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EVOLUTION AND IMPLICATIONS OF DECREASED PUBLIC INVOLVEMENT IN MINOR IRRIGATION MANAGEMENT IN BANGLADESH

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Purpose of the Series

The *Short Report Series on Locally Managed Irrigation* is designed to disseminate concise information on the role of local management in irrigation and irrigation management transfer or turnover experiences and policies. The *Series* is distributed worldwide to a broad range of people—policymakers, planners, researchers, donors and officials in both public and nongovernmental organizations—who are concerned with the irrigated agriculture sector. IIMI's goal is not to promote policies such as irrigation management transfer, but to enhance the knowledge base available to decision makers and advisors as they face questions of policy adoption and strategies for implementation.

Locally managed irrigation can be of many types, such as traditional farmer-constructed diversion or tank schemes, indigenous and often new lift irrigation, government-constructed but farmer-managed irrigation systems and systems where management is or has been transferred from an outside agency to a local user organization.

By "irrigation management transfer" we mean some degree of transfer of responsibility and authority for irrigation management from the government to farmer groups or other nongovernmental entities. This generally involves contraction kf the role of the state and expansion of the role of the private sector and water users in irrigation management. In other words, there is a shifting upstream of the point where management responsibility and control of the water supply are transferred from the irrigation authority to local management. This may involve changes in policies, procedures, practices and the performance of irrigated agriculture. It may or may not involve "privatization" of ownership of the assets of the irrigation system. The *Short Report Series* addresses questions such as the following:

What are the necessary conditions which support viable locally managed irrigation?

What socio-technical conditions, institutional arrangements and change processes lead to sustainable locally managed irrigation?

What is the range of different models that are being applied worldwide for turnover or transfer of responsibility for local management for recently developed irrigation?

What are the effects of management transfer on the productivity, profitability, financial viability, equity, efficiency and sustainability of irrigated agriculture?

What are the perspectives of farmers, managers, policymakers, urban consumers and other stakeholders in irrigated agriculture about irrigation management transfer?

What adjustments in government may be needed as a result of turnover to provide support to locally managed irrigation systems and to improve productivity in the public sector?

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Editors' Note

Although many of the countries in Asia have tapped their underground aquifers to supplement their surface water supplies, no country in the region is as dependent upon groundwater irrigation as Bangladesh. A lack of suitable reservoir locations and the complexity of the flat deltaic river plain, make large-scale surface irrigation difficult to develop and maintain. As a result, of the 2.84 million irrigated ha, only 6 percent or 172,000 ha are served by surface irrigation. Of the remaining area, more than 2.67 million ha are served by minor irrigation equipment, with the vast majority of the land being served by private shallow tubewells (STWs).

Initially, minor irrigation equipment was introduced through public agencies with support from a number of foreign donors as well as the government. However, the process of privatization to local ownership and management began in the late 1970s. At that time, the government made a deliberate policy decision to withdraw from active import and provision of minor irrigation equipment and to encourage the private sector to take the lead with the farmers becoming owners and operators rather than the government.

Although this policy has not always gone smoothly, by and large the government has stuck by its earlier decision. As a result, the area served by shallow tubewells alone has grown to 1.4 million ha served by approximately 400,000 STWs. In addition, another 500,000 ha are served by private low-lift pumps while 400,000 ha are served by deep tubewells. The increase in minor irrigation has been particularly dramatic during the dry season, so that today more than 42 percent of the country's total foodgrain production (rice and wheat) is grown during the dry season while in 1972 less than 5 percent of the country's foodgrains was grown during this season.

There are several lessons to be learned from the Bangladesh experience. In particular, the multiplier impacts of this policy on the private sector have been spectacular. Not only have importers moved in to fill the void left by the government, but local workshops, mechanics, spare-parts dealers, transportation and distribution networks have also grown to provide the necessary support required to service the vast number of pumping units. In small towns all over the country, bright young men and women have found an opportunity to go into business for themselves serving this growing market. In addition, local manufacturers have moved in to produce the necessary spare parts and informal credit institutions have filled in when formal credit institutions were unable to meet the rapid demand.

