	2	340	2
Hobiganj	27	46	4	155	4
Nilphamari	41	50	30	82	30
All	61	142	2	1,150	68
Number of motors sold (if any)					
Bogra	70	70	70	70	1
Comilla	18	28	6	6	6
Faridpur	3	6	1	1	5
All	12	22	1	1	12
Number of pumps sold (if any)					
Bogra	420	503	19	1,400	17
Comilla	68	114	16	400	22
Faridpur	59	70	9	215	12
Hobiganj	18	51	5	170	6
Nilphamari	86	64	42	82	4
All		204	5	1,400	61

Note: Some (but not all) traders sold a combination of engines, motors and pumps.

Source: IIMI/BSERT 1994 survey of traders in Bogra, Comilla, Faridpur, Hobiganj and Nilphamari districts.

Table 8. Concentration ratios of minor irrigation equipment traders in 1993/94.

	Engines: Ratio of three largest traders' sales to total sales	Motors: Ratio of three largest traders' sales to total sales	Pumps: Ratio of three largest traders' sales to total sales
Bogra	.474	----	.421
Comilla	.402	.810	.388
Faridpur	.561	.982	.524
Hobiganj	.867	----	.893
Nilphamari	.586	----	.835

Source: IIMI/BSERT 1994 survey of traders in Bogra, Comilla, Faridpur, Hobiganj and Nilphamari districts.

Table 9. Traders' sales margins on engines during peak and slack times.

	Peak period%	Slack period
Bogra	3.2	2.1
Comilla	4.2	3.8
Faridpur	1.4	1.3
Hobiganj	15.4	12.3
Nilphamari	7.6	4.3
All districts	4.9	3.8

Source: IIMI/BSERT 1994 survey of traders in Bogra, Comilla, Faridpur, Hobiganj and Nilphamari districts.

Table 10. *Investment in irrigation equipment businesses of sample traders.*

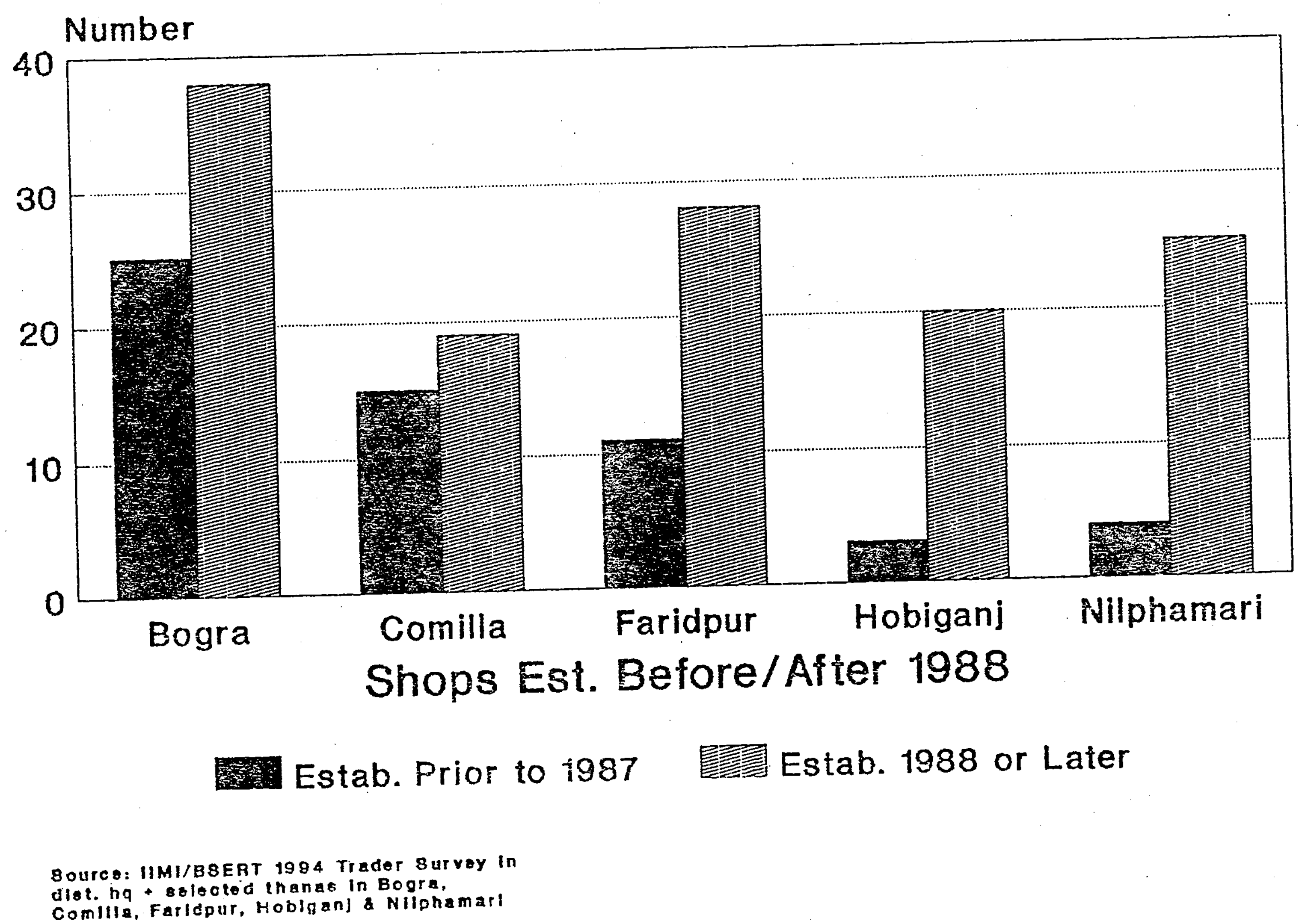
Type of investment	Taka		
	Mean	Median	Range
Initial inventory	229,183	60,000	1500-2000,000
Cost for shop construction	101,899	30,000	200-300,000
Current inventory cost	352,580	125,000	100-700,000

Table 11. *Sources of investment funds.*

Source of funding	Initial inventory and shop(%)	Current inventory(%)
Own funds	73	66
Suppliers inventory credit	8	16
Bank credit	9	13
Non-institutional credit	8	4
Unidentified	2	1

Source: IIMI/BSERT 1994 survey of traders in Bogra, Comilla, Faridpur, Hobiganj and Nilphamari districts.

Figure 1. Shops started before/after import/standardization easing in 1988.



Support Services for Minor Irrigation[49]

1.0 INTRODUCTION

The success of minor irrigation and the sustainability of irrigated agriculture in Bangladesh depend on the efficient supply of an array of important inputs and support services. In addition to irrigation equipment, there are needs for fuel and electricity to drive the engines and motors, mechanical services, credit delivery, fertilizers, pesticides, output marketing, transportation and storage facilities, and agricultural and irrigation extension services. Almost all of these inputs and services were previously provided by public sector agencies. Since the early eighties, however, the private sector has gradually taken over the provision of minor irrigation equipment, fuel, fertilizers and pesticides. During this time the mainstream irrigation agency, BADC (Bangladesh Agricultural Development Corporation), also gradually phased out its own provision of spare parts supplies, mechanical services and fuel to irrigation pump owners as well as its supply of fertilizer to farmers. Agricultural credit, extension services and electricity supply are still in the domain of the government.

Major issues of relevance to an examination of irrigation support services include:

a) How efficiently are inputs and services being delivered?
b) What have been the consequences of the shift of activity between the public and private sectors?
c) What constraints confront efforts to improve support services and what can be done to improve existing services and to develop needed new support activities?

This paper attempts to address these issues based on evidence collected primarily through district and thana level field surveys, supplemented to some extent by national information. Both suppliers and users of irrigation-related inputs and support services have been sampled—including pump owners, irrigator farmers, irrigation and equipment traders and rural mechanics. In addition, interviews and discussions have been conducted with officers of a number of agencies providing various irrigation related support services.

As with other parts of the overall study project on minor irrigation privatization, the emphasis in this paper is on the district and local level experience. The major irrigation related support services addressed in this report are credit, input supplies and mechanical services—and to a lesser extent agricultural extension, training, aquifer and other irrigation information, organizational support for irrigation group formation, electricity provision, and insurance facilities for irrigation equipment. The market for irrigation equipment is discussed in a separate paper.

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2.0 PROVISION OF CREDIT FOR MINOR IRRIGATION EQUIPMENT

The supply of timely, adequate and affordable credit can be an important element in the promotion of minor irrigation equipment sales. The public sector banks and cooperatives have a mandate to provide such credit—in addition to such complementary loans as those for crop production and other agricultural machinery. Institutional sources (including the banks as well as smaller credit providers such as NGOs and some agencies), however, cover only around 20 percent of all the credit needs of farmers (Rahman, 1985; Bangladesh Bank Annual Report 1992/93). The remaining 80 percent is either left unsatisfied or is provided by expensive non-institutional sources.

In this section an examination is made of both the record of rural banks (as the main institutional actors) in making irrigation loans and the experience of pump owners in getting credit. In addition, credit for irrigation equipment traders will be discussed.

2.1 Distribution of Bank Credit

In the provision of rural credit in Bangladesh the institutions of most relevance are such commercial banks as Sonali Bank (SB) and Janata Bank (JB) and the agricultural banks of Bangladesh Krishi Bank (BKB) and Rajshahi Krishi Unnayon Bank (RKUB). BKB and RKUB were established to supply credit for all types of agricultural enterprises (e.g., crops, livestock, fisheries and cottage industries in rural areas) in addition to their loan provision for minor irrigation equipment and other agricultural machinery. The involvement of the commercial banks in agricultural credit, however, goes back only to 1977 when the Special Agriculture Credit Programme (SACP) was adopted by the government to increase the flow of credit to farmers—and particularly to small and marginal cultivators.

Both the agricultural and commercial banks have networks of branches located at district and thana headquarters and often at other important rural business centers. None of them have any specialized staff for supervising irrigation loan activities. There are, however, a number of officers involved in field level irrigation loan activities as a part of each bank's broad agricultural loan administration. Interviews were conducted with such officers located in the study districts and thanas.

Level of irrigation sector loans

In recent years the rural banks have increased their disbursements of agricultural credit—mainly through crop loans. National agricultural equipment loans, however, have constituted only a nominal share of total credit disbursed. Such irrigation equipment loans distributed in 1992/93 comprised only 1 percent of disbursed agricultural credit. During the period from 1987/88 to 1992/93 the various lending institutions disbursed a sum of Taka 1.25 billion for minor irrigation equipment against a programmed amount of Taka 5.25 billion(Bangladesh Bank Annual Report 1992/93).

As noted during interviews with officials of selected banks in the study districts, distribution of irrigation equipment credit during 1993/94 appeared to be rather insignificant irrespective of type of minor irrigation technology or district (Table 1). Only the BKB at Comilla and RKUB at Bogra and Nilphamari have disbursed a few irrigation equipment loans (and these for a mere 60 STWs, 3 DTWs and 1 LLP) during the year 1993/94. Back in 1988/89, however, RKUB in Nilphamari district alone had distributed

a much larger number of irrigation equipment loans (for 5 DTWs and 2,526 STWs). This is in contrast to a general rise in crop loans during the same period, particularly through BKB and RKUB (Table 2). The causes of the decrease in the distribution of loans for irrigation equipment over the years have included, according to bank officers:

a) The recent liberalization policy for irrigation equipment importation which has encouraged traders to import relatively cheap engines from abroad (mainly from China)—as a result of which, interested farmers can now buy their irrigation equipment from the local market in cash;

b) The complex procedures farmers have to undergo in order to get bank loans. The complexity of the loaning procedures of banks is illustrated by the required large number of documents which must accompany loan application forms. These documents include: (I) copies of records of land right (Khatian); (ii) an original deed of conveyance and up-to-date rent receipt; (iii) properties acquired through inheritance require original records of rights, names, ages of all heirs, map and up-to-date rent receipt, (iv) properties acquired through gifts require original deed and up-date rent receipt, (v) photographs of an applicant; (vi) certificates from the chairman/members of the union council to prove an applicant's permanent residence in the locality and other relevant information; (vii) any other paper documents if required by the banks (Loan Manual of BKB, 1987). All these documents require careful scrutiny by bank officials at various levels (depending upon the amount of loan applied for). Information must be verified and, in some cases (pump owners note), there are said to be deliberate further delays by bank officials.

c) Huge defaults on previous loans and fear of default on new loans have discouraged farmers from contracting bank loans. The introduction of a passbook system has prevented farmers from concealing defaults on loans to some extent.

d) The terms and conditions of irrigation equipment loans have often been unpopular with borrowers. For example, in previous years RKUB at Nilphamari tried to impose rules that iron pipes must be purchased as accessories with engines—whereas cash constrained farmers were interested in buying only the engines and often used bamboo pipes with their irrigation units. (RKUB, it is understood, has relaxed these particular terms and conditions in order to encourage farmers to take loans for engines.)

Loan Recovery

Both national data (Bangladesh Bank 1992/93 as well as 1980/81) and local bank officials note that a large proportion of irrigation loans have been unrecovered in recent years. Bank officers cite the following causes:

a) Periodic government announcements of exemptions from repaying loans and interest up to Taka 5,000. Loan takers get into the mind frame where they assume that another exemption will be made at some time in the future so they wonder why they should repay their loan now.

b) The frequent misuse of borrowed funds (i.e., spending on things other than the irrigation equipment for which the loans were made) by loanees.

c) Machine breakdown causing poor return to pump owners and a subsequent inability to make loan payments.

Bankers' Opinions on Improving Irrigation Equipment Credit

Bank officials had a number of suggestions for improving irrigation equipment credit. They suggested that procedures should be streamlined and that incentives should be put in place to encourage better performance by those involved in making the loans. In addition, the government practice of making periodic exemptions of loan repayment should be permanently stopped. Finally, price supports, might make irrigated crops more profitable and loan repayment easier.

2.2 Pump Owner/Farmer Credit Experience

Interviews with pump owners confirmed the difficulties they face in getting loans—but their experience would appear to seriously contradict the opinion of some bank officers that the cheap machines now on the market mean that there is no longer much need for irrigation equipment credit. During the dry season of 1994, samples of pump owners and irrigating farmers were interviewed in the five districts chosen for the study.[50] Amongst other issues, the sample respondents were asked about their experience and needs regarding credit for irrigation equipment and O&M.

Sources of Funds

Of the sample pump owners, 28 percent had taken loans to purchase their irrigation equipment—mostly during the 1980's as few had more recent loans. Also, 27 percent used credit for at least part of their O&M costs (Table 3). The sources of credit differed greatly by use, however. Banks and other institutional lenders (BRDB and NGOs) provided more than 80 percent of the equipment loans but less than a third of the seasonal O&M credit. The use of the pump owners' own funds was quite heavy for both uses as 77 percent used own funds for equipment purchase and 90 percent for O&M. Of those own funds, savings were dominant for both uses—but the disposal of more valuable assets (land and livestock) was more common to finance equipment purchases than for O&M. The fairly heavy reliance on disposal of various types of assets would indicate a large un-met need for credit.

[50] For details of the sampling methodology see the paper on Study Background, Organization and General Methodology in this study.

Loan Amounts, Interest and Time to Get Loans

In Table 4 it can be seen that the Taka amount for STW loans reflects the fact that almost all such loans took place several years ago (prior to the liberalization of import restrictions and standardization requirements in the late 1980s) when the irrigation equipment market was dominated by much more expensive engines than is true today. As noted above, very few equipment loans have been made by institutional sources in the last few years. For those who did get loans the procedures seem to have been quite lengthy. It took almost a year to get a bank loan for a DTW (when those were still subsidized) and three and a half months for a STW. Given that the main purchase season for STWs is in the two to three months prior to the boro season, this amount of time may have discouraged many people from trying to get bank loans. In addition to the time, borrowers also had to pay some unofficial non-interest costs to get their loans. Informal case study reports make estimates of such costs that are considerably higher than those mentioned in association with specific loans reflected in Table 4. These unofficial loan costs added substantially to the loan expense. Of course, borrowing from less official sources could be much more expensive still.

Discouraged Prospective Equipment Purchasers

Irrigating farmers were asked if they would like to purchase their own irrigation equipment. The 134 who were interested were further asked why they had not already done so. Of the financial reasons cited (Table 5) 92 percent noted a lack of their own funds and 42 percent an inability to get credit. In fact, only 13 percent of the farmers felt that institutional credit in general was easily available—little changed from 1989. This is further evidence that credit availability may be a very important constraining factor affecting further growth and development of the minor irrigation sector.

2.3 Credit for Equipment Traders

As reported in the paper on the market for irrigation equipment,[51] equipment traders in the study districts used their own funds to finance 72 percent of their inventory and shop set-up. They used supplier credit for a further 8 percent, banks for 9 percent and got the final 8 percent from non-institutional credit sources. As might be expected, it would appear that more established credit sources (banks and suppliers) are somewhat more willing to extend credit once a shop is firmly established—but those sources are more hesitant to help a business just starting out. Traders interviewed through informal case studies noted their own needs for further credit—as well as the difficulties and frustrations faced in acquiring loans, as can be seen in the following vignettes.

[51]See the paper from this study on District and Local Level Markets for Minor Irrigation Equipment.

Mr. A: Engines and Spare Parts Dealer
The main problem is how to finance further expansion of my shop. For every Tk 100,000 you borrow you have to pay Tk 10,000 for formalities and another Tk 10,000 for bribes.

Mr. B: Parts Shop Trader
I would like to apply for a loan, but only without the "commission" bankers want a person to pay to get it. For every Tk 100,000 loan, you have to pay another TK 10,000 in bribes.

Mr. C: Engines and Spare Parts Dealer
Maybe they should create a separate bank, only for dealers in agricultural equipment. It is necessary to create a new bank, because the existing bankers are already too corrupt.

Mr. D: Pump Manufacturer
I recently bought a second hand machine to produce pumps. I wanted to buy a modern machine, but I cannot raise the capital to buy such a machine. There really is no difference between borrowing from private banks or from public banks as in both cases bribes are involved.

Mr. E: Spare Parts Trader
I really want to start my own workshop. I can produce all kind of spare parts, but I need capital first. I am too small. If I go to the bank they don't give me a taka and the people also ask high bribes.

Mr. F: Second Hand Engines Seller
One day I hope to sell new engines, but I lack the necessary capital. If you take a bank loan you have to pay a considerable amount of bribes.