As indicated in this paper, the relaxing of public controls has resulted in increased dry-season rice production, thus ensuring Bangladesh of improved food security. The willingness to allow the import of inexpensive Chinese engines has also resulted in more equity in the rural sector as even small farmers and landless groups have been able to acquire their own irrigation well from which they sell water from a share (normally 25%) of the crop. The ability of the private sector to take over the minor irrigation services previously provided by the public agencies has created new challenges for the government. The government is now being asked to assume new roles including providing farmers information about environmental conditions such as the status of the aquifer, the market information for new, nontraditional crops and technical information on new pump and engine technologies.

EVOLUTION AND IMPLICATIONS OF DECREASED PUBLIC INVOLVEMENT IN MINOR IRRIGATION MANAGEMENT IN BANGLADESH

M.A.S. Mandal and D.E. Parker[1]

INTRODUCTION

Minor irrigation plays a crucial role in Bangladesh's agriculture and, therefore, in the national economy. Bangladesh is a densely populated, mostly rural country beset by endemic poverty and malnutrition and 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 (MOPs), 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 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 assess the implications of this shift. What is the performance of a private management system in this sector in regard 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

1 An earlier version of this paper was presented at the International Conference on Irrigation Management Transfer, organized by the International Irrigation Management Institute (IIMI), held during 20-24 September 1994 in Wuhan, China. The authors are, respectively, Professor, Department of Agricultural Economics, Bangladesh Agricultural University (BAU) in Mymensingh, Bangladesh, and Head, Bangladesh Field Operations of IIMI. Dr. S.C. Dutta of BAU assisted in preparing the figures.

decline in dry season river flows, however, make large-scale surface irrigation difficult and such systems make up only 6 to 7 percent of the total 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 24,400 million cubic metres 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. High yielding variety (HYV), referred to as *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 *aman* (rainy season rice) in amount of production. This increase in production 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 labor, draft power and seeds are generally supplied by the farmer 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 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 labor. Of those with some land, about 70 percent have up to one hectare, though this small-farm category constitutes only 29 percent of the total farm area. The 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.

The smallness of farm size and high degree of land fragmentation means that the organization of a tubewell command area anywhere near the capacity of their pumps essentially needs the cooperation of a large number of farmers. The larger the size of the command area and more the number of farmers to be served, the higher are the transaction costs involved in negotiating with farmers, distributing water and managing the pumps.

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 in a suction mode. DTWs are normally of the 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 motor driven minor-irrigation technologies cover 2.3 million hectares (Mha)—82 percent of the coverage by all the irrigation technologies combined (Table 1). Of this area, STWs serve 1.4 Mha, DTWs 0.4 Mha and LLPs 0.5 Mha. Irrigation water from a low lift pump or a tubewell is distributed through 2–3 main, uncompacted, open earthen channels which are linked with a network of plot-to-plot field channels.

EVOLUTION OF PUBLIC AND PRIVATE SECTOR INVOLVEMENT IN MINOR IRRIGATION MANAGEMENT

In Bangladesh, minor irrigation, which was heavily dominated by the public sector, passed through a series of development phases involving both public and private actors until it became a predominantly private sector enterprise.

Public Sector Initiation Phase: 1951–74

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 1950s, however, public sector attempts to modernize irrigation were institutionalized with the creation of the Bangladesh Water Development Board (BWDB) in 1959 and the Bangladesh Agricultural Development Corporation (BADC) in 1961. BWDB was primarily involved in developing canal irrigation projects but during 1962–68, it launched a tubewell project in the northwestern part of the country using 380 four-cusec DTWs. For this project the agency provided electricity generation, pump operation and water distribution to farmers' fields. The project was heavily subsidized and bureaucratically managed and performed very poorly 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 first entered minor irrigation through an LLP system in 1961 and a DTW program the following year. 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. The DTW program began with 200 two- cusec wells in the Comilla area 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). BADC supplied fuel/oil and the Integrated Rural Development Program (IRDP) organized the cooperatives. 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 1970s. The STW rental program was converted to a sales program after 1974–75.

Public Sector Domination Phase: 1974–79

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 monopoly control over DTW and LLP procurement, installation and rental. However, the agency stopped providing a pump operator for LLPs, 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 purchases was put into place through the Bangladesh Krishi Bank.

Private Sector Expansion Phase: 1979–84

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 an 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 sell 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 failures within the agency bureaucracies, which still provided spare parts and various other support services (Hamid et al. 1982).

A Move toward Public Sector Control: 1984–87

In the 1983 dry season, there was a greater than expected drawdown of groundwater in a number of northern districts (Gill 1983). The alarm caused by 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 sub-district 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 irregularities and large loan repayment defaults. STW engine distributors 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: Since 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 slowdown following a doubling of diesel fuel prices at the time of the Gulf War. There has been a maturing of the equipment market as it spread from its earlier concentration in the national and regional centers to better serve district and sub-district 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 proven to be unsustainable in an unsubsidized environment. Major donors had continued to support large subsidies for this technology throughout the 1980s despite their poor economic showing and their frequent placement in areas best suited to STWs (Hanratty 1983; Johnson 1985). More recently, both donor and government policies have 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 to 1987 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 2).

During this same period, the number of LLPs (and the associated area served by LLPs) rose at 4.3 percent a year to a total of 52,000 (496,000 ha associated command area) 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 thousand hectares.

By 1993, the three motor-driven minor-irrigation technologies covered 2.3 million ha—26 percent of the nation's net cropped area, 34 percent of the potential irrigable area and 82 percent of the irrigated land area. 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 the 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. In addition, diversification of crops such as vegetables, pulses, fruits, oilseeds and tubers has been promoted by the availability of irrigation.

Choice of Equipment

The shift 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 choices previously forced on them through standardization policies. It appears that farmers choose these less-expensive engines, despite their higher periodic repair costs, because they could not afford the more costly ones. In addition, many farmers began to choose from the newly available range of horsepower open to them and thus were 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 sub-district centers and the number of mechanics in these centers as well as in the villages increased. Local manufacturers began to produce pumps and spare parts. In 1994, there seems to have been no shortage of spare parts at the district and local levels. The quality and life expectancy of many of the popular, inexpensive, domestically produced parts, however, are 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 always available in the private workshops.

Capacity Utilization of Equipment

The operation of DTWs was primarily through rental arrangements with BADC until the early 1980s, when both new and used wells were offered for sale at subsidized rates. As the rental wells sold very slowly, up to 12,000 DTWs were left under the 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 negative trend in capacity utilization of DTWs seems to have developed (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 was an incentive for STW owners to cover as much land as possible.

b) As STWs are small, 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 inputs such as fertilizer. In some areas, the rapid increase in minor irrigation equipment has led to competition for command area—with the more flexible and more easily managed STWs often "stealing" land not only from other STWs but often from what had earlier been DTW command areas as well. In some years and 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, unsubsidized ownership. One comparison between technologies showed that STWs (which are both 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, and Yield of Boro Rice

The costs of inputs to privately owned and operated minor irrigation equipment creates a high cash need for buying diesel and electricity, and repair and maintenance of machines and water conveyance structures during the irrigation season. In 1991, this cash need increased dramatically as the price of diesel doubled during the Gulf War and never returned to its pre-war levels (Table 3). To meet these cash needs, most minor irrigation charges were increased. Private wells, both STWs and DTWs, in many cases, have had somewhat higher water fees than rental DTWs. As a one-fourth crop share has been a 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 with a higher value of the water charge.

Profitability of Irrigated Boro Rice

The question of profitability is crucial to the sustainability of irrigated agriculture. While estimates vary, the authors' own calculations based on various assumptions regarding input and output quantities and prices show that irrigated boro cultivation is still normally profitable (Table 4). Profits have, however, declined during the 1980s due to rises in input costs relative to the price of rice (Mandal 1989). Labor and irrigation costs together account for two thirds of the total cost of production and 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 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 reported large drop in tobacco prices 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 taken together they irrigate only a much smaller proportion of the land. This disproportionate ratio 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 regard 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 land holders rather than a larger number of small farmers. This latter consideration is unlikely to be very significant, 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 not only as farmer irrigators but also as possible tubewell owners, the issue of access becomes more encouraging. Early results from a minor irrigation privatization study with which the authors are involved show that in the Bogra and Comilla areas, where private STWs have expanded very rapidly and intensively, a very high proportion (60% in Bogra and 80% in Comilla) of sample STW owners are small farmers who cultivate an average of only 1 hectare of land and sell water to other farmers. In Faridpur and Hobigonj, where STW irrigation has so far developed less intensively, a much smaller proportion of

STW owners are small farmers (Figure 4). A study by Mandal (1993) also 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 the number of small tubewell owners has greatly decreased the danger of what were earlier described as "landlords cum waterlords." 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 incomes with other irrigation- related activities—working as mechanics, drillers or spare-parts traders.