Mr. G: Engines and Spare Parts, Fuel and Other Dealer
As local banks cannot sanction loans above Tk 3 lakhs, I would have to apply for a loan in Dhaka. But if you go to Dhaka your application will definitely get lost. Moreover, in Dhaka a 10 percent bribe will not be enough.

Mr. H: Spare Parts, Engines and Hardware Shop Owner
My major constraint is lack of capital. At the moment I do not have a relationship with one of the banks. It is something I want to have but I hate the bribes and the hassles involved.

Mr. I: Engines, Spare Parts and Hardware Dealer
Owing to the lack of capital I must go to Dhaka at least once a week. If I had more money I could go only once a month. The interest rate of the banks is too high, and banking always involves bribing.

3.0 THE SUPPLY OF INPUTS FOR IRRIGATION EQUIPMENT OPERATION AND FOR IRRIGATED CROP PRODUCTION

In the earlier days of minor irrigation development the Bangladesh Agricultural Development Corporation (BADC) provided for the distribution of diesel and mobil for the operation of the irrigation equipment. That input support service was largely shifted to the private sector by the early 1980s. BADC also handled the distribution of fertilizer (used primarily, though not exclusively, on irrigated crops) throughout the country for many years—stopping only quite recently. As the functioning of irrigation equipment and the production of irrigated crops is dependent on these complementary inputs, it is useful to examine their present distribution system. As with credit, the experience of both the suppliers and the users of these inputs will be looked at.[52]

3.1 Suppliers of Fuel for Irrigation Machines and of Fertilizers/Pesticides for Irrigated Crops

To get a picture of the district and local level distribution networks for the distribution of irrigation equipment, fuel and crop inputs such as fertilizer, a sample of 60 traders was selected. There were six diesel/mobil traders and six fertilizer/pesticide dealers chosen in each study district. Fuel dealers included both filling stations and road-side barrel traders while fertilizer sellers included both large and small shops.

Growth of input shops

A comparative picture of the growth of input shops between 1988/89 and 1993/94 is presented in Table 6. It shows that the numbers of diesel/mobil and of fertilizer/pesticide shops has increased in all the selected districts between 1988/89 and 1993/94. It is evident from the table that the fertilizer/pesticides shops have particularly increased during this period when the private sector has become fully involved in the procurement and distribution of inputs. Bogra, as an early-starting irrigated area, had a high number of fuel and fertilizer shops even in 1988/89—but it, too, displayed a strong growth in these distributors over the following five years.

Traders' purchase and sale of inputs

In Table 7 it can be seen that, as expected, cash was the predominant mode of payment both for the traders' purchases of inputs as well as for their sales. Credit, however, also played an important part—comprising a quarter of all sales (for both types of commodity) and, through supplier credit, a quarter of fertilizer purchases though only a sixth of diesel purchases. This limited though significant availability of credit to traders for the purchase of inventory can be contrasted with the time when BADC was the sole supplier and only sold to the dealers in cash. In addition to the present availability of credit,

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[52]It should be kept in mind that this study took place in 1994 and therefore reflects the experience of the various suppliers and users of these inputs up to that time. The causes and effects of the 1995 fertilizer shortage are, therefore, not a part of this discussion.

the distance from where the traders of diesel/mobil and fertilizer/pesticides presently get their supplies has been reduced compared to 1988/89 (Table 8). The market distribution of these commodities, then, appears to have decreased the capital and supply distance constraints faced by traders.

Types of customers

Traders sell their commodities to different types of buyers (Table 9). Some are direct sales to pump owner/farmers while some are sales to other dealers (while diesel dealers, naturally also sell to transport owners). The level of sales to other retailers (and wholesale/retailers) is something of an indicator of the spread of traders down to the local level where the actual commodity users live. This spread is corroborated by the experience of pump owners who have indicated that the distance to where they can buy diesel/mobil has been reduced to a great extent compared to five years ago. Five years ago, pump owners on average would have traveled 6 km to buy diesel/mobil (the median was 4.5 km) , whereas in 1994 the average was 4 km (median 3). In 1994 90 percent could get their diesel within 8 km—while in 1989 90 percent found diesel available within 15 km. None of the pump owners was found to buy diesel/mobil from beyond the distance of 24 km in 1994.

Input supply availability to traders

Table 10 shows the traders' supply availability status for the selected inputs of the study areas. Most of the traders found the various inputs to generally have been easily available to them in 1994 (though separate information indicated that there was a brief period of fertilizer shortage in some areas that year). This general availability was perceived to have improved or stayed the same since 1989 as the market has expanded.

Prices

Table 11 presents the average per unit prices of fuel and fertilizers over the production period of the Boro season (November 1993 to April 1994). The prices of diesel and mobil remained more or less the same during the season with a slight increase in the peak period (February and March). The prices of most of the fertilizers fluctuated slightly over the months of the boro season—though zinc and MP had larger variations. Pesticide prices (not shown) have stayed stable for the past two years.

Problems faced by input traders

Funding difficulties predominated when input traders were asked about the problems they faced when starting their business (Table 12). Getting trading licenses was also a problem for a significant number.

Traders' desired conditions for future expansion of the input business

When asked under what conditions their business could be expanded, most input traders pointed to an increase in irrigation in their area as being of help (Table 13). Better provision of bank loans to the input

users as well as to input traders was also thought to be important. In addition, lower prices of inputs and higher prices for irrigated crops were seen as inspiring more business.

3.2 Pump Owners and Irrigating Farmers: The Users of Inputs

Pump owners and farmers were asked about their own access to fuel, fertilizer and pesticides. From Table 14 it can be seen that none of these inputs were a problem in 1994 to either group. Since 1989 there does seem to have been some improvement in availability of fertilizers and pesticides, particularly to the irrigating farmers. Diesel provision is also seen by pump owners as having improved somewhat in the last five years, though it doesn't seem to have been very bad at the beginning of that period.

4.0 REPAIR AND MAINTENANCE SERVICES FOR IRRIGATION EQUIPMENT

Repair and maintenance of irrigation equipment is of obvious importance to keeping the machines going throughout the dry season and preventing crop damage due to broken-down machines being out of commission for too long. Reports from the five study districts indicated an average of roughly 2 break-downs each during the season for diesel DTWs, STWs and LLPs. During the season DTWs were out of operation a total of almost 6 days (and up to 16)—while for STWs the average seasonal down time was 5 days (ranging up to 11), with the figure being 3.5 days for LLPs (ranging up to 11).[53] The availability and quality of mechanics and workshops, then, is of real importance to pump owners.

BADC, in the past, has provided repair services—particularly for DTWs. The agency had workshops and a number of mechanics in each district. By 1994 BADC had largely ceased providing these services, though many of its mechanics were still there. Pump owners would sometimes still go to BADC for help with their DTWs when private mechanics were not equipped with heavy implements like tripods and chain poles. Many of the former BADC mechanics would, on their own, provide some repair services to pump owners—at times with agency equipment. STWs are largely repaired by local private mechanics of various levels of competence. A few extracts from case study interviews with a few pump owners and agency officers include:

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[53]For more details on repair records see the paper from this study on Technical Aspects Affecting the Selection and Operation of Minor Irrigation Equipment.

Interviews with Pump owners

A: There are no mechanics who live in this village, so if he needs one he uses the (private) service of a BADC mechanic from Hobigonj.

B: The only problem he has now is to find a private mechanic who can maintain and repair the DTW. He has never tried BADC again, because he believes that now that BADC has sold the DTW they don't have any responsibility any more.

C: D.T. doesn't have a high opinion about mechanics. They don't have sufficient qualifications to do a good job. Most of them are quacks. BADC has a few qualified mechanics but their number is too low to serve all the farmers. D.T., however, does have a suggestion to solve this problem with mechanics. The government should verify the mechanics' qualification. Only when there are good mechanics, development of minor irrigation can really take place. Maybe BADC can provide them with good training so that they can improve their knowledge and skills. The government should give trained mechanics a certificate.

Interviews with BADC officials

A: A few years ago BADC employed 75 mechanics here. Now there are 42 left. These mechanics were mainly engaged with the maintenance of LLPs. Now they are all busy with their private jobs in the field. Unlike in some other districts, very few DTW owners still come here to request BADC's service, instead they go directly to the BADC mechanics and pay them.

B: Although the DTW program has officially been terminated, BADC has still got 26 mechanics that go to the field to check some of the wells and to report on their condition. There used to be 35 mechanics, but 9 of them retired or were transferred. Farmers still ask BADC to do some of the servicing as they don't have the necessary equipment like tripods and chain poles to do the servicing themselves. Moreover, most private mechanics are not skilled enough to do the servicing of DTWs.

As can be seen in Table 15, pump owners who had previously had repair services, spare parts, etc. from BADC generally have preferred the flexibility and timeliness of the market's present provision of these services—though lack of adequate training of the private mechanics (as noted above) is a concern.

A survey was taken of mechanics in the study areas.[54] 53 percent had formal mechanical training of some sort—with BADC being the main provider of that training. Training was seen as very useful by the mechanics (Table 16), more than a third of whom had little relevant mechanical background from their previous work experiences. Training seemed to make a difference in the work market, affecting their incomes—as mechanics with some sort of training earned almost 15 percent more during the season than those without it (Tk 25,100 vs Tk 21,900—figures include commissions on help with equipment sales).[55]

A third of the mechanics did not have adequate tools. For complicated mechanical problems the equipment owners, then, had to go to distant workshops. Most (95%) of the mechanics had some sort of link with a workshop in the area.

The service range of sample mechanics was quite wide. They serviced between 47 and 92 machines (mostly STWs) during the season—and did work in an average of 27 villages (though that does not imply that other mechanics did no work in any of those villages). The mechanics' opinions of the availability of mechanics in their area are shown in Table 17. According to this source, there has been a substantial improvement in availability since 1989 (with 72% feeling it was at least sufficient in 1994 vs 30% in 1989). The percentage of pump owners thinking that mechanics were reasonably available rose from 49 percent to 89 percent in the same period.

Mechanics play an active role as middlemen in the irrigation equipment market. More than eighty five percent helped farmers buying (or selling) new or used engines or motors. Two thirds at times assisted second-hand shop owners to buy old equipment from pump owners. Commissions for these activities averaged about Tk 4,000 per season. A few would sell spare parts as a side line.

Problems that mechanics faced are shown in Table 18. Tools, spare parts and workshop facilities seemed to have been more of a problem in the more recently developed minor irrigation districts of Hobiganj and Nilphamari than elsewhere. Training, as has been noted from both pump owners and mechanics, is seen as important. Now that BADC is no longer in the business of providing support services such as mechanical training, there is a real concern that good quality training will be much less available than it has been in the past. Given the continued growth of minor irrigation equipment in the field, it is quite possible that availability of trained mechanics will become something of a constraint unless other agencies and organizations increase their own training programs for mechanics.

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[54]For sampling details see the paper from this study on Study Background, Organization and general Methodology.

[55]This difference was statistically significant at the 5% level when controlling for age, previous mechanical experience, days of training and years of education.

5.0 OTHER SUPPORT SERVICES

A number of other support services and inputs are provided by various government agencies and, to some extent, by non-governmental organizations. An overview of pump owners' views on the usefulness and availability of some of these services is presented in Table 19. The services listed include various types of information and training, conflict resolution, group formation and management, warranty and insurance, pump siting advice and system layout and design. All were seen as at least somewhat useful by a large majority of the sample pump owners—and most were seen as very useful. As to availability, however, most of these services were unavailable as far as the respondents knew (with the exception of information on mechanics/spare parts and output prices and, to some extent, training for mechanics and drillers). Some of these support services are discussed below.

5.1 Extension

The Directorate of Agricultural Extension (DAE) provides its services through its nationwide network starting from the national level down to the Union (with block supervisors) and village level (with model farmers). The DAE does not have any staff for providing specifically irrigation related extension services. The district and thana level offices of the organization have, however, several technical staff who are generally meant for agricultural extension services—and irrigation related extension is included in their work jurisdiction.

DAE district and thana officials reported that irrigation related activities had increased in recent years. They had provided various types of training to model farmers, pump owners, fertilizer dealers, equipment traders, rural mechanics, block supervisors, housewives etc.— who in turn were expected to teach other people living in the villages. Types of training provided included (a) on-farm water management; (b) general information on irrigation equipment; © group formation; (d) crop production; (e) repair and maintenance of equipment; and (f) field demonstrations. DAE also organizes short training courses for farmers on specific topics to meet the requirements of projects such as the Crop Diversification Programme (CDP) and the Agricultural Support Services Programme (ASSP).

The normal point of contact between the agency and villagers is the block supervisor (BS). The irrigation-related functions of the block supervisor include advising farmers on: (I) water management practices; (ii) crop water requirements; (iii) timing of irrigation; (iv) other input use and production practices; and (v) draining excess water from the fields. The BSs have to perform these jobs in addition to various other non-irrigation related activities such as agricultural loan assessments, preparing voter lists and arranging adult education, etc. All of these functions, it appears (Table 20) are supposed to be done in the 5 to 16 villages a BS must supervise. As many of these officers have inadequate field transport and accommodation, it is difficult for them to do a very thorough job in any one village.

DAE officers noted a number of problems encountered in the agency's provision of irrigation related extension services:

a) Shortage of trained resource persons
b) Inadequate training for the Block Supervisors on irrigation development and expansion strategy
c) Lack of logistic supports for strengthening extension training programs

d) Lack of teaching materials
e) Lack of transport facilities for field staff
f) Shortage of program funds

In addition to DAE as the mainstream public sector agency, some NGOs such as BRAC, Proshika and the Grameen Bank are also involved in minor irrigation development in different regions of the country. While their programme areas are limited, they do, in some places, organize irrigation training and extension activities for their field workers and client farmers.

5.2 Aquifer Information

As has been noted in another paper from this study, the installation of additional tubewells in an area is mostly a trial and error exercise as pump owners have no solid information about groundwater in their areas.[56] Very little information is provided to pump owners or prospective owners regarding their local aquifers. There have been national efforts to assess groundwater, of course—i.e., through the MPO (Master Plan Organization) and its successors, using agency test wells. There is no program to disseminate this information, however—and there are questions as to whether it is sufficiently micro-area specific to be of use to farmers. The DPHE (Department of Public Health Engineering) does collect information on static water levels from selected wells in each thana for use in sinking wells for drinking water. Dissemination of this information, again, has been a problem.

5.3 Pump Siting and Channel Improvement Advice

In the study areas no program existed for providing services in the areas of pump siting and channel design/improvement. In the 1980s the IMP (Irrigation Management Program) implemented by the LGED, DAE and BRDB had some functions in this area—but this program no longer exists. The NMIDP (National Minor Irrigation Development Program) and NEMIP (Northeast Minor Irrigation Program) have program elements relating to this area that they are starting to implement.

5.4 Group Formation and Management

During the period when BADC was the sole provider of DTWs, BRDB (Bangladesh Rural Development Board) used to provide support for group formation and training. Their program of farmers cooperative societies (KSSs) was quite widespread in the country as DTWs were, for a long time, sold only to groups, particularly KSSs. With the privatization of minor irrigation this advantage for cooperatives has disappeared. In any case, KSSs were particularly associated with DTWs rather than with the presently faster growing STW and LLP technologies.

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[56]See the paper from this study on Water Adequacy Issues.

The minor irrigation programs of NGOs such as Proshika and BRAC work primarily with groups that these NGOs have helped form and maintain. These groups are provided some elements of management training and irrigation extension information.

5.5 Insurance of Irrigation Equipment

Of the 240 sample pump owners, only 4 had insurance on their equipment—mostly purchased as part of their bank loan at the time of purchase of their machine. Covered risks included explosion, fire and theft. One insurance company claimed in 1993/94 to have covered 10 DTWs, 300 STWs and 2 LLPs in Bogra and 7 DTWs and 94 STWs in Faridpur—though its business had dropped off a good deal in Nilphamari over the past five years. These numbers are small in relation to the number of irrigation units in these districts. The level of performance with respect to the payment of insurance claims is not very clear given the very small number of insured machines.

5.6 Electricity for Minor Irrigation

The PDB (Power Development Board) and REB (Rural Electrification Board) provide electrical connections for minor irrigation equipment in some areas—and both agencies claim that such connections have been growing in number over the past several years. 51 of the 240 sample pump owners had electrically operated equipment, mainly from PDB.

To get electricity connections pump owners claimed that they had to pay various non-official costs (bribes, subscriptions, donations etc.) in addition to the normal official costs—irrespective of which agency provided the electricity. The amount of such non-official costs paid to the PDB in the study districts ranged from Tk 2,000 for a STW to Tk 45,600 for a DTW (Table 21). On top of this the pump owners generally had to wait 5 to 8 months to get their connection from PDB (though REB was faster).

Frequent power cuts and the theft of electric wires have become common problems in almost all the districts. The electricity agencies also report that the connections to irrigation equipment are often cut off due to non-payment of electricity bills. Such disconnections were found to be particularly high in Nilphamari.

6. SUMMARY AND CONCLUSIONS

With the exception of input supplies (such as diesel/mobil and fertilizer/pesticides), some mechanical services and some information (regarding output prices and spare parts/mechanics), support services and inputs for the minor irrigation sector were generally found to be lacking or hard to get at the district and local level. Among them, the lack of effective access to credit is probably one of the most important. Many of the others (good training for mechanics and others, aquifer information, siting and layout advice, group management services, insurance, etc.) could also help the performance and sustainability of the

sector and enhance access to pump ownership for people now excluded by funding and other constraints. Certainly pump owners feel those services would be helpful to them.

Credit

While much of the recent expansion of STWs and LLPs has been done without much reliance on bank loans, there is evidence that credit has been an important constraint. Pump owners significantly disinvest in other productive assets (land and livestock, for example) in order to buy their equipment. Traders' stock is also limited by the extent of their own funds when they are unable to get credit. In both cases the market could expand faster if credit could be provided at reasonable rates and without the large hassles and non-official side payments which are typical of loan application procedures today. Credit for minor irrigation is part of a wider rural credit picture which has been a thorny problem in Bangladesh for some time. Aside from the benefit of general reforms of rural credit facilities, though, there would appear to be some programmatic possibilities specific to minor irrigation. The channeling of irrigation equipment loan funds through trader networks, for example, might be an effective way of processing credit as traders would have an incentive to facilitate loan procedures so as to make more equipment sales.