THE FUTURE: A CONTINUATION OF PRIVATE DEVELOPMENT OR A RETURN TO PUBLIC CONTROL

The transition from public to private control in the minor irrigation sector has, overall, had very positive results in the nature and pace of expansion of STWs and LLPs. Development has been rapid and small farmers appear to be gaining access to technology as they have been able to purchase inexpensive equipment that fits their needs and without having to undergo the transaction costs of dealing with public sector agencies. Also, private pumps seem to be associated with a somewhat better delivery of water—though, of course, at an unsubsidized water charge.

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

Recently, concern has also been expressed in some quarters regarding the possible negative impact of increased groundwater extraction by the increasing number of private sector tubewells. According to these views, unregulated extraction of groundwater may lead to land subsidence, lowering of the underground water level, and drying up of drinking water pumps and surface water sources. The extent and duration of such damage is in some dispute—though most of Bangladesh's shallow aquifers appear to fully recharge each year and periods and places of seasonal excessive drawdown appear to be small. However, there are strong preferences for reimposing regulatory measures on groundwater exploitation, particularly, among some agency personnel (the Groundwater Management Ordinance of 1985 has been kept in abeyance but has not actually been abolished).

The same sources have expressed concern over the need to protect the prospective pump owners from unstandardized engines. There is an assumption that farmers purchasing irrigation equipment are unaware that the inexpensive imported engines now prevailent in the market are less durable and require more repairs than other options. In the field, however, farmers are found to be fully aware of the durability of their engine. For them the lower initial cost and the availability of a variety of engine sizes that fit their needs are of most importance.

While the development of a public policy on these issues in the near future is not clear, the positions supporting regulation and standardization are likely to get serious attention. From this paper's earlier examination of the evolution of minor irrigation privatization, it was clear that whenever there was an increase in regulation and control from the public sector, there was very sluggish growth in minor irrigation—greatly retarding the transformation to 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 large, negative side effects of attempting to solve the problem through regulation.

LESSONS LEARNED

Minor irrigation in Bangladesh has undergone an evolutionary process in response to availability of external funds, availability of technologies, the interest of the public sector agencies and practical experience gained through different programs. The Bangladesh experience, although it is related to lift irrigation systems, offers a number of important lessons to other countries switching over from publicly managed irrigation systems to local privately managed irrigation. Some of them are:

1. Although minor irrigation controlled by the public sector agencies (BADC and BWDB) was heavily subsidized and managed with a low level of efficiency, it played a great role in popularizing the high-cost and high-risk modern mechanical irrigation for HYV rice cultivation in the dry season, which later on proved to be the engine of growth in the country's overall cereal production.

2. Groundwater as well as surface water lift irrigation has led to a significant increase in the cash requirement to pay for irrigation equipment as well as fuel, electricity, spare parts and repair services. In Bangladesh, irrigation-related agencies (e.g., BADC, BWDB and the nationalized commercial banks) provided financial support in the initial years. But the major impetus to the promotion of groundwater irrigation in the private sector came through the liberalization of equipment imports and a credit program for equipment distribution.

3. During the period of bureaucratic control on the procurement and distribution of minor irrigation equipment, private workshops started to grow and supplement repair facilities to irrigation equipment virtually without any government support. Many of the irrigation agency mechanics and technical staff who were retrenched or left jobs have taken up local manufacturing of irrigation spare parts and are providing private repair services profitably.

4. The Bangladesh experience clearly shows that public sector regulation and control (e.g., restrictions of equipment imports and regulation of pump spacing) were imposed due to inadequate factual understanding resulting in very slow growth of minor irrigation. But when improved empirical knowledge gained through research and policy discussions were available, it prompted the public sector to remove restrictions and controls, which had generally favourable impacts in terms of growth of irrigated area, increase in dry season rice production and improvement of farmers' access to irrigation.

5. The move towards private sector involvement in irrigation equipment procurement and distribution, with simultaneous withdrawal of engine standardization requirements by the government, opened up a wider range of choices for farmers regarding engine type, quality and prices, and the market for irrigation equipment has been reasonably competitive without any significant negative externalities with respect to equity or environmental aspects.

6. The withdrawal of BADC from the irrigation sector has led to some unresolved problems because the private sector is not yet developed to sell DTWs, supply DTW spare parts and provide repair facilities (for sophisticated equipment). Unsubsidized DTW sales are highly unlikely due to the very high price of DTWs. This has affected the operation of the existing DTWs and installation of new DTWs, and in low water table areas where DTWs are the only technically feasible option this might be a concern.

7. Despite very high irrigation costs (about 20% of the total cost) and input costs borne by the Bangladeshi farmers, irrigated boro rice cultivation still remains normally profitable. However, the fluctuations in farmers' profitability due to fluctuation in the price of rice and input costs, including diesel and electricity charges, affect the farmers' demand for irrigation coverage.

8. While the traditional role of the public sector in the procurement, distribution and maintenance of irrigation equipment has been transferred to the private sector, there is a need for a new role for the public sector in regard to providing aquifer and market information, on-farm water management training, appropriate credit and extension services to facilitate irrigation development in the private sector.

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Table 1. Minor irrigation equipment operated and total area irrigated during 1992–93 in Bangladesh.

Irrigation technology	Number 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	267,510	100.0
In Addition:			% of all irrigated area
Canal Irrigation	—	172,085	6.0
National Irrigation	—	2,843,315	100.0

Notes: 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 (1993).

Table 2. Total area irrigated by different irrigation technologies, from 1982–83 to 1992–93, in Bangladesh.

Year	Area irrigated ('000 ha)					
	STW	**DTW**	**LLP**	**Traditional**	**Canal**	**Total**
1982–83	371.5	243.3	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
1985–86	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. These assumptions are somewhat unrealistic because 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 3. 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 % of O&M cost
Rental DTW (Rajshahi)						
1990	21.6	3.4	36,390	1,685	3,272	194
1991	15.6	4.6	51,591	3,320	4,026	121
Private DTW (Rajshahi)						
1990	23.7	4.8	37,921	1,602	3,928	245
1991	18.01	5.6	62,534	3,472	6,621	190
Private and rental DTW (Tangail)						
1990	15.78	4.4	37,520	2,378	5,610	236
Private and rental DTW (Jhenidah)						
1990	19.00	4.29	39,980	2,104	3,490	166
Private STW (Tangail)						
1990	4.28	4.6	12,800	2,990	5,665	196
Private STW (Jhenidah)						
1990	2.52	4.7	7,749	3,075	6,414	208

Notes: a. 1 US $ = (Approximately) Taka 40.

b. Diesel price was raised by the government from Taka 6.90/litre to Taka 14.14/liter.

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.