Mechanical Services

While private sector mechanics capable of repairing STWs and LLPs do seem to be growing in number at the district and local levels, there are some constraints. Good training is valuable—but with the exit of BADC from the mechanical training picture there is concern that there will be fewer qualified mechanics in the future. So far, private sector training has not taken up the slack. Some form of institutional facilitation of such training is needed. A believable certification system would increase pump owners ability to choose good mechanics and would encourage more mechanics to get training by enhancing its value.

For DTWs the problem is not only one of the training of mechanics. Specialized tools and well equipped workshops are needed for many repair and over-hauling functions on these units. With DTWs no longer being subsidized and having a shrinking market, the private sector has not filled the gap left by the withdrawal of BADC's DTW repair service. At least for the remaining life of the existing DTWs there may be a need for institutional support for mechanical services to DTWs.

Informational and Advice Services

Most informational and advice services are not terribly well suited for private sector implementation as a firm is unable to charge most beneficiaries for such services. As a result, such services are traditionally a part of public sector programs. So far, however, their provision by the public sector has been rather limited. Strengthening of the village-level irrigation services of DAE would be a help. The collection and dissemination of local aquifer information could also save pump owners from the cost of their present trial and error method of pump installation. There may also be methods of disseminating simple mechanical advice tracts through equipment dealers.

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Table 1. Distribution of loans for irrigation equipment purchase during 1988/89 and 1993/94 in the study districts.

District	Banks	Number of units purchased with bank loans					
		DTW		STW		LLP	
		1988/89	1993/94	1988/89	1993/94	1988/89	1993/94
Bogra	RKUB	-	-	30	15	-	-
	Sonali	-	-	-	-	-	-
	Janata	-	-	37	-	26	-
Comilla	BKB	-	3	-	6	-	1
	Sonali	-	1	-	-	-	-
	Janata	19	-	-	-	-	-
Faridpur	BKB	-	-	-	-	-	-
	Sonali	10	-	7	-	-	-
	Janata	-	-	1	-	-	-
Hobiganj	BKB	-	-	-	-	-	-
	Sonali	8	-	-	-	-	-
	Janata	-	-	-	-	-	-
Nilphamari	RKUB	5	-	2526	38	619	-
	Sonali	16	-	1414	-	1	-
	Janata	-	-	-	-	-	-

Source: IIMI/BSERT 1994 interviews with district and thana-level officers of BKB/ RKUB, Sonali Bank and Janata Bank in Bogra, Comilla, Faridpur, Hobiganj and Nilphamari districts

Table 2. Distribution of crop loans by banks in five study districts during 1988/89 and 1993/94. (Amount of crop loans in '000 Taka)

District	RKUB/BKB		Sonali		Janata	
	1988/89	1993/94	1988/89	1993/94	1988/89	1993/94
Bogra	22,846	45,692	26	1,383	6,722	14,234
Comilla	NA	30,374	19,765	36,423	NA	49,895
Faridpur	NA	12,300	20,062	18,229	11,728	5,425
Hobigonj	NA	27,500	8,032	273	16,185	9,545
Nilphamari	NA	44,500	90	15,000	-	-

NA Not available (as these figures were often not easily accessible during interviews).

Source: IIMI/BSERT 1994 interviews with district and thana-level officers of BKB/ RKUB, Sonali Bank and Janata Bank in Bogra, Comilla, Faridpur, Hobiganj and Nilphamari districts.

Table 3. Distribution of 240 sample pump owners by source of funds for purchase of irrigation equipment and for O&M costs.

	Equipment Purchase		O&M Costs	
	No.	%	No.	%
Credit Total	66	28% (of 240)	64	27% (of 240)
Banks	44	67% (of 66)	12	19% (of 64)
BRDB	5	8% "	0	-
NGOs	6	9% "	6	9% "
Money Lenders	0	-	26	41% "
Friends and Relatives	5	8% "	26	41% "
Other Credit Source	6	9% "	11	17% "
Own Funds Total	185	77% (of 240)	215	90% (of 240)
Savings	154	83% (of 185)	182	76% (of 215)
Sale of Land	18	10% "	3	1% "
Mortgage of Land	31	17% "	22	10% "
Sale of Livestock	33	18% "	23	11% "
Sale of Other Assets	27	15% "	51	24% "
Other Sources	24	13% "	25	25% "

Note: Some pump owners had multiple sources of funds so percentages of items do not total 100.
Source: IIMI/BSERT 1994 Pump Owner Survey in Bogra, Comilla, Faridpur, Hobiganj and Nilphamari districts.

Table 4. Average amount of loan received by pump owners for irrigation equipment purchase.

Particulars	DTW	STW	LLP
Banks			
Time taken (months)	10	3.5	6
Average amount (Tk)	104,892	25,562	15,000
(n)	(13)	(28)	(3)
Interest rate (%)	16	15	16
Non-interest cost (%)	4.5	7.5	-
BRDB			
Time taken (months)	16	4	-
Average amount (Tk)	162,000	32,875	-
	(1)	(4)	-
Interest rate (%)	17	13	
NGOs			
Time taken (months)	1.5	-	-
Average amount (Tk)	129,167	-	-
	(6)	-	-
Interest rate (%)	21		
Friends & relatives			
Time taken (months)	-	-	-
Average amount (Tk)	40,000	39,000	2,000
	(2)	(2)	(1)
Interest rate (%)	120	125	
Others			
Time taken (months)	3	8	-
Average amount (Tk)	63,000	28,895	-
	(2)	(4)	-
Interest rate (%)	29.5	11	

Note: Figures in parentheses indicate loan cases.
Source: IIMI/BSERT 1994 Pump Owners Survey in Bogra, Comilla, Faridpur, Hobiganj and Nilphamari Districts.

Table 5. Of farmers interested in buying irrigation equipment, financial reasons for not making the purchase.

Technology	Reasons (percent)					
	Lack of own funds		Lack of credit		Both	
	No.	%	No.	%	No.	%
DTW (26)	21	81	10	39	9	35
STW (75)	70	93	38	51	37	49
LLP (33)	32	97	8	24	8	24
All (134)	123	92	56	42	54	40

Note: Brackets indicate number of farmers interested in purchasing irrigation equipment by type of the system they now use.
Source: IIMI/BSERT 1994 Irrigating Farmers Survey in Bogra, Comilla, Faridpur, Hobiganj and Nilphamari Districts.

Table 6. Comparative picture of input shops in selected thanas of the study districts.

Type of input by district	Number of shops In 1988/89	Number of shops In 1993/94	Percent change
Bogra			
Diesel/mobil	39	41	+5
Fertilizers/ Pesticides	61	88	+44
Comilla			
Diesel/mobil	7	11	+57
Fertilizers/ Pesticides	9	21	+133
Faridpur			
Diesel/mobil	22	36	+64
Fertilizers/ Pesticides	15	36	+140
Hobigonj			
Diesel/mobil	11	18	+64
Fertilizers/ Pesticides	15	20	+33
Nilphamari			
Diesel/mobil	46	53	+15
Fertilizers/ Pesticides	33	54	+64

Note: The number of shops in the table represents the shops existing in the sample thana level markets in the 5 districts under study.
Source: IIMI/BSERT 1994 Input Traders Survey in Bogra, Comilla, Faridpur, Hobiganj and Nilphamari districts.

Table 7. Extent of cash and credit purchase and sale of diesel/mobil and fertilizer.

Study Area	Diesel/Mobil Purchase (%)		Diesel/Mobil Sale (%)		Fertilizer Purchase (%)		Fertilizer Sale (%)	
	Cash	Credit	Cash	Credit	Cash	Credit	Cash	Credit
Bogra	88	12	74	26	85	15	76	24
Comilla	83	17	77	23	69	31	67	33
Faridpur	75	25	68	32	93	7	72	28
Hobigonj	100	0	73	27	81	19	75	25
Nilphamari	72	28	85	15	44	56	86	14
All districts	84	16	75	25	74	26	75	25

Source: IIMI/BSERT 1994 Input Traders Survey in Bogra, Comilla, Faridpur, Hobiganj and Nilphamari districts

Table 8. Proportion of agricultural input traders receiving supplies from various distances.

Range of distance (km)	% of diesel/mobil traders 1993/94	% of diesel/mobil traders 1988/89	% of fertilizer traders 1993/94	% of fertilizer traders 1988/89
Less than 20	23	16	33	8
20 - 40	10	4	7	15
41 - 60	23	28	0	0
61 - 80	14	16	7	8
81 - 100	3	4	7	15
101 and above	27	32	46	54

Source: IIMI/BSERT 1994 Input Traders Survey in Bogra, Comilla, Faridpur, Hobiganj and Nilphamari districts

Table 9. *Proportion of sales of diesel/mobil and fertilizer to different types of buyers (percent).*

Types of buyer	Bogra	Comilla	Faridpur	Hobigonj	Nilpha-mari	All districts
A. Diesel/mobil						
Pump owner/farmers/ owners of power tillers	40	47	55	52	59	51
Wholesaler	0	19	4	3	3	6
Retailer	6	6	15	7	12	9
Wholesaler cum retailers	13	4	0	25	0	8
Transport owner	41	24	26	13	26	26
Total	100	100	100	100	100	100
B. Fertilizer						
Pump owner/farmers	44	85	57	47	89	64
Wholesaler	1	0	16	28	10	11
Retailer	28	8	21	11	1	14
Wholesaler cum retailers	27	7	6	14	0	11
Total	100	100	100	100	100	100

Source: IIMI/BSERT 1994 Input Traders Survey in Bogra, Comilla, Faridpur, Hobiganj and Nilphamari districts.

Table 10. *Availability of agricultural input supply to traders: 1988/89 and 1993/94.*

	% of respondents in 1993/94		Present availability compared to 1988/89		
Inputs	Easily available	Not Easily available	More available	Same as before	Less available
Diesel	97	3	49	32	19
Mobil	100	0	49	32	19
Urea	90	10	86	0	14
TSP	90	10	47	23	30
MP	70	30	47	5	47
Zinc	100	0	43	23	33
DAP	83	17	23	23	54
Gypsum	100	0	20	21	21
Pesticides	100	0	59	19	19

Note: Percentages are of those traders actually dealing in a particular commodity. Not all traders dealt in all inputs.
Source: IIMI/BSERT 1994 Input Trader Survey in Bogra, Comilla, Faridpur, Hobiganj and Nilphamari districts

Table 11. Average prices of inputs during the boro season in 1993/94.

Items	Prices of inputs in different months					
	November 1993	December 1993	January 1994	February 1994	March 1994	April 1994
Diesel (Tk/Lit.)	14.06 (0.42)	14.21 (0.42)	14.24 (0.51)	14.30 (0.66)	14.30 (0.66)	14.29 (0.66)
Mobil (Tk/Lit.)	35.41 (3.48)	35.41 (3.48)	35.41 (3.48)	35.41 (3.48)	35.41 (3.48)	35.41 (3.48)
Urea (Tk/Kg)	5.16 (0.78)	5.21 (0.78)	5.22 (0.66)	5.18 (0.64)	5.02 (0.62)	4.87 (0.37)
TSP (Tk/Kg)	8.49 (0.58)	8.67 (0.83)	8.66 (0.81)	8.59 (0.52)	8.50 (0.51)	8.43 (0.60)
MP (Tk/Kg)	8.81 (2.39)	9.29 (2.51)	8.59 (1.36)	8.88 (1.53)	8.13 (1.24)	7.67 (0.81)
Zinc (Tk/Kg)	32.63 (15.95)	32.63 (15.93)	28.18 (15.08)	29.76 (14.15)	29.71 (14.20)	29.71 (14.15)
DAP (Tk/Kg)	8.01 (0.81)	8.01 (0.86)	8.04 (0.81)	7.99 (0.76)	7.99 (0.73)	8.21 (0.23)
Gypsum (Tk/Kg)	3.37 (0.63)	3.39 (0.63)	3.54 (0.70)	3.48 (0.68)	3.46 (0.69)	3.46 (0.69)

Note: Figures in the parentheses indicate standard deviation of per unit average prices of the particular inputs.
Source: IIMI/BSERT 1994 Input Traders Survey in Bogra, Comilla, Faridpur, Hobiganj and Nilphamari districts.

Table 12. Problems faced by diesel/mobil and fertilizer traders in starting their businesses.

Nature of problem	Diesel/mobil		Fertilizer	
	Number of respondents	Percent	Number of respondents	Percent
Shortage of own funds	22	73	24	80
Sufficient credit could not be arranged from banks	3	10	7	23
Hassles in acquiring credit from bank	10	33	3	10
Difficulty in getting license	8	27	7	23
Difficulty in purchasing supplies	-	-	4	13
Transportation of supplies	2	7	5	17
Too much competition	5	17	1	3
Other	5	17	3	10

Source: IIMI/BSERT 1994 Input Traders Survey in Bogra, Comilla, Faridpur, Hobiganj and Nilphamari districts.

Table 13. Facilities required by traders for expanding their input businesses.

Facilities required	Diesel/mobil		Fertilizer	
	Number of respon-dents	Percent	Number of respon-dents	Percent
1. Increased irrigation in the area	22	73	26	87
2. Better provision of bank loan to users of agricultural inputs	9	30	10	33
3. Better provision of bank loan for traders of agricultural inputs	10	33	7	23
4. Availability of bank loans at lower interest rate	11	37	10	33
5. Timely repayment of amounts due by the government and private customers	1	3	4	13
6. Smooth supply of inputs	4	13	-	-
7. Technical information: particularly for fertilizer and pesticides	-	-	1	3
8. Lower prices of inputs	12	46	15	50
9. High prices for farm produce	14	47	11	37
10. Quality control on inputs	2	7	-	-

Source: IIMI/BSERT 1994 Input Traders Survey in Bogra, Comilla, Faridpur, Hobiganj and Nilphamari districts

Table 14. Availability of input supplies to sample pump owners and irrigating farmers.

Inputs	Pump owners (Percent)		Farmers (Percent)	
	Availability In 1994	Availability In 1989	Availability In 1994	Availability In 1989
Diesel	94	86	-	-
Fertilizers	98	92	96	78
Pesticides	94	89	91	76

Source: IIMI/BSERT 1994 Pump Owner and Farmer Surveys in Bogra, Comilla, Faridpur, Hobiganj and Nilphamari districts.

Table 15. Opinions of irrigation equipment owners about the shift from badc to a private distribution system.

Services	Preference for BADC as provider (% response)			Preference for present market as provider (% responses)		
	DTW	STW	LLP	DTW	STW	LLP
Irrigation equipment distribution & installation	35	23	30	65	77	70
Mechanical services	29	15	26	71	85	74
Spare parts	47	15	21	53	85	79
Diesel/Mobil	23	18	15	77	82	85

Note: Responses are only from hose pump owners who were owners/part-owners/managers of DTWs/STWs/LLPs when BADC provided services (i.e., distribution, installation, DTW rental, mechanics, fuel)to that pump system in the past.

Source: IIMI/BSERT 1994 Equipment Owners Survey in Bogra, Comilla, Faridpur, Hobiganj and Nilphamari districts.

Table 16. Mechanics' opinion about the usefulness of training (percent).

Source of training	Extent of usefulness		Total
	Very useful	Somewhat useful	
Formal training			
BADC	81	19	100
BRDB	100	-	100
Vocational school	100	-	100
NGOs	100	-	100
Other organizations	67	33	100
Informal training			
BADC mechanic	90	10	100
Workshop mechanic	94	6	100
Other mechanic	90	10	100

Source: IIMI/BSERT 1994 Mechanics Survey in Bogra, Comilla, Faridpur, Hobiganj and Nilphamari districts.

Table 17. Mechanics' opinion about the availability of mechanics in their area.

Status	% of responses	
	1993/94	1988/89
Insufficient	28	70
Sufficient	42	28
More than sufficient	30	2

Source: IIMI/BSERT 1994 Mechanics Survey in Bogra, Comilla, Faridpur, Hobiganj and Nilphamari districts.

Table 18. Mechanics' perceptions about their problems servicing irrigation equipment.

Problems faced	Bogra (%)	Comilla (%)	Faridpur (%)	Hobigonj (%)	Nilphamari (%)
Lack of sufficient training	45	-	-	9	45
Lack of purchasing ability of tools	19	10	14	33	24
Non-availability of some spare parts	10	14	38	24	14
Lack of workshop facility in the locality	13	7	13	40	27
Other reasons	25	25	25	25	-

Source: IIMI/BSERT 1994 Mechanics Survey in Bogra, Comilla, Faridpur, Hobiganj and Nilphamari districts.

Table 19. Availability and expected usefulness of various support services.

Support services related to minor irrigation	Expected usefulness			Where service is thought to be available		
	Very useful	Some-what useful	Not Needed	Market	Agency	Not available or not known where or whether available
1. Information						
a. Mechanics/spare parts	89	11	-	97	1	2
b. Aquifer/water availability	57	34	9	3	9	88
c. Output prices/high value crops	87	10	3	66	2	32
2. Training						
a. Mechanics and drillers	84	16	-	44	12	44
b. Pump operators/drivers	67	28	5	57	1	42
c. Group organization	20	50	30	5	7	88
d. Water management	53	39	8	9	6	85
3. Conflict resolution service	43	37	20	9	1	90
4. System design and layout	33	44	23	2	6	92
5. Pump siting advice service	60	32	8	13	10	77
6. Group formation and management	24	49	27	3	8	89
7. Insurance for crops/ machines	56	35	9	0	2	98
8. Machine warranty	91	9	-	13	0	87
9. Output marketing/ procurement service	83	17	-	40	5	55

*Source:*IIMI/BSERT 1994 pump owner survey in Bogra, Comilla, Faridpur, Hobiganj and Nilphamari districts.

Table 20. Average work load of a DAE block supervisors.

Type	Bogra		Comilla		Faridpur		Hobigonj		Nilphamari	
	Expected	Actual	Expected	Actual	Expected	Actual	Expected	Actual	Expected	Actual
Villages (no)	1	5-6	7-8	7-8	2-3	5-8	3-4	15-16	5-7	5-7
Farm house-holds (No.)	150 200	17657 -	800-1200	800-1200	200-300	500-800	250-300	800-1200	800-1200	600-700
Pumps (no)	10	79	NA	NA	25-30	40-50	15-20	19-20	35	31
Irri-Area (ha)	500	953	NA	NA	162-202	142-162	150-200	150-500	100-150	248

Source: IIMI/BSERT 1994 Interviews with DAE officials in Bogra, Comilla, Faridpur, Hobiganj and Nilphamari districts.