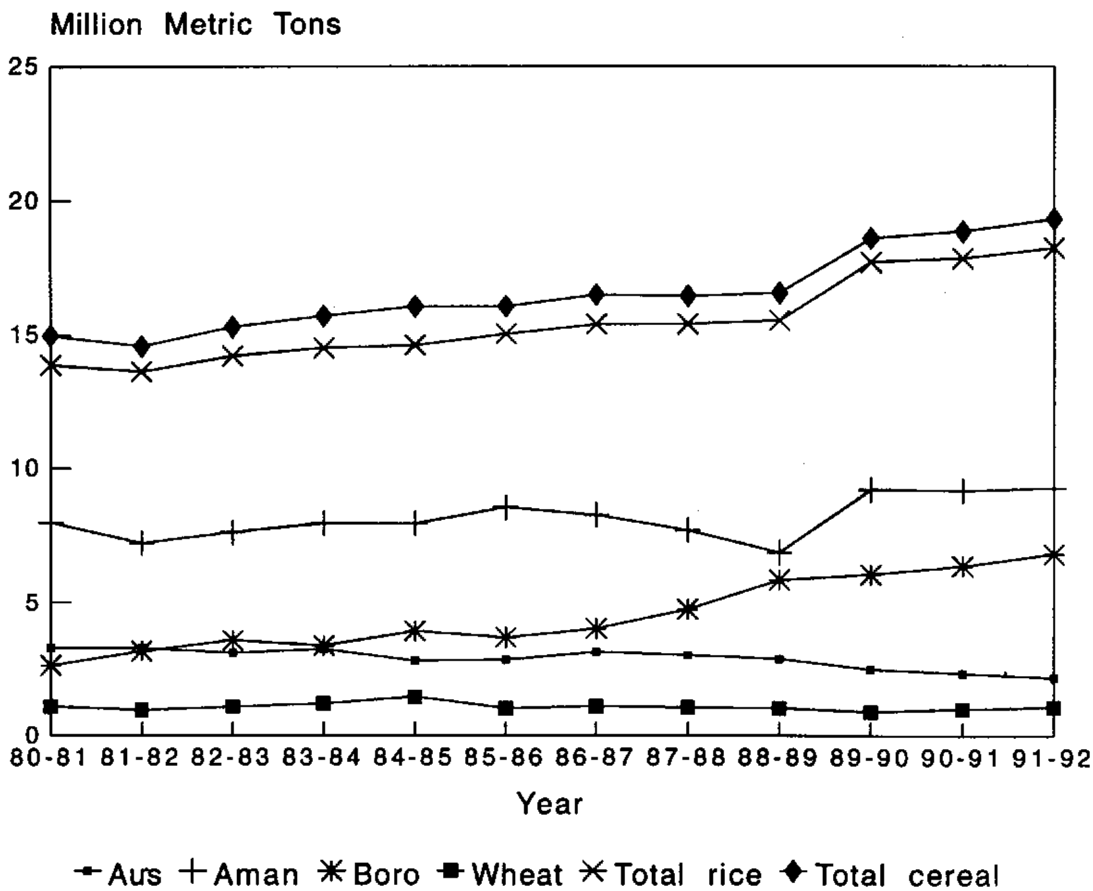
Table 4. Estimated costs and returns of tubewell irrigated HYV boro rice per hectare (in 1994 prices).

Items	Quantity	Value (Taka)	% share of total return
A. *Total Returns*		26,940	100
Paddy	4.2 MT x Taka 6,200/MT	26,040	97
Straw	3.0 MT x Taka 300/MT	900	3
B. *Total Costs*		19,263	72
Labor	200 man days x Taka 40/day	8,000	30
Tillage	45 bullock pair day x Taka 50/pair day or power tiller services	2,250	8
Seeding	Assuming some home grown and some purchased seedings	800	3
Fertilizers:			
Urea	240 kg x Taka 6/kg	1,440	6
TSP	126 kg x Taka 8/kg	1,008	4
MP	40 kg x Taka 8/kg	320	1
DAP	5 kg x Taka 9/kg	45	0
Pesticides	—	400	1
Irrigation	Assuming cash payment in 3 installments	5,000	19
C. *Net Returns* (A–B)		7,677	28

Note: 1 US$ = (Approximately) Taka 40.