Table 21. Average cost to get electricity connections for irrigation pumps.

Study areas	Cost of electricity connections											
	PDB						REB					
	Official cost (Tk)			Non-official costs (Tk)			Official cost (Tk)			Non-official costs (Tk)		
	DTW	STW	LLP	DTW	STW	LLP	DTW	STW	LLP	DTW	STW	LLP
Bogra	34500 (36905)	-	-	45600 (34703)	-	-	-	-	-	-	-	-
Comilla	16545 (14229)	4667 (6351)	3440 (3843)	15143 (17658)	1850 (1626)	2200 (3328)	-	-	-	-	-	-
Faridpur	23000 (0)	10889 (2886)	9167 (9684)	25000 (0)	13086 (6762)	8000 (6083)	-	-	-	-	-	-
Hobigonj	35000 (0)	-	6331 (3225)	-	-	43786 (27270)	2000 (0)	-	-	-	-	-
Nilphamari	-	14750 (18738)	-	-	2000 (0)	-	13750 (1768)	-	-	2000 (0)	-	-

Note: Figures in parentheses are standard deviations.

Source: IIMI/BSERT 1994 Interviews with PDB and REB officials in Bogra, Comilla, Faridpur, Hobiganj and Nilphamari districts.

Enhancing Rural Finance for Minor Irrigation Equipment[57]

INTRODUCTION

The purpose of the present report is to identify privatization guidelines for credit programs for minor irrigation equipment importers, traders, producers, and output purchases. The report is part of a study of minor irrigation privatization conducted by the International Irrigation Management Institute (IIMI) and the Bangladesh Agricultural University (BAU) Bureau of Socio-Economic Research and Training (BSERT) in collaboration with the Ministry of Agriculture and with funding provided by the Asian Development Bank.

This report includes a summary of the changing views of credit and finance, a discussion of formal and informal financial markets and agribusiness credit in input and output markets in Bangladesh, a review of existing public and private finance programs for district and thana level agricultural and irrigation machinery traders and workshops, identification of possible topics for analysis by the Bangladesh Agricultural University (BAU) Bureau of Socio-Economic Research and Training (BSERT) research team on the survey data modules related to credit, and concludes with indicative privatization guidelines for credit programs.

The IIMI/BSERT research team selected two advanced districts (Bogra and Comilla) in minor irrigation development and three districts (Faridpur, Hobigonj and Nilphamari) that are less advanced in minor irrigation development for the privatization study. Minor irrigation equipment in the IIMI/BSERT study includes deep tube wells (DTW), shallow tube wells (STW), low lift pumps (LLP) and modern inputs such as seeds, fertilizer and pesticides. Questionnaires were developed and interviews were completed with producers/pump owners, irrigation equipment traders, modern input traders, repair workshops, women and men wage laborers, banks, and government officials in the five districts in 1994. Selected case study interviews were also completed. Data coding and checking was completed in September. Survey results are being analyzed by the IIMI/BSERT team and will be completed by June of 1995.

The field work for the present report was completed during late December of 1994 to mid January of 1995. The authors conducted interviews with private firms and public officials in Dhaka and in two of the districts (Nilphamari and Comilla) studied by the IIMI/BSERT research team. The field work schedule had to adjust to the frequent general strikes (Hartals) which paralyzed normal life in late December and continued into January.

Minor irrigation is very important to food production, poverty alleviation and economic growth in Bangladesh. A change to market oriented policies in combination with minor irrigation equipment, high yield varieties, and modern input use have achieved high growth rates of food production in Bangladesh.

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[57]This paper has been prepared as part of the Study on Minor Irrigation Privatization in Bangladesh conducted by IIMI (the International irrigation Management Institute) in association with the Ministry of Agriculture with funding from the Asian Development Bank. Donald W. Larson and A.M.M. Shawkat Ali prepared this report during January, 1995 for inclusion in the over-all Study.

Food grain production has increased at 2.6 percent per year, faster than population growth of about 2.2 percent per year, for the last 20 years causing the real price of rice to decline (Haggeblade 1994). This real income gain benefits all consumers and especially, the poor who spend up to 70 percent of their income on food.

Nationally the irrigated area was estimated at 6.5 million acres in the 1993-94 winter season (Rabi) with rice accounting for over 6 million acres (Table 1). Irrigated area has expanded rapidly, especially since 1987, when the Government of Bangladesh (GOB) adopted a market liberalization and privatization policy for minor irrigation. More expansion of irrigated area can be achieved because the irrigable area of the country is estimated at about 11 million acres. STW, the fastest growing irrigation mode, accounts for 53 percent of the acreage followed by LLP and DTW. STW is the fastest growing mode and is preferred by most farmers. STW is dependable as evidenced by only a 6 percent ratio of non-operating units to total units compared to a 27 percent rate for DTW and 10 percent for LLP.

CHANGING VIEWS OF CREDIT AND FINANCE

Traditional Credit Projects

Agricultural credit has often been viewed as essential for the expansion of food production, for the adoption of new farming technology, and for the improvement of rural incomes, especially for small farmers. Since the 1960s, many developing countries including Bangladesh have emphasized the expansion of food production, especially grains, to improve food consumption levels for rapidly growing populations. The Green Revolution technologies offered new hope for increased production, but adoption of the new technology usually required more cash expenses by farmers to purchase the input package of new seed varieties, chemical fertilizers, and pesticides. An expansion of credit to purchase the new inputs was viewed as necessary for large and small farmers to adopt the new technology. Neither informal lenders nor formal financial institutions were considered willing and able to meet this increased demand for credit. This view led governments and donors to conclude that credit market failure existed and that government intervention through selective policies and projects could solve the problem. This view provided donors and governments the rationale to support special credit projects, frequently at subsidized rates of interest, to speed adoption of the new technology and to expand food production (Meyer and Larson 1993).

Specialized government owned credit agencies were created to channel funds to low income farmers to improve production and income, or to other low income groups to improve their income. Credit was usually provided at subsidized interest rates and frequently packaged with specified amounts of seed, fertilizer and pesticide that each targeted farmer should receive per hectare of crop produced.

Donors and governments placed much emphasis upon evaluation of the production impact of these targeted credit projects. The evaluations assumed that credit led to the technology adoption and to increased output. The evaluations failed to recognize the fungibility of credit so that the borrower may allocate the increased liquidity to the use with the highest expected return which may not be the new technology. If the technology was highly profitable, farmers may have been willing to purchase the inputs using informal finance or their own savings as a substitute for credit.

The traditional credit project placed no emphasis upon savings mobilization, financial market institutions or macro-economic and financial policies. Evaluations of the traditional credit projects found that many of these projects failed to reach the intended target groups with the cheap funds, had very poor loan repayment records, and that the participating financial institutions were financially weakened after the project was completed. Projects frequently collapsed when the donor funds were spent. A major conclusion from this experience is that a new view of rural financial markets, not traditional credit projects, is needed (Adams et al. 1984).

New View of Rural Financial Markets

The new view emphasizes liberalization of rural financial markets to achieve improved resource allocation through reliance upon competitive private markets. A major theme is that correct macro-economic and financial policies are necessary conditions to promote financial market development and general economic development. In the new view, satisfactory rural financial market performance is not possible in an adverse macro-economic and financial setting. The new view emphasizes floating exchange rates, less targeting of loans, more flexible interest rates for loans and deposits, more emphasis on deposit mobilization, less concessionary lines of rediscounting from central banks, more appropriate financial technologies to reduce transaction costs, building viable financial institutions and improved performance of rural financial markets (Meyer and Larson 1993).

The new view found that governments intervene in financial markets using several policy measures that frequently lead to many distortions and a high degree of financial market repression. Government intervention policies in many developing countries included interest rate ceilings on loans and fixed rates on deposits, high reserve requirements, fixed and overvalued foreign exchange rates, targeted lending at highly subsidized interest rates, government ownership of banks, and high transaction costs to borrowers and lenders. Policy makers in many countries recognized the problems of financial market repression in the 1980s and began to correct these policy distortions to create a more stable macro-economic and financial environment. Much policy reform has been accomplished in the 1980s but much remains to be done in many countries.

Positive real interest rates paid on deposits and charged on loans, nominal interest rates adjusted for inflation, characterize the new view. When positive real interest rates are paid on deposits, savers have an incentive to hold financial assets because of the opportunity to earn an attractive return on the financial assets. Positive real interest rates create an incentive for individuals to delay present consumption in favor of increased future consumption. In far too many cases governments control interest rates at some nominal level less than the inflation rate causing interest rates paid on deposits to be negative in real terms. When this occurs, savers have no incentive to save and a high incentive to consume. Savers are being taxed by holding financial assets and will want to hold as few financial assets as possible. Saving in other form such as inventories, land or jewelry is superior to holding financial assets.

When positive real interest rates are charged on loans, borrowers have the incentive to invest in only those projects that have an economic rate of return high enough to pay all the costs. Investment projects with a low rate of return will not be economically viable. When the financial market allocates resources between savers and investors in this way the market is operating efficiently. It is common for

governments to fix a maximum lending rate that is sometimes below the inflation rate causing the real rate of interest to be negative. In this situation the demand for loanable funds becomes infinitely large, because borrowers want to borrow the maximum and to repay the loans at some future date with a currency of lower value. Borrowers will propose any investment possible to borrow the cheap credit so resources will be allocated very inefficiently. Credit rationing will occur because banks cannot possibly satisfy the huge demand for funds that takes place. This creates many opportunities for distortions and bribes in the financial system. The negative real interest rates become a subsidy to the borrowers and a tax on the savers.

RURAL FINANCIAL MARKETS IN BANGLADESH

Formal Financial Institutions

Until the 1980's, the public credit programs, based on the need for government intervention, were pursued to stimulate rural development, in particular, food production. This approach led not only to the establishment of specialized farm credit institutions like BKB but it also led the state-owned commercial banks to provide farm credit. This happened in the late seventies following the Special Agricultural Credit Program (SACP). These banks had to open branches in the rural areas.

Government intervention also occurred in the cooperative sector. The Integrated Rural Development Program (IRDP) was launched in 1970 and later transformed into what is known as the Bangladesh Rural Development Board (BRDB). The BRDB finances employment and production programs for the rural poor and farmers affiliated with Thana Central Cooperative Associations, and their primary societies such as the Krishi Samabaya Samity (KSS) two-tier cooperative structure, and also provides credit to its own members.

During the early and late 1970s, non-government organizations (NGOs) and also Grameen Bank started programs as alternative sources of credit for the rural poor. Additionally, during the 1980's, GOB privatization policy led to the growth of private commercial banks.

Following these developments, the financial institutions consist of the following:

Type of Financial Institution and Number of Firms

a. Bangladesh Bank (BB, Central Bank) 1
b. Nationalized Commercial Banks (NCBs) 4
c. Private Commercial Banks (PCBs)10
d. Foreign Banks (FBs) 6
e. Development Financial Institutions (DFIs) 4
f. Grameen Bank (GB) 1
g. Non-Government Organizations (NGOs) - over 10,000
h. Non-Banking Financial Institutions (NBFIs) 9
I. Post Office Savings Banks (POSB) -

For purpose of the present study, the relevant institutions are the NCBs, PCBs and two DFIs (Bangladesh Krishi Bank, BKB and Rajshahi Krishi Unnayan Bank, RKUB), Bangladesh Rural Development Board (BRDB), Grameen Bank (GB) and NGOs like Bangladesh Rural Advancement Committee (BRAC) and Proshika. These are the major institutions that lend to the rural sector including agriculture and minor irrigation equipments (Figure 1).

It was not until the early nineties, however, that the GOB adopted specific financial sector policy reform measures (FSRP) in consonance with the new view of rural financial markets.

Interest Rates

Effective from January 1, 1990, the Bangladesh Bank (BB) declared its new interest policy under which two important developments took place. **First,** the system of refinance for agricultural credit was abolished. Under the refinance mechanism, the banks would first disburse agricultural loans and then claim reimbursement from the BB with an interest rate which was generally lower than the prevailing bank rate. **Second,** the system of administered interest rates (i.e. interest rates as fixed by the BB for different lending programs) was eliminated. The banks now could fix their own interest rate within a band determined by the BB.

Some exceptions were made for Bangladesh Krishi Bank (BKB) and Rajshahi Krishi Unnayan Bank (RKUB). These two banks could avail of the refinance facility according to a revised interest rate matrix until June 30, 1991 (Bangladesh Bank, *Annual Report 1991-92*, p.48). Effective from July 1, 1991, the decision was taken to provide refinance to these institutions at prevailing bank rates. In case of lending to BRDB by the NCBs, the system of refinance was allowed to continue at the existing rate of interest.

Finally, effective from 1991-92, all banks were authorized to prepare and implement their own agricultural credit programs, a task which was hither to done by the Bangladesh Bank. The banks were enjoined by the BB to rely on their own funds to carry out the lending program. At the same time, the BB assured the banks that depending on a satisfactory level of lending and recovery and the overall liquidity position, refinance would be made available (Bangladesh Bank, *Annual Report 1991-92*, p.45). Another important development during the period was that the agricultural loan ceiling of up to 2.50 acres was increased to 5 acres.

In order to speed up economic development following a market led growth strategy, the BB in April 1992 abolished a band on interest rates in all sectors except agriculture, exports, and small and cottage industries. During the same year, a minimum ceiling on deposit interest rates was also established. The same policy continued into 1992-93 until the bank lending rate of 8.5 percent was reduced thrice and on April 24, 1993, it was fixed at 6.5 percent. Similarly the minimum interest rates paid on fixed deposits and savings were reduced to 5 percent and 6 percent, respectively. On January 1, 1995, the bank reduced lending rates to 5.5 percent. With all these changes the interest rate structure has changed from negative real rates of interest in the early 1980s to positive real rates in the early 1990s. The current loan rate, ranging from 11 to 16 percent, is clearly positive in real terms at an inflation rate of 1.3 percent annually for 1994. The interest rates are as shown in Annex I.

Several other important changes have made in the last 2 to 3 years. Interest due on loans is now calculated using simple annual interest only, rather than calculating interest due by compounding periodically at a stated interest rate as had been done in the past. This change lowers the cost of funds

to borrowers. In an attempt to encourage repayment of past due loans, banks will waive 50 percent of the past due interest and 100 percent of the penalty interest. These changes have helped banks to improve collection of past due loans. For selected investments in livestock, dairy and others, a credit guarantee scheme is available from the BB to assume some of the bank risk for these loans. If the borrower has 20 percent equity for a proposed investment, the 80 balance can be financed through this credit guarantee scheme. To reduce costs and improve credit delivery, the BKB is experimenting with the concept of a credit delivery agent who borrows from the bank, assuming the credit risk with the bank, who then lends the funds to borrowers and collects payment from these borrowers. The credit delivery agent earns an interest rate spread determined by the bank to compensate for his costs of lending and default.

Agricultural Loan Disbursement and Recovery

As already stated, public sector credit hinged on a refinance facility from BB until the 1990's. The flow of credit since 1980/81 is shown in Table 2 . Loan disbursement of Tk 11.0 billion 1993/94 equals about U.S. 275 million at the exchange rate of Tk 40 per U.S.$ in January, 1995.

The credit picture is indeed dismal. Since 1986-87, the recovery rate shows a decreasing trend except for the year 1988-89. The loan recovery rate has improved slightly since 1990/91. The alarmingly low recovery rate and consequential piling up of overdue amount indicates that the public sector credit program has become dysfunctional from a financial management point of view. It is relevant to mention that the overdue amount of Tk. 42.0 billion is in fact under stated if the loan forgiveness amounts are added. The GOB loan forgiveness happened twice, first in 1987-88 and then in 1991-92. Without the loan forgiveness, the overdue as a percentage of arrears amounts to about 82 percent.

These are several reasons for this state of affairs. **First,** indiscriminate lending following public policy statements from political personalities. **Second,** local influences exerted upon bank managers to lend. **Third,** malpractice on the part bank staff in some cases. **Fourth,** absence of focus on timely recovery. **Fifth,** loan forgiveness policies pursued by successive governments. **Sixth,** lax attitude of the borrowers to repay. **Seventh,** unwillingness or inability of the bank managers to recover money. **Eighth,** liberal loan classification criteria and absence of enforcement of the same (See Hakim 1988 for more discussion of these loan recovery problems).

The liberal loan classification system allowed overdue loans exceeding 12 months to be classified as substandard, those over 36 months as doubtful and 60 months as bad and loss. Following the financial sector reform program (FSRP), a new system has been put in place. Since December 1994, overdue loans exceeding 3 months have to be classified as substandard, those over 6 months as doubtful and those over one year as bad and loss. The banks have to build up necessary reserves for the entire amount of classified loans. The banks have to curtail funds from profits to meet the loan loss provision requirement.

BB has instructed the lending institutions to cut 10 percent of their substandard loans, 50% of the doubtful loans and 100% of the bad loans. Available evidence indicates that of total loans advanced including agriculture, bad and loss loans according to the previous criteria would amount to 12 percent of the total disbursement of Tk. 250 billion. Under the new system, the amount would be more than 32

percent of the total disbursement. The amount of total classified loans under the previous system was 32 percent; which under the new system would be more than 80 percent.

The amount classified in agricultural lending might be around Tk. 40 billion or more. Enquiries made with BB reveal that the commercial banks have already started classifying their loans according to the new system but they are progressing slowly because adequate information from all branches is still arriving. It is believed that the condition of the PCBs with regard to non-performing loans are worse than the NCBs. In the case of some PCBs, over 90 percent of the loans are bad. Recently, loan recovery from current due is said to be 75 percent which is a big improvement over past performance.

Despite the very low loan recovery situation, agricultural loan disbursement in recent years has shown an increasing trend (Tables 2 and 3).

About 66 percent of the agricultural loans are provided by the two DFIs, (BKB and RKUB) while the Participating Commercial Banks, almost wholly the NCBs, provide about 31 percent (Table 3). The Bangladesh Rural Development Board (BRDB) which is a public sector organization for promotion of cooperatives ranks third. Overall disbursement is increasing in these three years. A more detailed account of the agricultural lending program in Annex II and III shows that actual disbursement is much lower than what is programmed. Thus actual disbursement in 1990-91 was 45.5 percent of what was programmed. In 1991-92, disbursement was 60 percent and in 1992-93 it went down to 57 percent. Whilst this is the general trend in loan disbursement, the case of minor irrigation is similar.

Credit for Minor Irrigation

During the period from 1987-88 to 1992-93, different lending institutions had lent a sum of Tk. 1.25 billion for minor irrigation. There is adequate evidence that the amount actually disbursed is much less than what was programmed. On an overall basis, only 23.8 percent of the programmed amount was disbursed. The actual disbursement in different years ranged from 10.7 percent to 46.2 percent of the amount programmed (Table 4).

Table 4 indicates that lending institutions are not short of cash; however, their lending performance is poor. This is possibly explained by fear of non recovery, overly bureaucratic disbursement procedures, and earlier loan default on the part of the borrower.

Lending by institution for minor irrigation indicates that BKB is the biggest lender followed by BRDB and then Sonali (Table 5). Overall lending is declining except for the year 1990-91 and after 1991-92 there is a sharp decline. The private sector banks, except Uttara, do not lend for minor irrigation equipment. Uttara, however, has long been a nationalized sector bank and was privatized in the late eighties. Similarly Rupali was in the nationalized sector but is now a private limited company. Recovery performance by institution is not available with BB; however, their assessment is that given the very low rate of recovery of agriculture loans in recent times (15% to 18%) recovery rate for minor irrigation would be around 10 to 12 percent.

Additional financial outlets are provided by the Grameen Bank (GB) and NGOs. Grameen Bank is widely known as a unique financial institution for group based lending to the rural poor and obtaining high recovery rates of 98 to 100 percent. Grameen Bank started a DTW program in Tangail that is mainly concentrated in the North-West districts of Rangpur and Dinajpur. GB bought a total of 805 DTWs from BADC and BWDB and established The Grameen Krishi Foundation.

Two more NGOs (BRAC and Proshika Manobik Unnayan Kendra, Proshika Human Development Center) are very prominent in minor irrigation lending. Both are group based lending programs.

BRAC's Irrigation Program creates employment opportunities for the landless poor. Under the program, individual Village Organization (VO) members, including women, become shareholders in an irrigation group and elect an operations committee. This group receives from the Rural Development Program/Rural Credit Project (RDP/RCP) a capital loan to buy a DTW and an operating loan to pay for fuel and wages. Farmers pay the group in cash or in kind for water from the DTW. Cash payments for the irrigation fees have increased from 25 to 30 percent of the payments in the past to more than 60 percent today. This program had 592 DTW in the 1992/93 boro season irrigating 27, 124 acres.

Proshika has pursued a pioneering irrigation management strategy since 1980, which attempts to develop an alternative sustainable irrigation system managed by the poor, to reconstitute the dominant-dependent relation. The objective of this strategy has been to extend access of the poor to irrigation bound water resources (surface and ground).

Proshika endeavors to ensure poor people access into those areas which lets them develop an irrigation service selling enterprise. This enables them to share the increased productivity of land leading to empowerment of the landless and marginal peasant groups in the rural setting.

The Proshika irrigation program has four components:

1) Mechanized irrigation projects like DTW, STW, LLP, etc.
2) Manual irrigation projects such as treadle pumps.
3) Ecological agriculture practices in irrigated command areas.
4) Power tillers as mechanical draft power.

Since the inception of the program through 1992-93, the program has expanded to a total of 820 irrigation projects at an average rate of 63 new projects every year. Proshika target groups implement all the projects.

Other NGOs include CCDB, and CRWRC. Maloney and Ahmed have studied at length NGO credit programs. Among others they have noted that NGOs have a wide range of methods and topics of record keeping. The percentages of past due loans are not comparable among the different agencies because of differences in computation. Some agencies carry a burden of old unredeemable loans on their books while others compute current loans only. Some count back interest due, but others do not. Some NGOs do not consider a loan as overdue until after several months or even two years, or they do not count overdue on installments until after the final payment is overdue. Some have a loan fund which has revolved many times so the total amount lent is not clear. A few NGOs do not have records but only rough estimates of credit activity and repayment. For all these reasons comparisons of scope, repayment rates, and effectiveness are difficult.

Informal Financial Markets

Informal financial markets, that is lending outside the regulated formal financial institutions, continues to be important in Bangladesh. A national survey of rural households in 1987 showed that more than a third had borrowed during the year, with 70 percent of the loans worth 60 percent of the total value

borrowed coming from informal financial market sources. While the ratio of informal-to-total credit in rural areas has declined over time, the total value of informal financial transactions has likely increased due to the dual expansion in the overall economy and increased formal lending, which may in turn provide additional funds for informal lending (Adams 1992).

As is the case in most countries, half or more of the informal loans are provided by friends and relatives--often on highly concessionary rates, open-ended repayment terms and typically involving reciprocity. Most of the other informal loans are extended on commercial terms by agribusinesses, owners of local retail shops, and part-time moneylenders. Many of these loans are embedded in other market transactions that might include borrowers selling their products to the lender, labor arrangements, land tenure contracts, and individuals extending their goods on consignment for later sale (Chowdhury 1993). These loan contracts involve explicit as well as implicit terms. For example, a lender may be socially obligated to intervene with authorities should one of his borrowers encounter difficulties. In contrast to most formal lending in Bangladesh, informal lenders are viewed as being dependable, they make loans quickly, offer flexible terms, and impose few transaction costs on borrowers. One interpretation of the high loan recovery rates in informal finance is that borrowers value a sustained relationship with informal lenders (Adams and Fitchett 1992).

The present authors recognize that the topic of informal finance is controversial. In one view, informal lending is exploitative, with high interest rates, land foreclosures, or associated price gouging being cited as evidence. An alternative view is that some interest rates may be high, but that borrower transaction costs on informal loans are low, that high opportunity costs of funds exist in rural areas, that the risk and costs in rural lending are high, and that there are few apparent barriers to entry for informal lending. It has also been argued that most merchants and traders offer loans to compete for business (Meyer and Larson 1993).

Lending is only half of the picture in informal finance. Someone must defer consumption on each taka that is informally lent. The savings may be marshaled by the individual providing the loan or by informal groups. The large amounts of funds that circulate in informal financial markets and the success of Grameen Bank and BRAC in mobilizing deposits suggest that voluntary savings capacities in rural areas may be larger than heretofore thought.

Agribusiness Markets and Credit

For agribusiness financing, the informal finance associated with modern input markets, and the informal lending in major product markets offer insights on what is currently being done and opportunities to expand formal and informal financing. At higher levels in the marketing chain, input and output dealers are normally separate, although they overlap farther down the marketing chain near the producer. The people and the business for the two categories may be different even though they are similar in principle and may refinance through the same mechanisms.

Input Markets

Private agricultural input dealers in seeds, pesticides, fertilizer, deep tube wells (DTW), shallow tube wells (STW), low lift pumps (LLP) and other agricultural equipment are increasing rapidly in number. In the majority of cases these are new dealers (69 percent of BSERT sampled traders started in 1988 or later) who are mostly independent of older firms that handle farm products (Parker, D.E., S.K. Raha and M.A. Hakim 1994).

Investment capital, working capital and credit arrangements are becoming increasingly important in these markets. The investment costs and sources of funding for the IIMI/BSERT sample of traders indicates an average shop cost of TK. 30,000 and average inventory of Tk. 125,000 (Table 6). The source of funds for current inventory is own funds 66 percent, supplier credit 16 percent and bank credit 13 percent.

Bangladesh uses annually over 2.1 million metric tons of fertilizer materials which are valued at about 300 million dollars. The fertilizer market has grown at an average annual rate of 5 percent since 1984, despite the almost complete elimination of most fertilizer price subsidies in recent years. At un-subsidized prices, an additional 1 taka in fertilizer will increase paddy yields and value of output by 2 to 3 taka (Chowdhury 1993). The fertilizer market has changed dramatically in recent years through increased private sector participation to include an estimated 130,000 dealers.

Many fertilizer wholesalers use the cash credits available from the banking system for working capital and for on-lending to lower levels in the marketing chain. Some short-term credit flows from the wholesaler to the retailer and then to the farmer but the amount appears to be small and cannot be well documented. If more funds were available, wholesalers indicated a willingness to lend more to their customers. In addition, many wholesalers would expand their business with more credit by selling new products such as pesticides and agricultural machinery, or by building warehouses (IFDC 1990/91).

The GOB privatization policy for fertilizer has produced some positive results that can be replicated in other agribusinesses sectors. Competition in the fertilizer sector has reduced prices and costs of distribution. GOB subsidized fertilizer prices, sales on credit, and subsidized distribution costs are gone, yet the sector is performing well. Most would not have predicted such a result. Because of increased efficiencies, farmers have saved an estimated Takas 924 million (roughly two and a quarter million dollars) in 1990-91 from lower fertilizer prices. Other tangible benefits include increased availability of supply, improved timeliness of distribution, and better service to customers. A young, dynamic, successful and entrepreneurial class has emerged in the growing fertilizer business that is providing the farmers with many benefits (IFDC 1990/91).

Private sector merchants of agricultural equipment have become increasingly important since the GOB reforms to encourage privatization in the late 1970s. Private sector participation has increased from less than 10 percent of sales to over 90 percent while the government owned Bangladesh Agricultural Development Corporation (BADC) share has decreased to less than 10 percent of total sales. Sales of minor irrigation equipment, mainly for shallow tube wells (STW), include electric motors, diesel engines, pumps, pipes, and fittings, account for a large part of these sales. Other agricultural equipment such as power tillers and spares also represent an important portion of sales.

Credit is used as a competitive device to increase sales. The IIMI/BSERT trader survey found that 90 percent of sample traders provided at least some sales to customers on credit. Credit accounted for 23 percent and cash for 77 percent of sales. Credit flows from importers to wholesalers to retailers on

a short term basis; often no explicit interest is charged. However, credit sales tended to have a price that averaged 2 percent higher than cash.

A second study of traders conducted by the Crop Diversification Program in 20 districts found that 61 percent of dealers awarded credit to their customers in 1990/91: The credit took the form of a delayed payment for 1 to 2 weeks with repayment in cash 69 percent and in kind 31 percent.

In the IIMI/BSERT sample survey of producers/pump owners, funds used to purchase irrigation equipment are own funds 70 percent and credit funds for 20 percent (Table 7). Pump owner funds for operating and maintenance are mainly own funds 62 percent and money lenders 19 percent (Table 8). In this same survey, pump owners were asked to compare availability of inputs and support services in 1993/94 compared to 1988/89 (Table 9). The most striking result is the overall improvement in availability of all items except for credit. Credit availability has declined according to 87 percent of pump owners.

Output Markets

Bangladesh has elaborate, largely competitive and efficient marketing systems for its major agricultural products. There are considerable amounts of credit connected with these marketing systems, extending down to the farmer; a variety of studies have been made both of these systems and the connected credit. A considerable amount of bank credit is involved with these marketing systems, some portion of which is presently lent to farmers. The constraints to expanding bank lending seem particularly present in paddy and rice trading, due largely to the legacy of previous anti-hoarding laws and regulations and low current repayment rates (World Bank 1992).

Bangladesh's rural commodity markets, especially those for rice, wheat, jute, and potato are generally efficient and competitive and involve a large amount of trade credit. The banks continue to extend credit to traders -- especially to those at secondary and terminal (tertiary) markets, and they in turn do a considerable amount of on-lending. Depending on the market, this on-lending has either been facilitated by special programs, or discouraged by bank regulations.

The use of informal and formal credit by 620 farmer cultivators was studied by IFPRI for 1989/90 from a sample survey covering 34 upazilas from 21 districts (Choudhury 1993). As can be seen from Table 10, only 14 percent of all farms took bank credit in the amount of Tk.6,900 for 4.3 months at 16.6 percent annual interest. Informal credit use was more frequent at 18 percent, for smaller amounts (Tk. 5,400), and marginally higher interest rates of 19 percent annually. The same study also found that only 4 percent of farms had used the pre-harvest credit contract (dhaner upore) that is frequently mentioned as a usurious credit arrangement and he concluded that this arrangement is quantitatively insignificant. The general results suggest a high incidence of internal finance among these cultivators. Farmers obtained a non-negligible part of trade credit demand.

Credit use among 115 paddy traders and 521 rice traders was studied in 12 "surplus" and 9 "deficit" cereal producing districts in 1990/91. The study concludes that trade credit is actively disbursed and received in all levels of the marketing chain. Over 75 percent of agents disburse trade credit and about 66 percent receive it. Net disbursement was estimated at Tk. 33.9 billion or Tk. 179,500 per establishment. Bank credit was only 4 percent of rice credit market's net disbursement. Paddy and rice wholesalers (aratdars) account for only 20 percent of the sample but 60 percent of trade credit.

disbursement and 58 percent of trade credit receipts. The study concludes that informal credit has a towering presence and performs a fairly positive role in rice markets (Choudhury 1993). Repayment rates are not discussed explicitly but one can safely conclude that repayments rates must be high or the trade credits would cease to be important.

The success of informal trade credit contrasts sharply with the poor repayment rate for the Food grain sector loan portfolio with commercial banks (Table 11). The average line of credit was Tk. 640,000 (US$ 16,000) with a one year maturity and the average amount borrowed was Tk. 380,000 (US$ 9,500). Forty percent of the loans and 81 percent of the amount was overdue. Nearly 50 percent of the loans and 72 percent of the amount was overdue for more than a year suggesting a low probability of recovering the amount due (Slover 1994). This may also explain some of the bank reluctance to lend more to rice traders.

CURRENT PRIVATE AND PUBLIC FINANCE FOR MINOR IRRIGATION EQUIPMENT AT THE NATIONAL, DISTRICT AND THANA LEVEL

North-East Minor Irrigation Project

The GOB has initiated a North-East Minor Irrigation Project (NEMIP) financed by a US$ 73 million loan from the Asian Development Bank (ADB Loan No. 1125); US$ 2.7 million Special Fund from the GOB, and US$ 17.4 million by local banks and borrowers. The NEMIP is approved for 6 years beginning in December 1993.

The project objectives are: a) to improve the amount and equity of agricultural incomes, b) to enhance the nutritional balance of food crop production, and c) to improve the contribution of agriculture to the national economy. The project includes three components and three implementing agencies:

(1) The Bangladesh Bank for credit of US$ 43 million for financing the procurement of various minor irrigation equipments and farm machineries by sub-borrowers through participating banks. Participating banks include NCB's and PCB's. Borrowers can finance 80 percent of the cost at prevailing market interest rates (20 percent equity required) of diesel engines, pumps, pipes, power tillers and similar equipment through this program for one year with up to a three month grace period.

(2) The Local Government and Engineering Department (LGED) for transportation infrastructure construction of about 6000 meters of bridges and culverts to provide easy access from farms to growth centers and drainage facilities to the cropping areas.

(3) The Department of Agriculture Extension for ground water exploration and development, irrigated demonstration farms and farm technology and investment and benefit monitoring and evaluation.

Project implementation has been delayed due to staffing difficulties; however the problems have been solved and project implementation has begun. Work on the last two components is underway but the credit component is behind schedule. In July 1994, the ADB reduced the credit component from US$ 43 million to US$ 18 million because of lack of demand for this credit in the project area. The credit component is an innovative program involving traders, bankers and others that will require full technical support from the project if it is to succeed. The U.S. AID experience with the fertilizer distribution project indicates that substantial technical support is needed. The credit component has no planned long term or short term technical assistance to support that activity in the project appraisal report. In contrast, the first two components seem to be fully supported by the planned technical assistance. The project needs short term technical assistance on the credit component to speed understanding of the credit component and to initiate use of the funds among traders, bankers and others.

National Minor Irrigation Development Project

The GOB/World Bank/EU funded National Minor Irrigation Development Project (NMIDP) aims at promoting growth in agriculture through increased private investment in minor irrigation development. This objective is to be achieved by (a) providing wider and more equitable access to minor irrigation through the introduction of more affordable and manageable irrigation technologies; (b) institutionalizing policy changes recently introduced by GOB to liberalize trade and siting of equipment; © upgrading BADC's capability to support the private sector through advice, market information and quality enhancement; (d) facilitating access to DTW ownership by opening ownership to various forms of association besides traditional cooperatives; and (e) assisting GOB in introducing and maintaining a nation-wide minor irrigation development program.

It is an innovative project that seeks to respond to the needs of farmers to a range of DTW facilities providing opportunities for the private sector to market DTWs of different capabilities. It calls for phasing out subsidies of 2-cusec DTWs, equalizing duties on imported equipment between public and private sectors, elimination of standardization requirement, providing private sector access to resources on the same terms as public agencies and eventual phasing out of public sector direct involvement in DTWs. The project is under implementation but the progress is slow (World Bank 1991).

Agribusiness Technology Project

The GOB/USAID Agribusiness Technology Project (ATD) is designed to use technical assistance, commodity imports, and credit to accelerate private sector investment in production and marketing of agricultural inputs by promoting open competitive markets and increased private sector participation in imports, production, marketing, and distribution. This will include seed, agri-equipment, post-harvest processing, horticulture and poultry. The 10 year project for US$ 80 million, scheduled to begin in 1994, has been delayed and reduced to an estimated US$ 4 million. ATD will begin in 1995. The new project expands beyond and builds upon the experience of the recently completed Fertilizer Distribution Improvement Project. The contractor on both projects is the International Fertilizer Development Center.

Crop Diversification Program

The Crop Diversification Program (CDP), with funding from the Canadian International Development Assistance Agency (CIDA), aims to promote, train, and assist the Department of Agricultural Extension for expansion of oilseed, tuber, and pulse production. Through this program, input dealers were studied in 90 Thanas in 1992. The report is in 2 volumes of which volume I is the main report and volume II contains the statistical annex. In the Thanas, an estimated 11,529 agricultural input dealers (fertilizer, seed POL, irrigation equipment and farm machinery) either in combination or singly were identified. Fertilizer dealers dominate the numbers (88%) followed by pesticides (53%). The wholesale dealers at the Thana level are low in number ranging from 0.8% to 6%. The retailers dominate the market.

The report found that nine private commercial banks (PCBs), four nationalized commercial banks (NCBs) and two specialized agricultural banks and one cooperative bank operated in the Thanas. The NCBs had the most branches (692) followed by the specialized agricultural credit banks (244). On average, there are about 12 branches per Thana. Four banks, BKB, RKUB, Rupali and Sonali, were interviewed. In addition, one NGO, BRAC was also interviewed.