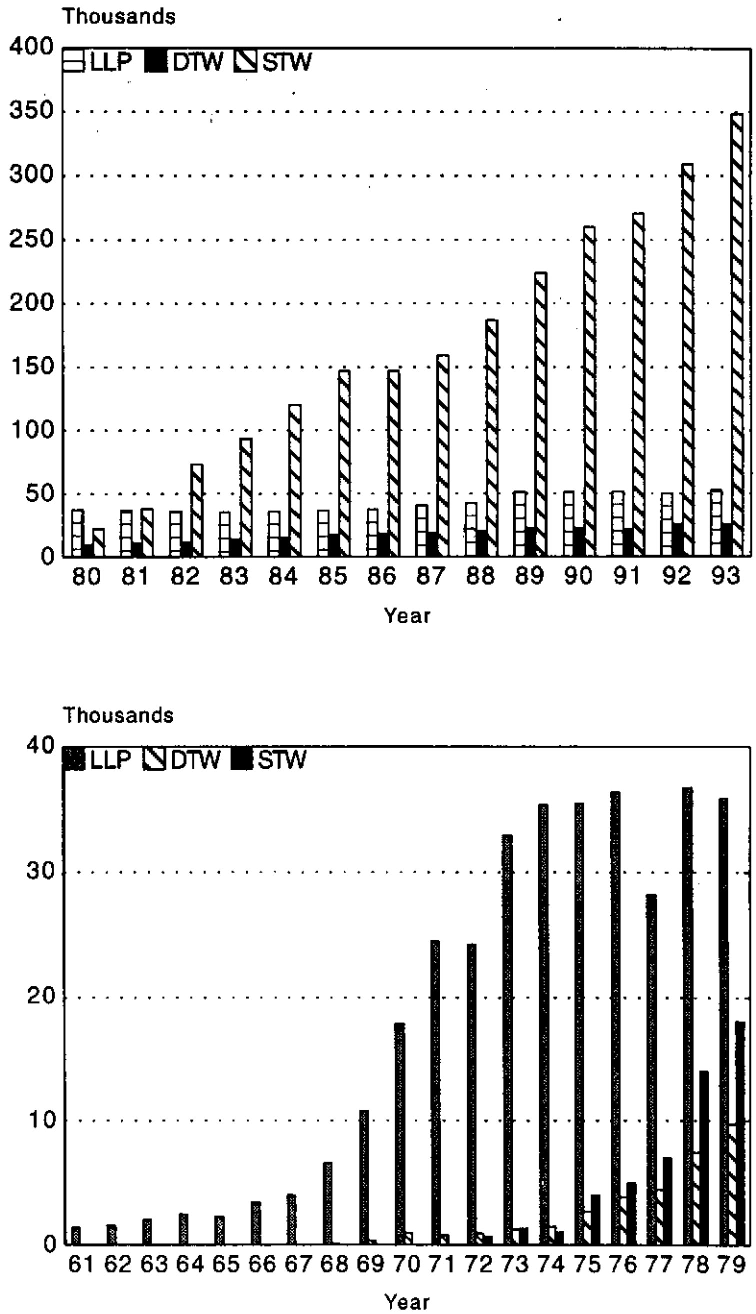
Sources: Estimates are based on data regarding physical input and output quantities from the Agro-Economic Research Unit (1988), Gisselquist 1991 and several recent M.Sc. Agricultural Economics theses submitted to BAU, Mymensingh. The input and output prices, and the needed adjustments in input and output quantities are based on the authors' field trips to different districts during the 1994 irrigation season.

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



Sources: BBS 1990, 1992, 1993, Khalil 1991.

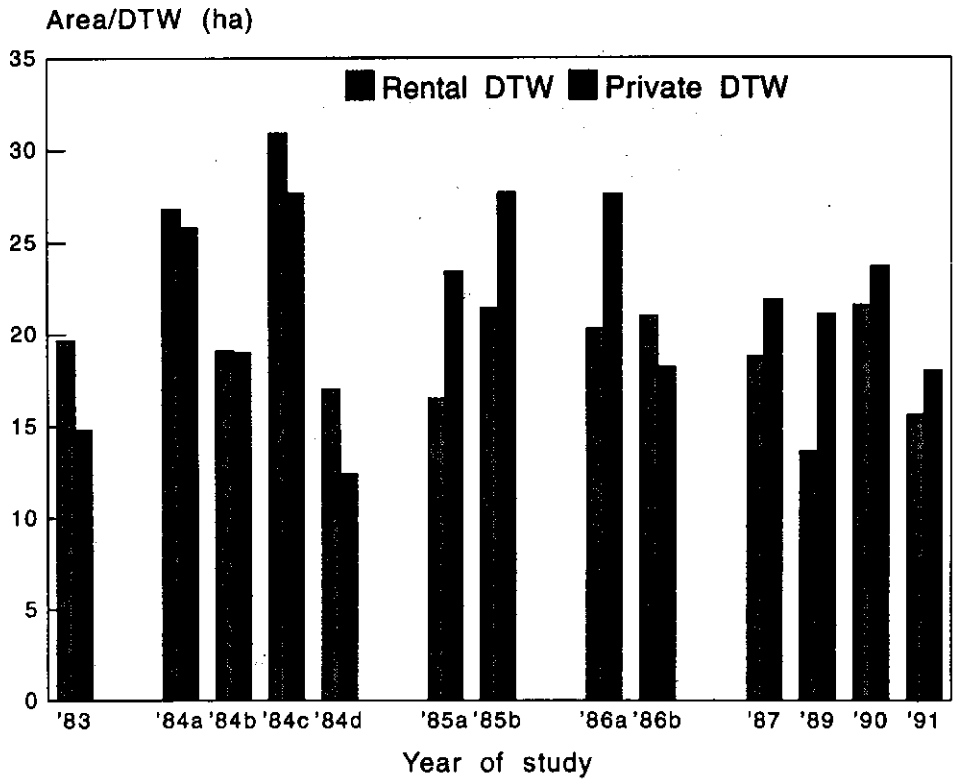
Figure 2. Number of minor irrigation equipment in Bangladesh, 1961–62 to 1992–93.