Most of the dealers/traders did not avail any bank credit; ranging from 91 to 100 percent. In terms of lending to the agricultural sector, the NCBs and the specialized agricultural credit banks play a leading role.

For irrigation and farm equipment, these banks follow more or less the same credit norms. For DTW, 3 acres of land must be mortgaged to the banks along with the equipment. The down payment requirement is Tk. 6500.00 and the repayment period is 9 years, in semiannual installments excluding a grace period of six months. For LLP and STW, 0.5 acres of land including the equipment are mortgaged to the bank. The down payment requirement for LLP or STW is Tk.1000.00. The repayment period is 5-6 years in annual installments with a one year grace period for BKB, RKUB and Rupali while in Sonali Bank the repayment period is 6 years in semiannual installments with a 6 months grace period.

For power tillers/tractors credit, 50 percent of the value of the equipment is taken as security and for the remaining amount collateral securities are required. In case of power tiller, down payment requirement is 10% of the price while in case of tractor it is 30%. Repayment period is 6 years in semiannual instalment with a 6 months grace period.

The average time taken to process a loan case varies from bank to bank ranging from 7-60 days.

At upazila level 70 bank managers were interviewed to ascertain the credit support to the dealers/traders of agricultural inputs. Out of the 70 managers, 63 percent belong to BKB, 17 percent to Sonali, 13 percent to RKUB, 3 percent each to Agrani and Rupali and 1 percent to Janata.

The results of the survey indicate that overall credit support to dealers/traders is rather weak and there is a lot of scope for strengthening the credit support program. Thus in 1991, of the 70 branches surveyed, only 48 (69%) had programs providing credit to the dealers. Of these 48 branches, only 41 made disbursements and there was reasonable recovery in only 27 branches. Thus, the overall scenario has two aspects. First, of the branches having a program for credit support, seven branches did not make any disbursement and, second, 22 branches did not have any program at all. A related aspect is that no credit is provided to dealers in POL.

The program for credit support in the 48 branches was estimated at Tk. 35 million in 1990-91. This means an average per branch credit provision of Tk. 0.73 million. Credit disbursement equaled Tk. 17 million which is about 51 percent of the estimated credit support. This means that about 49 percent of

the credit provision remained unutilized. Five hundred ninety seven dealers/traders obtained credit which is an average per dealer of Tk. 29,950.00.

Insufficient credit support is explained by (a) low level of recovery (b) previous irregular credit provided due to corruption and © lack of credit worthiness. In some cases, local interference dissuades managers from providing loans. Of these reasons, low level of recovery appears to be the principal constraining factor. This factor emanates from a number of reasons such as lack of strict supervision, lax attitudes of the borrowers which is further strengthened by loan forgiveness by the government.

POSSIBLE TOPICS FOR ANALYSIS FROM IIMI/BSERT IRRIGATION SURVEYS

The following are possible topics that the IIMI/BSERT team may wish to consider for analysis subject to the data availability, time and financial resource constraints that they confront in this project. The IIMI/BSERT team is to be commended for what they have already accomplished in terms of questionnaire design, sampling procedure, interviews completed, and data processing for the study on the privatization of minor irrigation with IIMI. Interviews were completed with 240 pump owners, 187 irrigation equipment traders, and 45 repair workshops in the five districts surveyed (For a complete discussion of the survey methodology see IIMI/BSERT Progress Report No. 2 of April, 1994). Much survey data has already been analyzed and presented at a November 1994 workshop. More analysis is underway and will be presented in future papers and reports.

Statistical techniques such as Chi square, t test, analysis of variance, ordinary least squares, and logit models could be used to test the significance of relationships between borrower or firm characteristics such as age, education, land ownership, etc. and firm behavior in terms of loan repayment, profitability, yields, new technology adoption, labor employment, etc. Statistical differences in selected variables among the five districts surveyed can also be tested with these models. These tests can be run on statistical packages such as Statistical Package for Social Sciences (SPSS) that are available on microcomputers in Bangladesh.

Loan Recovery Models

Variations in repayment rates can be analyzed at the macro-economic level as well as at the micro level of the borrower. An innovative piece on the political economy of loan recovery in Bangladesh found that government political intervention reduces loan recovery (Khalily and Meyer 1993). As is well documented in the literature, Bangladesh has a rich history of government political intervention in credit markets through policies such as loan forgiveness and credit committees in election years. Five variables - inflation rate, election years, interest exemptions years, credit committee years, and bank type - were included in a model to explain loan recovery. The model parameters were estimated using ordinary least squares regression model with pooled data for five banks for the 1980-89 period. An R squared of 0.94 was obtained for the unrestricted model. The empirical results showed that elections, inflation rates, credit committees, and bank type affect rural loan recovery negatively, while interest exemptions affect it positively. The policy implications of the political intervention reducing loan recovery are clear.

Credit Scoring Models

Credit scoring models are widely used to attempt to explain variations in loan repayment rates at the micro level. The typical approach is to select a sample of loan applications already approved by the bank and classify them into "good loans" (loans that are current or paid off) and "bad loans" (loans that are delinquent or in default). Credit scoring models select those variables from among many possible variables that statistically can classify the loan into one group or the other.

One can use a linear probability model, probit and logit models, and/or a discriminant analysis model to analyze loan recovery (For a discussion of these models see Altman et al.).

Credit scoring models can assist lenders in making sound individual loan decisions and loan portfolio decisions in terms of accepting various levels of risk and the pricing of loans based on the risk level. The models can also be used to assist in loan monitoring to identify problem loans that need more attention. Credit scoring models do not substitute for good loan officer decision making.

A problem of these models is that credit scoring models are generally static, one period models that ignore the multi-period, dynamic nature of a credit relationship. The models are based on historical data under conditions that probably will change in the future. The models have not incorporated fully the value of future loans to the borrower as an incentive to repay the current loan. Presently, the credit scoring models have achieved very modest success and are not widely used by lenders. The models must have more predictive success to ensure widespread use.

Some of the data commonly used in the credit scoring models includes borrower characteristic variables, loan characteristic variables, lender characteristic variables, and regulatory variables. These may include age, gender, marital status, education, years in farming, land ownership status, tenancy, group size, group membership, number of bank supervision visits, assets, liabilities, income, bank rating of client, use of funds such as food crop, industrial crop, export crop, livestock product, machinery, loan collateral, source of funds such as bank resources, international donor, or government.

Borrower Transaction Costs

Analysis of borrower transaction costs could shed valuable light on the frequently mentioned problem of the high costs of borrowing from banks. Borrowers complain about the travel and time costs, fees and charges, bribes, and other non-interest costs that must be paid to borrow from banks. One estimate adds 6 percentage points to the loan interest rate to cover these added borrower costs. It would be instructive to estimate these costs for different size borrowers and types of lenders. IIMI/BSERT questionnaires appear to have sufficient detail to analyze these costs. Such research might identify ways to reduce the borrower transaction costs.

Lender Transaction Costs

In a similar way, study of financial intermediation costs by type of bank and size of branch might be useful. According to the Slover study, the average costs (total expenditure excluding interest costs divided by average deposits and average borrowing) ranged from 2.12 to 2.51 percent in the NCBs and

1.88 to 3.84 percent in the PCBs in February of 1994. More importantly, no costs are presented for the BKB or the RKUB the most important rural credit institutions. It might be useful to analyze these lender transaction costs at the district and branch level in the project area for selected banks. The research might identify ways to reduce lender costs and pass the savings on to the borrowers.

CONCLUSIONS

The new view of rural financial markets departs markedly from the traditional agricultural credit projects that focused primarily on lending to targeted groups of beneficiaries at subsidized interest rates. Numerous evaluations of these traditional projects have found that the intended beneficiaries were not the main recipients of the cheap credit, that the loan recovery was very low, and that the financial institutions were not strengthened as a result of the project.

A more comprehensive new view of rural financial markets has been developed that emphasizes correct macro-economic and financial policies, appropriate financial technologies and sustainable financial institutions as necessary conditions for rural financial market development. GOB has adopted this view, has reduced control of financial markets by liberalizing interest rates and the exchange rate, has the correct macro policies in place (lower inflation rates and fiscal deficit), and is attempting to have sustainable financial institutions. GOB must continue to move ahead on creating competitive, private financial markets. They must resist pressures that may arise to return to the traditional views of government intervention in highly regulated financial markets.

The GOB policy of privatization of input and output markets such as rice, fertilizer and minor irrigation equipment has been very successful, especially since 1988. Sales of LLPs, STWs, engines, fertilizer, pesticides, power tillers and other equipment have increased rapidly. The number of traders and dealers in these goods and services has also expanded very rapidly. Food grain production, increasing at 2.6 percent annually compared to population growth of about 2.2 percent annually for the last 20 years, has resulted in declining real prices of rice benefitting all consumers. GOB must build upon this success by expanding the market liberalization to other input and output markets. Seed markets among others appear to be strong candidates for more privatization. GOB has defined a new role for government that creates appropriate conditions for efficient performance of private markets, facilitates that performance through appropriate regulation but "gets out of the way" to let the private sector perform the economic tasks.

Demand for agribusiness credit has expanded as the number of traders and sales increased. Working capital from the banking system and short term informal trade credits are widely used among traders and dealers in output markets such as rice and input markets for fertilizer and minor irrigation equipment. Traders are interested in more working capital from the banking system to expand and improve their operations. Increased trade credit is expected to flow from importers/wholesalers to dealers and to farmers. Increased amounts of trade credit at the higher levels of the marketing chain would also increase trade credit to dealers and to farmers.

Rural financial markets have performed dismally in a dynamic and productive rural economy. Bangladesh farmers are largely self financing their activities; less than 20 percent receive credit from banks. Loan recovery and financial institution sustainability are very problematic in Bangladesh. Not

all the current institutions will survive. Major changes in number and size of financial institutions likely will take place in the next few years as banks adjust to the new financial realities. These adjustments may lead to increased privatization of banking and financial activities.

Strong support services are important for a strong agriculture. One would expect that agriculture support services such as input markets, output markets and finance institutions would prosper in a dynamic and productive agriculture. This has not occurred in Bangladesh. The IIMI/BSERT research and other studies have shown that minor irrigation equipment sales, other input sales, and output sales have performed well but that rural credit performance through formal institutions has been less than satisfactory. This unusual case merits further study and experimentation with new alternatives because credit market failure could adversely impact on agricultural production in the future.

RECOMMENDATIONS

The GOB recognizes that it has no effective means for rural credit (Bangladesh Observer, June 27, 1994). The old credit institutional means and policies have not been effective. The GOB desires to try innovative technologies to increase farmer and agribusiness trader access to credit and financial markets. New approaches are being used successfully by Grameen Bank, and some NGOs like BRAC and Proshika, but their programs focus mainly on credit to groups of women in poor areas. These programs generally do not work with farmers and certainly not with individual borrowers.

The BKB is experimenting with credit delivery agents as a means to reach small borrowers at a lower cost and assure recovery. The delivery agent borrows from the BKB and on-lends to borrowers and collects from the borrowers for repayment to the BKB. The entire loan taken by the credit delivery agent is fully secured by him. The credit delivery agent obtains funds from the bank at a favorable rate that allows the agent to cover the lending costs and default risk. The concept may work very well if the bank is very careful about selection of the credit delivery agents. Selection should be based upon clearly defined business and financial objectives so as to avoid the risk of selecting credit agents who may use the resources for political objectives. A credit guarantee scheme is also being used to encourage bank lending for investment activities where the BB and the lending bank share the default risk through the credit guarantee scheme. These types of alternatives need to be studied to see if they are working successfully.

Leasing may be an alternative for some agricultural equipment such as power tillers and tractors. Companies such as the Singer Company have used leasing successfully. Singer has used lease/purchase to work very effectively as a means to finance sales of sewing machines. At least one dealer is using leasing to finance the sale of power tillers to a group of farmers. This may be an attractive alternative for future sales of power tillers and other equipment.

Trade credits are another attractive alternative. The present study has discussed the strengths of informal financial markets such as trade credits as alternatives that work well for borrower and lender in terms of access to funds, low transaction costs, convenience, flexibility, and high repayment rates. Many young, more educated, and dynamic entrepreneurs have invested their talents and resources as dealers in minor irrigation equipment, fertilizer and other inputs in recent years. Bankers know little about

these dealers and the dealers knowledge of banking is limited. The bankers and the traders will depend increasingly on each other in the future as demand for financing increases.

The authors recommend that a pilot project be funded for three to five years to study the privatization of minor irrigation and to experiment with alternative credit delivery systems. The sustainability of the privatization process of minor irrigation depends on effective credit services: a) the availability of working capital loans for importers and traders, and b) access to credit for the ultimate purchaser of the minor irrigation equipment.

The project objective is to increase food production, employment and income among poor people in rural areas. A low income rural area that is beginning to grow rapidly such as the Nilphamari district will be selected for the proposed project. The project will work in two or three thanas in the proposed district. The proposed project would complement and strengthen the North East Minor Irrigation Project that is mainly focused on engineering construction and farm demonstration aspects of irrigation.

The proposed project will have three components: (1) a revolving credit component from BB through commercial banks to finance short term working capital for traders, dealers, and workshops of minor irrigation equipment, (2) a component to monitor the effect of privatization of minor irrigation equipment and associated services on increased food production, employment and poverty alleviation in Bangladesh, and (3) a training component consisting of workshops and seminars to work with bankers and merchants on using the credit fund, to disseminate technical information and business principles to dealers, and to report results of the monitoring component. The project will employ local and expatriate long and short term technical assistance, office staff and computer equipment to implement the components. Funding in the amount of US$ 5 million is proposed for this project.

The revolving credit component will operate from the Bangladesh Bank to qualified participating banks for lending to traders and dealers in the project areas. The interest rate spread must be attractive to encourage bank participation. This component may experiment with more than one credit delivery system to reach traders, dealers and farmers in the selected thanas. In the first thana, the credit component may involve only the traders, bankers, and farmers. In a second thana, NGOs may be included to work closely with the traders, bankers and farmers on the selection of creditworthy borrowers and the follow up activities.

The second component will monitor the effect of privatization in minor irrigation on food production, employment, and poverty alleviation. This will involve collection and analysis of information to monitor privatization in minor irrigation. Relevant information will be collected and analyzed from the production sector and the support services including input markets, output markets, and credit markets.

The third component will include workshops, seminars and other forums to disseminate information about the project to traders, bankers, and farmers. Recent experience from the fertilizer distribution improvement project suggests that this component will be important to improve communication and understanding among bankers, traders and farmers about project activities, and sound business practices and principles. Results of the monitoring of privatization will also be reported as part of this component.

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Several traders, farmers, pump owners, and others in Nilphamari, Saidpur, and Comilla.

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Table 1. *National totals of irrigation equipment in operation and corresponding irrigation command areas, 1993-94.*

Irrigation mode	No. of equipment operating	Unadjusted irrigated area ('000 acres)				Adjusted ('000 acres)	Irrigated area (% to total)
		Boro	Wheat	Others	Total		
Surface set Shallow Tubewells	348,213	97	476	352	3,652	104	
Deep set Shallow Tubewells	11,084		11	6	114		
Total Shallow Tubewells	359,297	2,921	487	358	3,766	3,447	53.2
Low lift pumps:less 1 cusec	16,521	135	16	45	197	152	
Low lift pumps: 1 cusec	16,393	353	9	15	376	302	
Low lift pumps: 2 cusec	19,014	729	9	14	752	631	
Low lift Pumps: 3 cusec	264	17			18	17	
Low lift Pumps:4 + above cusec	336	47			47	19	
Total Low lift pumps	52,528	1,281	35	75	1,391	1,121	17.3
Deep tubewells:	25,049	1,087	105	78	1,269	980	15.1
Treadle pumps:	123,594	30	11	21	62	61	
Rower pumps:	8,409	1		2	4	5	
Hand tubewells:	11,338	5	1	6	12	7	
Total,Manually operated pumps	143,341	37	13	29	79	72	1.1
Artesian and Traditional:	642,491	714	43	102	859	859	13.3
Grand Total	1,222,706	6,039	683	643	7,365	6,479	100.0

Source: Ministry of Agriculture, Assisted Transformation to Irrigated Agriculture Project (ATIA), FAO Project, 1994.

Table 2. Disbursement and recovery rate of agriculture credit, 1980/81 to 1993/94. Tk/million.

Year	Disburse-ment	Amount due for recovery	Amount recovered	Arrears	Overdue	Recovery over amount due
1980/81	3,734	4,524	2,214	5,785	2,349	49%
1981/82	4,238	6,483	3,143	8,399	3,243	48%
1982/83	6,786	8,173	4,423	13,515	4,566	42%
1983/84	10,053	12,402	5,176	20,771	7,557	42%
1984/85	11,498	15,150	5,839	30,342	11,589	39%
1985/86	6,317	23,752	6,072	35,143	17,788	26%
1986/87	6,673	26,835	11,076	32,944	15,760	41%
1987/88	6,563	25,282	5,960	83,635	19,324	24%
1988/89	8,076	21,177	5,780	47,117	23,557	27%
1989/90	6,868	39,863	7,019	53,813	39,863	18%
1990/91	5,956	41,282	6,253	57,035	39,338	15%
1991/92	7,946	41,702	6,621	53,696	35,723	16%
1992/93	8,419	47,199	8,692	55,675	38,544	18%
1993/94	11,007	51,419	9,791	51,419	42,037	19%

Source: Bangladesh Bank. Annual Reports for the relevant years.

Table 3. Agricultural loan disbursement by lending institutions, 1990-91 to 1992-93 Tk/million.

Institution	1990-91	1991-92	1992-93
BKB	3,241.7 (54.4)	4417.8 (55.6)	4,634.2 (55.1)
RKUB	370.6 (6.2)	617.1 (7.8)	1,004.3 (11.9)
Participating commercial banks	1,821.6 (30.6)	2,706.9 (34.1)	2,626.5 (31.2)
BRDB	499.4 (8.4)	173.5 (2.2)	119.2 (1.4)
BSBL	22.7 (0.38)	30.6 (0.39)	34.3 (0.41)
Total	5,956.0	7,945.9	8,418.5

Note: Figures in the parentheses indicate percent of the total.

Source: Bangladesh Bank, Annual Reports 1991-92, 1992-93, p.63 and 45.

Table 4. Programmed and actual disbursement of credit in minor irrigation Tk/million.