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

Sources: Hanratty 1993; Gisselquist 1991; David 1994; Hamid 1991; BBS 1993; AST 1989, 1991; DAE/ATIA 1994.

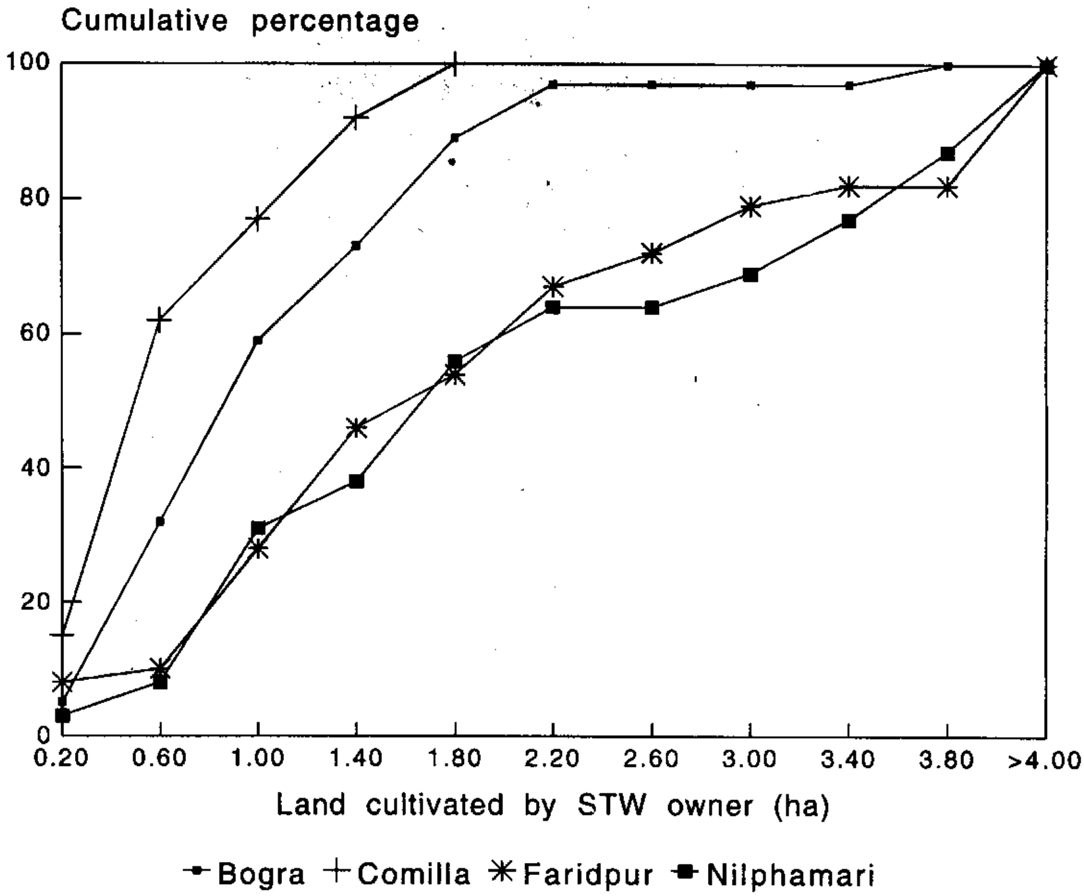
Figure 3. Irrigated boro area per DTW (ha).



Note: '83 refers to 1983, and so on.

Sources: Data refer to different locations and are collated 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 eclectically 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 al., 1991.

Figure 4. Land cultivated by STW owners (ha).



Source: Preliminary calculation from IIMI/BSERT Data, 1994.