Year	Programmed	Actual disbursement
1987-88	1,028	190.6 (10.7)
1988-89	805.0	371.9 (46.2)
1990-91	1,500.0	342.0 (22.8)
1991-92	1,037.3	235.8 (22.7)
1992-93	883.8	111.0 (12.5)
Total	5,254.1	1,251.3 (23.8)

Note: Figures in parentheses indicate percent of the total.
Source: Bangladesh Bank, Annual Reports for the relevant years.

Table 5. Lending performance of different institutions for minor irrigation, 1988-89 to 1993-94 Tk/million.

Sl. no.	Financial year	Sonali Bank	BRDB	Janata Bank	Agroni Bank	Rupali Bank	Uttara Bank	BKB	RAKUB	Total
01	1988-89	69.0	54.5	2.7	4.2	1.0	-	141.6	10.0	228.5
02	1989-90	6.0	31.0	1.8	1.5	0.7	-	66.9	13.5	123.0
03	1990-91	13.4	232.1	16.1	2.4	0.2	-	61.5	16.3	342.0
04	1991-92	27.0	72.7	3.6	11.0	-	0.2	88.9	32.4	235.8
05	1992-93	6.0	43.7	3.6	3.6	-	-	38.1	16.0	111.0
06	1993-94	1.3	2.3	0.2	0.2	-	-	3.8	5.9	13.7
07	1994 Nov.	-	-	0.2	-	-	-	4.9	3.1	8.2

Note: Figures for 1987-88 are not available.

Source: Bangladesh Bank.

Table 6. Investment in irrigation equipment business by sample traders in five districts of Bangladesh, 1994.

A: Amount of Investment

Initial inventory cost at time of establishment

Mean	Tk. 229,183
Median	Tk. 60,000
Range	Tk. 1,5000 to 20,000,000

Initial shop cost

Mean	Tk. 101,899
Median	Tk. 30,000
Range	Tk. 200 to 3,000,000

Current inventory cost

Mean	Tk. 352,580
Median	Tk. 125,000
Range	Tk. 1,000 to 7,000,000

B: Sources of Investment Funds

	Initial inventory and shop	Current inventory
Average sources of funding		
Own funds	73%	66%
Supplier inventory credit	8%	16%
Bank credit	9%	13%
Non-institutional credit	8%	4%
Unidentified	2%	1%

Source: Survey of traders in Bogra, Comilla, Faridpur, Hobiganj and Nilphamari Districts. IIMI/BSERT Research Team, 1994.

Table 7. Distribution of pump owners by sources of funds for procuring irrigation equipment, 1994 (percent).

Sources of funds	DTW	STW	LLP	All technologies
Own funds	43.5	68.7	92.1	70.0
Credit	36.9	22.9	1.6	20.0
Own funds + Credit	17.4	6.8	6.3	8.8
Bank + Shop Credit	-	0.8	-	0.4
No response	2.2	0.8	-	0.8
Total	100.0	100.0	100.0	100.0

Source: Field Surveys in Bogra, Comilla, Faridpur, Hobiganj and Nilphamari, IIMI/BSERT Research Team, 1994.

Table 8. Distribution of pump owners by sources of credit for operation and maintenance of irrigation pumps, 1994.

Sources of credit for O&M	DTW		STW		LLP	
	No. of farmers	Percent of total sample	No. of farmers	Percent of total sample	No. of farmers	Percent of total sample
Own funds	34	73.9	86	65.7	39	61.0
Banks	2	4.5	5	3.8	5	7.9
NGOs	3	6.5	2	1.5	1	1.6
Money lenders	2	4.2	12	9.2	12	19.1
Friends & relatives	5	10.9	16	12.2	5	7.9
Other sources	-	-	10	7.6	1	1.6
Total	46	100.0	131	100.00	63	100.00

Source: Field Survey in Bogra, Comilla, Faridpur, Hobiganj and Nilphamari districts, IIMI/BSERT Research Team, 1994.

Table 9. Pump owners opinion regarding inputs and support services, 1994 (percent).

Items	Current year (1993/94)		Five years ago (1988/89)	
	Easily available	Not easily available	Easily available	Not easily available
Availability of machines	94.1	5.9	69.1	30.9
Availability of spare parts	95.0	5.0	66.1	33.9
Availability of mechanics	88.8	11.2	51.1	48.9
Availability of tubewell drillers	70.6	29.4	47.9	52.1
Extension services	8.7	91.3	11.6	88.4
Credit facilities	13.5	86.5	19.3	80.7
Insurance facilities	2.7	97.3	0.7	99.3
Diesel supply	97.4	2.6	85.6	14.4
Electricity supply	26.2	73.8	15.4	84.6
Availability of fertilizers	97.5	2.5	91.5	8.5
Availability of pesticides	93.7	6.3	88.9	11.1

Source: Field Survey in Bogra, Comilla, Faridpur, Hobiganj, and Nilphamari districts, 1994. IIMI/BSERT Research Team.

Table 10. Rice growers' access to institutional and other non-institutional credit, 1989/90, Bangladesh.

	Ownership size class					Deficit type	
	Marginal	Small	Medium	Large	All	Progressive	Non-Progressive
			Institutional				
No. of farms taking bank credit	1	21	30	44	96	45	51
% of farm taking bank	3	15	12	17	14	10	22
Average amount taken in bank credit (Tk. 000)	2.2	3.8	4.8	10.0	6.9	5.0	8.6
Average duration of bank credit (months)	4.0	4.0	4.0	5.0	4.3	4.0	5.0
Average interest per	16.0	15.7	18.0	16.4	16.6	17.6	15.7
			Noninstitutional Credit				
No. of farms taking noninstitutional credit	2	25	53	44	124	70	54
% of farms taking such credit	7	18	21	17	18	16	23
Average amount taken in informal credit	3.0	4.4	3.5	8.3	5.4	6.0	4.5
Average rate of interest per year (%)	120	19.3	15.2	18.8	11.0	29.4	

Note: Interest rates are weighted averages, weights being size class specific total credit contracted.
Source: IFPRI, Choudhury, 1993.

Table 11. Food grain sector loan portfolio of commercial banks as of October 31,1993 (loan amount in millions of taka).

Name of bank	No.Of branches	No. of borrowers	Amount sanctioned	Amount outstanding	No. Of overdue accounts	Loan amount overdue	Delinquency rate
Agrani	6	21	5.51	4.89	12	2.81	57
Al Baraka	2	4	8.30	7.36	4	7.36	100
AB Bank	1	2	0.28	0.06	0	0	0
City Bank	1	1	0.75	1.36	1	1.36	100
IFIC Bank	1	3	5.10	1.27	0	0	0
Pubali	5	9	6.34	4.25	1	0.18	4
National	6	22	14.74	14.15	8	5.90	42
Janata	74	340	280.75	128.85	132	126.52	98
UCBL	2	7	2.30	1.53	0	0	0
IBBL	4	14	9.07	5.71	2	0.21	4
Sonali	18	58	29.89	24.34	30	12.08	50
Total	120	481	363.03	193.78	190	156.42	81

Source: IFDC Food grain Credit Survey, November 1993.

Annex I

Interest rate structure in the banking sector of Bangladesh

Sl. no.	Classification of loan	Interest rate limit	Rate of subsidy	
		From July 1, 1992 to June 30, 1993	From July 1, 1992 to Jan. 22,1993	From January 23, to June 30, 1993
1	Agriculture	1.00-15.00	-	-
2	Term Loan in Large and Medium Industries	*	-	-
3	Current Capital of Jute Industries	*	-	-
4	Current Capital of other Industries except Jute	*	-	-
5	Jute Trade	*	-	-
6	Jute and Jute Good Export	7.50-10.50	0.75 **	-
7	Other Exports	7.50-10.50	0.75 **	-
8	Other Commercial Loan	*	-	-
9	House Building Loan (Urban)	*	-	-
10	Special Programme A. Term Loan in Small Industries B. Other Special Programme	8.00-13.00 *	3.50 -	3.00 -
11	Others	*	-	-

* Interest rate limit has been effectively withdrawn from the agriculture, export and small and cottage industries sector since April 1,1992 and authority has been given to all banks to determine the interest rate in those sectors. Subsidy has also been withdrawn from small and cottage industries since January 23.

Note: Loans including all current loans should fall in any of the above 11 classes.

** Interest subsidy has absolutely been withdrawn from export loan since August 31,1992.

\- Nil.

Source: Bangladesh Bank, Annual Report, 1992-93, p. 109.

Annex II

Comparative view of lending in agriculture sector for 1990-91 and 1991-92

Tk/million

Item	1990-91	1991-92	Yearly change (+) (-)
A) Lending Programmes	**13100**	**13221**	**+121 (+0.92)**
a. Crop Loan (Except Tea)	6500	6293.7	-206.3 (-3.17)
b. Irrigation Equipment	**1500**	**1037.3**	**-462.7 (-30.85)**
c. Livestock	750	821.4	+71.4 (+9.52)
d. Others including Tea and Fisheries	4350	5068.6	+718.6 (+16.52)
B) Disbursement	**5956**	**7945.9**	**+1989.9 (+33.41)**
a. Crop Loan (Except Tea)	2199.3	3463.9	+1264.6 (+57.50)
b. Irrigation Equipment	**342**	**235.8**	**-106.2 (-31.05)**
c. Livestock	353.8	673.8	+320.0 (+90.45)
d. Others including Tea & Fisheries	3060	3572.4	+511.5 (+16.71)
C) Recoverable Amount	**45590.7**	**41701.5**	**-3889.2 (-8.53)**
D) Recovery	6253.2	6621.1	+367.9 (+5.88)
E) Overdue	39337.5	35723.0	-3614.5 (-9.19)
F) Outstanding	57034.5	53695.6	+3338.9 (-5.85)

Note: Figures in parentheses indicate yearly percent change.

Source: Bangladesh Bank, Annual Report 1990-91, 1991-92, p. 60 and p.43.

Annex III

Comparative view of lending in agriculture sector for 1991-92 and 1992-93

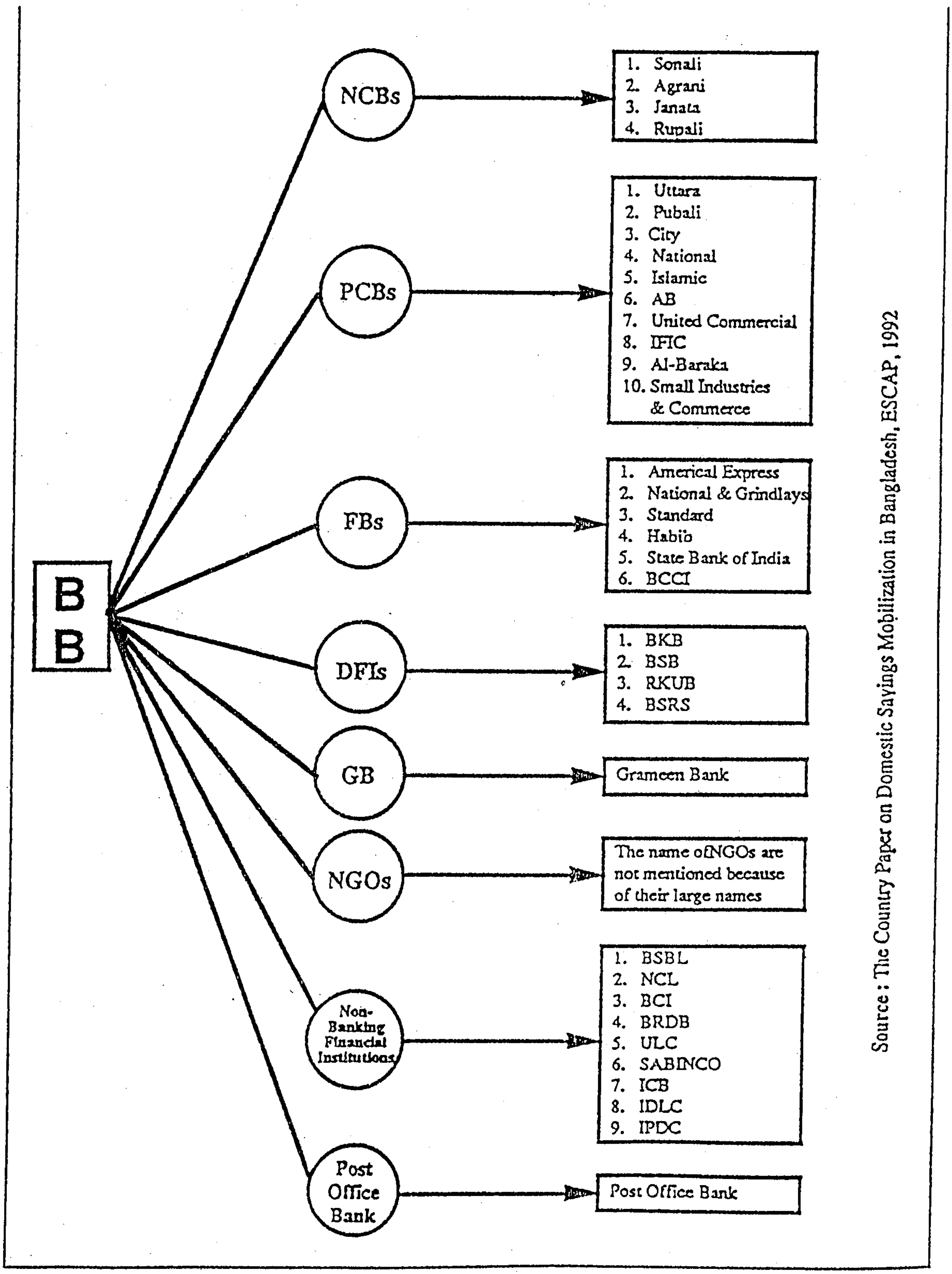
Tk/million

Item	1991-92	1992-93	Yearly change (+) (-)
A) Lending Programmes	13221	**14744**	**+1523.1 (+11.52)**
a. Crop Loan (Except Tea)	6293.7	7278.3	+984.6 (+15.64)
b. Irrigation Equipment	**1037.3**	**883.8**	**-153.5 (-14.80)**
c. Livestock	821.4	1049.1	+227.7 (+27.72)
d. Others including Tea and Fisheries	5068.6	5532.9	+464.3 (+9.16)
B) Disbursement	**7945.9**	**8418.5**	**+472.6 (+5.95)**
a. Crop Loan (Except Tea)	3463.9	3820.6	+356.7 (+10.30)
b. Irrigation Equipment	**235.8**	**111.0**	**-124.8 (-52.93)**
c. Livestock	673.8	707.6	+33.8 (+5.02)
d. Others including Tea & Fisheries	3572.4	3779.3	+206.9 (+5.79)
C) Recoverable Amount	41701.5	47199.3	+5497.8 (+13.18)
D) Recovery	6621.1	8692.3	+2071.2 (+31.28)
E) Overdue	35723.0	38543.6	+2820.6 (+7.90)
F) Outstanding	53695.6	56928.4	+3232.8 (+6.02)

Note: Figures in parentheses indicate yearly percent change.

Source: Bangladesh Bank, Annual Report 1991-92, 1992-93, p. 60 and p.43.

Figure 1. Framework of financial system.



Recommendations for the Future of Minor Irrigation in Bangladesh [58]

1. INTRODUCTION

The policies associated with the privatization of minor irrigation in Bangladesh have included:

a. A shift of the distribution of irrigation equipment and direct inputs for irrigation (fuel, spare parts) and irrigated agriculture (fertilizers, etc.) from public agencies to private sector traders.

b. Liberalization of policies related to the importation of irrigation equipment, standardization of its scale and quality and regulation of its spacing.

c. The dropping of subsidies for irrigation equipment.

d. The sale of publicly owned pumps to private individuals and groups.

As can be seen from the findings of this study on minor irrigation privatization, the first two of these areas of change have been associated with rapid growth in Shallow Tubewell (STW) and Low-Lift Pump (LLP) irrigation in the country. Returns to pump owners have been attractive, the resulting irrigation of crops has been profitable to farmers and access to both ownership and use of these irrigation technologies has been fairly equitable—with small farmers (those having no more than one hectare) taking a growing share. Small farmers' access has been especially facilitated by the post-privatization cheapness of the imported equipment and by its wider range of scale. Any return to restricting pump owners' choice regarding scale, price, quality and location is likely to have severe negative productivity and equity impacts.

Even for the relatively thriving STWs and LLPs, however, there are areas where there is need for improvement in order to facilitate the further development of irrigated agriculture. Many support services for minor irrigation are currently underdeveloped. Such supports as aquifer and technical information services, training (particularly for mechanics), better credit facilities, etc. could all have a positive effect. Some degree of public sector involvement is needed in many of these areas as there would appear to be insufficient incentive for the private market to provide them to the extent needed.

For Deep Tubewells (DTWs) the various privatization policies, particularly the dropping of heavy subsidies, have highlighted the weaknesses of this technology. As can be seen in this Study, the typical

[58]These recommendations have been drawn up by IIMI (the International Irrigation Management Institute) on the basis of findings from its Study on Minor Irrigation Privatization in Bangladesh. IIMI has been conducting this Study in association with the Ministry of Agriculture with funding from the Asian Development Bank. The research has been done by IIMI and BSERT (the Bureau of Socioeconomic Research and Training of BAU, the Bangladesh Agricultural University). These recommendations are those of IIMI alone and should not be seen as necessarily representing the views of others who have been associated with the Study. Feed-back from participants at the final workshop for this study (May 17-18, 1995), however, has been most helpful in the final preparation of this document.

DTW is not a financially viable enterprise without subsidies—either for owners or for the full command area seen as a 'farm'. Even with the old level of subsidies, typical returns are low and a large proportion of owners would appear to have insufficient revenue in excess of O&M costs to pay installments on their purchase loans. Added to this, a large number of existing DTWs are in areas quite appropriate for the less expensive and more profitable STWs. DTWs are having a hard time competing. Mechanical services are also a problem and the private sector market has not, in general, found it profitable to invest in the heavy equipment needed for DTW repair and over-hauling. All this has raised the question of what to do with the remaining deep tubewells in the field.

Based on its findings in this study (and after consideration of the very useful feedback from participants at the final workshop for the study, May 17-18, 1995), the following recommendations are made by IIMI in the hope that they will be of use in the further development of the minor irrigation sector in Bangladesh.

2. CREDIT

By all accounts, including statements by senior government officials, rural credit programs in Bangladesh have been extremely unsuccessful in reaching the small farmers and disadvantaged. Very little of the recent spread of minor irrigation equipment can be attributed to formal credit programs. One of the successes of the privatization of minor irrigation in the country has been the rapid expansion of the STWs/LLPs without the help of a viable formal credit program. This indicates that farmers have been able to generate a tremendous amount of local resources in response to the profitable opportunities offered by these technologies. However, as documented by the field data in this study, while some of these funds have come from internal savings, other funds have been raised by selling assets such as land and livestock—indicating a real need for credit if reasonably available. Prospective pump owners (as well as other actors in the minor irrigation sector) have found the hurdles and extra expenses associated with getting bank loans to be prohibitive barriers .

Further expansion and maturation of the minor irrigation market as well as the continued expansion of the network of dealers, workshops and other support facilities is being constrained by the lack of readily available credit supplies. As documented in the papers produced for this study, traditional formal credit programs through agricultural credit banks have proved unsuccessful in Bangladesh and have lost large amounts in unrecovered loans. General rural credit reform, then, is needed—to facilitate growth not only in minor irrigation but more generally in the whole agricultural sector. The following recommendations, therefore, are made in regards to possible programs which could specifically target minor irrigation.

a) One form of credit that has worked well in Bangladesh (as well as in other similar countries) is "trade credit." The success of informal trade credit, where over Tk 33.9 billion was distributed and collected in 1990/91, can be compared to the 1993 food grain loan portfolio from commercial banks where over 81 percent of the Tk 193 million outstanding is overdue. Based on the underlying attributes of trade credit, it is recommended that an expanded program be implemented where credit funds are funneled directly through wholesalers and traders to enable small retailers and farmers to purchase

minor irrigation equipment on reasonable credit terms. A successful example of such a program is the one presently being implemented by Singer that has provided an opportunity for poor families to purchase sewing machines on credit terms that fit their budgets.

Under a trade credit program, all costs of determining credit-worthiness and credit collection would be the responsibility of the wholesalers and traders. They, in turn, would also have to post any collateral for the credit funds. This program would charge market interest rates and be self-supporting—and relies on the positive incentives it provides traders who stand to increase their sales through their participation. As commercial banks in Bangladesh have, in general, very little experience in financing trader credit it is possible that their initial hesitancy over such a program may necessitate some encouragement from Government. Perhaps a pilot scheme of trader credit could help identify and solve possible constraints to this promising approach.

b) A second form of credit that has been documented as a success in Bangladesh is the credit program for farmer and women's groups developed by Grameen Bank. For very small and landless farmers and women, a credit program through a Grameen Bank type model where loans are made to credit groups rather than individuals is also a possibility for expanding ownership of minor irrigation equipment by small and landless farmers. As above, this program would charge market rates and be designed to be financially viable.

3. TECHNICAL INFORMATION

From the data collected in this study it would appear that there is often a mismatch between engine size and pump capacity. Not only does that mean that a larger (more expensive) engine may have been purchased than is needed and that there is a waste of fuel, but this mismatch can also reduce the life of the pump and other associated well equipment. The following recommendations are, therefore made:

a) A technical extension guideline for matching engines and pumps should be developed and distributed widely. As noted by a workshop panelist, it is important that such a guide be clear about the different engine/pump matches that are appropriate for different water levels (head). There are, for example different needs for deep set pumps than for irrigation units drawing from much shallower depths. The language and terms of the guide should, of course, be made easily understandable by prospective pump owners, mechanics, etc. Large numbers of this guide (perhaps 500,000 or more) should be printed in Bangla as well as English and copies provided free of cost to all wholesale and retail dealers, workshops, credit suppliers, mechanics and extension agents in the country.[59]

b) A similar guide that provides pump and engine test data for the most popular engine and pump units in the country should also be prepared by an independent laboratory and distributed widely. At present there may be difficulty finding an independent organization to do the tests which has the requisite laboratory and technical facilities. Funding would need to be found for an on-going testing

[59] It is understood that NMIDP is starting to disseminate technical information along these lines in its program areas.

program and for the widespread dissemination of its results. Again, it is important that the language and terms be easily understood by the prospective users.

These two documents will provide the basic information required to make a rational decision about the type and size of engine and pump that is optimal for different conditions.

4. HARDWARE

The relaxing of mandated technical standards allowed the less expensive Chinese engines to enter the market. Lower prices for this hardware, combined with rapid increases in prices of Japanese and European engines, have resulted in almost total dominance by the cheaper Chinese engines. However, although cheaper, these engines are not more durable. In contrast, they are recognized by all parties as being less durable and having a shorter life. Thus there is a tradeoff between durability and affordability. In some cases this has led to a suggestion for a return to the mandated system of technical standards in order to protect the consumers from inferior products. With respect to this issue, based on the information collected in this study, the following recommendations are made:

a) Farmers interviewed indicated that they clearly recognized the fact that the Chinese engines are less durable. Yet, as shown by the data collected, the lower purchase price (and ready availability of cheap spare parts), even with a shorter life, still provides a significant profit from the purchase and use of this less expensive equipment—as compared to the very low returns expected from the purchase of the more expensive Japanese equipment. Given the economics of the technology, we recommend not trying to reinstitute mandated technical standards. However, the information provided in recommendation 3 above (technical information) should be widely distributed to ensure that farmers purchase equipment that matches with their well and pump as well as engines that have proven to most efficient (in their price range) by independent testing.

b) Given that the market for small diesel engines is very big and will continue to grow (both for first-time purchases and replacements), there is a strong rationale for trying to produce a certain percentage of these engines within the country. It is possible that the labour costs and economies of scale in China are such that Bangladesh cannot produce engines at competitive prices—but this question should be explored. It is important, however, that tariff and other import barriers not be used as a form of encouragement to the local manufacture of engines. Such measures would mean significantly higher costs for the hundreds of thousands of farmers wishing to purchase this equipment. It has been, after all, the low price of the engines and other equipment which has made the recent rapid growth in the minor irrigation sector possible. Never-the-less, from interviews with manufacturers of engine spare parts, there do appear to be anomalies in the structure of current import restrictions on raw materials (that would be used for the local manufacture of engines). These problems do put local manufacturers at a disadvantage. Attempts should be made to correct this situation—without raising engine prices through tariffs, etc.

5. SPARE PARTS

Success of the privatization program has created a continuously expanding need for spare parts for minor irrigation equipment. One measure of the success of this program, as documented in the research results, has been the rapid growth in spare parts dealers at all levels of the market chain. Another measure of the success has been the steady expansion of the ability to produce spare parts within the country. The positive side of the local production of spare parts has been the ability to produce parts at one quarter of the price of imported parts. The negative side has been the fact that sometimes locally made parts are not of the same quality as the imported ones, at times resulting in a reduced effective life of the engine. Drawing on the information collected from spare parts dealers, mechanics and farmers, the following recommendations are made:

a) Local manufacture of spare parts for the minor irrigation sector is good for the economy, saves foreign exchange and increases the productivity of the industrial sector. The growth of this manufacture has been one of the successes of the privatization program. To help this phenomenon continue there needs to be an effort to remove policies that restrict further expansion. As for hardware manufacture mentioned above, a rationalization is needed of import restrictions and taxes on imported complex metals and sophisticated manufacturing equipment used for making spare parts.

   As found in interviews in this Study and confirmed by workshop discussion, there is a lack of expertise in Bangladesh in dealing with sophisticated metals. The government could institute a small business industrial education program to help local companies develop more sophisticated metallurgy capacity so that they can manufacture higher quality parts such as high-speed bearings, high-quality piston rings, heat-treated heads and manifolds. Such a program will expend beyond the minor irrigation sector and thus have positive returns throughout the entire economy.

b) Another major success of the privatization of minor irrigation equipment has been the dramatic expansion in the number of spare parts dealers. The field surveys clearly indicated an explosive growth in dealers, many of whom shifted from other completely unrelated market activities. In order to improve the ability of these traders to serve the needs of this sector, as well as to enhance their profitability in a very competitive business, there is a need for an outreach program to teach business management principles for these new spare parts dealers—in particular, modern techniques of inventory control. Technical material developed in the previous recommendation (and in the technical information section above) will help educate these dealers, but focussed business material aimed at improving management information systems for spare parts dealers, perhaps developed in conjunction with the trader credit program, will also have a very high payoff in terms of improving the quality of service to the sector.

c) The quality of spare parts manufactured in this country, as noted earlier, has sometimes been a problem. They are cheap—and are bought for that reason. Also, pump owners are often unable to tell the difference (in the shop) between imported and local parts so will ask for local parts (despite quality problems) simply because they don't want to pay expensive imported prices for something that is really a low quality imitation. Pump owners would be benefited by a program of quality control

and trustworthy labeling of spare parts. They may often be willing to pay more for higher quality parts if they are sure that they are actually getting what they are paying for. Requiring the Bangladesh Standards and Testing Institute's stamp of approval as a mark of quality on acceptable locally manufactured spare parts is one means of ensuring high quality and making it credible. Efforts should be made to identify and expose those who sell or make mislabeled or substituted spare parts.

6. MECHANICS

One of the problems identified through the survey data of this study has been the shortage of well trained, adequately equipped mechanics in the field. Additionally, it is difficult for pump owners to determine which mechanics are actually qualified. With the elimination of BADC's mechanics training program, there are few opportunities for proper mechanical training and little way of identifying which mechanics have proper training in the maintenance and repair of minor irrigation equipment.[60] In general, except for those mechanics who have left BADC and a few other groundwater development programs, most of the mechanics in the field have little formal training—with the bulk of their training coming from on-the-job and informal apprenticeships. This study has shown the market value of mechanical training—with trained mechanics (mostly from BADC programs) earning more than mechanics who have not had formal training Given the need for an increasingly large number of mechanics to support the minor irrigation sector, the following recommendations are made:

a) A system of providing good quality training and of certifying mechanics needs to be instituted. This could be organized through technical schools and colleges, professional organizations such as the Institute of Engineers- Bangladesh (IEB), NGOs or through private contractors. The former BADC workshop facilities might provide possible locations for such training courses. Mechanics should have to pay a part of the cost of this course—although decreased tuition and loans could also be made available to those who cannot afford the full costs. An important outcome should be a certificate issued to each graduate certifying that person is a trained minor irrigation equipment mechanic.

   Effort would also have to go into protecting the quality and meaning of such certification. Spare parts dealers, equipment traders, workshops and pump owners should be educated about the value of using trained and certified mechanics to ensure that repairs are done properly. To the extent that warranties on equipment become more a part of the business, restrictions that any work carried out by a non-certified mechanic would void the warranty might be one way of emphasizing the importance of utilizing certified mechanics. Efforts should be made to cut down or eliminate forgery of certificates—though in ways that do not raise so many procedural hassles to prospective mechanics as to discourage them from entering the field. The use of well trained, certified

[60]Some organizations are, of course, providing some training or are planning to. NMIDP, for example, is to provide training to BADC mechanics entering the private sector. Given the number of well-trained mechanics needed in the growing minor irrigation sector, more programs are needed.

mechanics will significantly extend the life of minor irrigation equipment as well as increase its efficiency. Mechanics should also be trained to be able to make recommendations that reduce the mismatch between engines and pumps.

b) Many mechanics do not have access to adequate tools, often complaining that they are too expensive. As an extension of the "traders credit" program identified earlier, equipment traders could provide tool kit loans to support the purchase of the necessary tools by qualified mechanics in their area.[61]

7. AQUIFER CHARACTERISTICS

One of the most debated aspects of minor irrigation development in Bangladesh (and as also demonstrated at the Study workshop in May, 1995) is the question of whether the aquifer is being over-exploited. One side of the debate argues that aquifer changes are just temporary, seasonal phenomena, while the other side claims that these changes are leading to a long-term secular decline in groundwater levels and flow rates from the wells. The present research was not designed to be an aquifer study—though a certain amount of relevant water information was gathered for parts of the five district study area in 1994. In the study areas during the 1994 irrigation season there was not a significant change in the discharge of the wells between the beginning and end of the season nor was there a critical decline in the depth of the groundwater. Some areas had good April rains while others did not. Even in the wells in close enough proximity to suffer interference from other wells, it was not possible to measure a significant decline in the rate of pump discharge.

Interviews with pump owners revealed various methods of coping with the normal seasonal declines in static water level. Increased operating hours per day, deep setting of pumps, etc. were used during the season. Between seasons there were instances of upgrading equipment and, if need be, dropping out of the water selling business if competition from other wells was too intense. Interviews did not reveal evidence that there had been a long term decline in the water table between seasons—though increased competition between wells may, in some places, be taking the in-season depth of the water table to deeper levels than before. The following recommendations are made on the basis of this study:

a) The dropping of spacing regulations has been one of the liberalization policies which has had a positive effect on the growth of the minor irrigation sector. Regulations, while essentially unenforceable and ineffective in a sector with many hundreds of thousands of scattered pumps, can never-the-less cause a great deal of hassle (and extra cost) to prospective pump owners who must get government officials to approve their siting. Reintroducing spacing regulations would be unlikely

[61] It is understood that the European Commission is considering supporting former BADC mechanics with tool sets (through NMIDP). Efforts are also needed, however, to assist new mechanics in getting tool boxes.

to have much of an effect on discharge and would entail large costs to the sector's development. [62] In any case, village communities are likely to have their own mechanisms for dealing with conflicting uses of resources such as water. Also, the STW technology restricts pumping beyond the pumping depths of the centrifugal lift so there is a limit to how far water levels can decline due to this type of irrigation. STWs are sufficiently cheap and movable that the entry and exit of wells in an area can lead towards the discovery of the local carrying capacity (i.e. number of wells) of the local aquifer if more scientific testing information on water depths is unavailable.

The development and dissemination to prospective pump owners of local aquifer information would be a support service that could save pump owners from the expense of the trial and error method of discovering the capacity of their aquifers.

b) To be able to answer questions about the possibility of long term declines in water tables and the possible failure of aquifers to fully recharge, Bangladesh must institute a long-run program of monitoring and modeling its aquifers over time. This would help the country manage its water resources to optimize their use. Workshop participants repeatedly noted the need for such information. Actually, Bangladesh has already developed some of the best models in the region—which could be used to fulfill part of this purpose. However, these models are not now being used nor are the required good quality data being collected to enable these models to be used to track changes in aquifer levels.[63]

8. DEEP TUBEWELLS

In Bangladesh DTWs have only proven to be marketable when they are sold at a heavily subsidized price. Farmers have determined (and the financial figures from this study indicate that they are correct) that this type of technology cannot be operated at a profit without very significant levels of assistance. DTWs are often located in areas where STWs can work—and the profitability of unsubsidized STWs is greatly at contrast to the larger technology. Even when sold at a subsidized price, many of the DTW groups have not made their payments for the wells (often because they did not earn enough to cover the payment, as shown in this study). Thus investment in DTWs has cost the government large sums in capital costs as well as the expense of supporting a large infrastructure to provide major maintenance

[62]From the workshop discussion was evident that there are two distinct command area issues which are often confused with each other. One is that STW competition *for water* is driving water levels down so far as to be damaging to the sustainability of the resource and its local use. The other is that STW competition *for land* to irrigate is causing a decrease in average command area below the designed technical capacity of the units. The market can be quite good at dealing with the latter issue as the optimal command area for an owner manager depends on many things (transaction costs, input prices, preferred small scale for decreased risk, etc.) in addition to technical capacities. Decreases in command area for this (land completion) reason may well simply reflect farmer preferences and the real cost of irrigation management.

[63]Recently NMIDP has been building data bases and upgrading the predictive capacity of the models referred to. There are plans to disseminate this information to local areas. A caution should be added, however, that Bangladesh needs such an aquifer data and dissemination program for the foreseeable future --- a future that is much longer than that of a particular program such as NMIDP. Past hand-over attempts of such programs have been discouraging.

for the wells through such agencies as BADC. Now that BADC is no longer providing technical support for DTWs, there is a real concern about how long these wells will continue to function. In contrast to the market for STWs, the private market has yet to determine that providing support services (i.e., repair and spare parts) for DTWs is a viable economic venture. Given this situation, the following recommendations are made:

a) As long as the government chooses to proceed with its policy of unsubsidized privatization of minor irrigation, the spread and development of DTWs should not be encouraged through any programs.

b) In the many areas where the STW technology is appropriate but where, never-the-less, DTWs have been installed, the recommendation is to institute a program of phasing these wells out. Such a program could include the provision of credit to encourage the development and spread of STWs. Maintenance and other costs for existing DTWs in these areas should be left to the private market at actual costs for the services. When these DTWs reach the end of their productive lives it should be left to local entrepreneurs in the area to replace them with STWs.[64]

c) In areas where it is not possible to use STWs (regular or deep-set) and DTWs are already in place, the government should help establish a private sector program (possibly through an NGO or a private contractor) to provide support services such as spare parts, mechanics, workshops and field equipment) to keep these wells operating until they reach the end of their expected lives. Access by such a program might be made to the old BADC workshop facilities. The beneficiaries would be expected to pay the fair market costs for these services but the government may need to provide some subsidy to cover the management costs of the program which cannot be recovered from the beneficiaries. There would, obviously, be no need for such a program after the tubewells eventually become defunct.

   From Workshop discussions it was also pointed out that electrification programs (including efficient and hassle-free methods of getting connections) in these highland areas may open the way for much cheaper force mode technologies than are currently being used. Crop diversification programs that are effective in encouraging the growing of high value irrigated crops might make such technologies quite profitable.

d) In areas where it is not possible to use STWs but where DTWs cannot function without subsidies, other investment alternatives (including non-irrigation options) should be explored. In these areas it should not be automatically assumed that all the potentially cultivable land should be irrigated, particularly when it cannot be irrigated at a financially viable cost. Programs for the spread of non-irrigated high value crops, rural industries, etc., might prove to be much more viable than the expensive DTWs.

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[64]Discussion at the workshop included some views that advice and other support services for DTWs would be helpful in these STW-friendly areas in addition to the areas where STWs cannot function (which are discussed separately in section 'c'). DTW owners have sunk costs which they can only recover over time if such support services are provided. This, then, is something of a fairness issue to farmers who have invested in the DTW technology under the assumption that services would be available. The alternative argument is that, on efficiency grounds, there is little reason to subsidize one technology (through public support for certain services) while an available alternative technology can thrive without such subsidies.