Utilization of Water under Different Deep Tubewell Management Systems in the Rajshahi Area of Bangladesh

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ABSTRACT

A STUDY WAS conducted in the deep tubewell (DTW) irrigation projects of Rajshahi.The DTWS were operated under four different management systems, i.e., Barind Integrated Area Development Project (BIADP) of Bangladesh Agriculture Development Corporation (BADC), BADC Rental Program, Rental-Rajshahi Krishi Unyan Bank (RAKUB), and private systems (owned by farmers).

In BIADP Project, informal groups are provided with deep tubewells and the groups are to pay irrigation charges based on estimated command area. Management responsibility lies with the farmer groups or the leaders of such groups but BADC retains enough control on the wells to ensure that irrigation charges are paid by the group.

The farmer groups pay BADC an annual rent of Taka (Tk) 5,000 (approximately US$135.14) in the rental program. The groups are responsible for operation and maintenance costs. BADC retains some responsibilities for repair, but has little control over management aspects.

The government has been selling DTWs to farmer groups since 1973. The groups are responsible for all aspects of operation and management.

The rental program of BADC is supported by RAKUB for seasonal crop production credit requirements. Credit is provided for operation and maintenance (0&M) and other relevant services.

Rajshahi is a dry area of the country where temperature ranges from 5 to 46^{0}C and total rainfall during the months of May to September is around 1,200 millimeters (mm). A negligible amount of rain occurs during the months of October to April. The soils range from clay to loam with seepage and percolation rates of 2.3 to 3.5 mm/day. The dominant cropping patterns of the area are boro-fallow-aman, wheat-aus-aman, and potato-aus-aman. Water distribution in each DTW is characterized by block rotation as well as by head-, middle- and tail-rotation systems. The designed discharge of each DTW was 56.6 liters per second (lps). But actual discharge varied from 26 to 51 lps. Discharge of all the wells were below the designed capacity. Full irrigation was applied for the boro season and supplementary irrigation was applied during the aman season.

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INTRODUCTION

Deep tubewell (DTW) irrigation is an important means for rice cultivation during the dry period in Bangladesh. There were about 25,000 DTWs in the field irrigating 610,000 ha of land which constituted 19.6 percent of the total irrigated area of the country. By the end of the Fourth Five-Year Plan (FFYP) there may be another 17,500 DTWs which may irrigate an additional area of 430,000 ha (Planning Commission 1990).

The Bangladesh Water Development Board (BWDB) started its irrigation program in 1964/1965. BADC joined the program in 1967/1968. Both BWDB and BADC are autonomous public agencies. Deep tubewells of BWDB are managed by the agency itself. But the BADC DTWs are operated under several ownership and management systems. Some are managed by BADC itself as in the case of the Barind Area Integrated Development Project (BIADP) and others are rented and privately owned by formal or informal farmer groups. The management systems of the study sites included the following:

BADC's Barind Integrated Area Development Project (BIADP)

In this program informal farmer groups are provided with wells and required to pay irrigation charges based on the estimated command area. BADC provides repair and maintenance services to a value of up to one-third of the charge. The farmer groups collect a fee from the irrigators to meet the costs of the BIADP charge, any further repairs, fuel and oil and the salaries or honoraria of the tubewell managers, operators and drainmen. Management responsibilities lie with the farmer groups or their leaders, but BADC retains enough control on the wells to ensure that irrigation charges are paid by the groups.

BADC Rental Program

BADC has a number of DTWs under its rental program. These wells were installed between 1967 and 1978 and were rented to farmer groups (both formal and informal). In the 1980s, BADC tried to sell the wells to the groups but this effort was mostly unsuccessful. As a result, the rental program continues. The farmer groups pay BADC an annual rent of Tk 5,000. The groups are responsible for operation and maintenance costs. BADC retains some repair responsibilities but has little control over well management. The tubewell managers collect fees to cover operation and management as well as the rental charges, but it is seldom that the rent is paid to BADC.

BADC Rental Program Supported by RAKUB

Under this program the DTW rental group receives O&M credit and other backup services from the bank. The bank helps in the management of funds and the collection of irrigation charges from the various irrigators. The RAKUB Program worked well up to 1990, but came to a standstill in 1991.

Private Ownership and Management

The Government has been selling DTWs at subsidized rates to farmer groups since 1979. The groups are responsible for all aspects of operation and management. Most of these farmer groups exist in name only with the wells being owned and run by one or a few individuals. Capital loans were taken to purchase the wells, but the level of loan repayment was very low, despite the fact that the fees collected from the farmers were sufficient to pay the loan installments as well as O&M costs.

OBJECTIVES

i) To identify major characteristics of the systems.

ii) To examine the status of water utilization performance of the alternative systems under study.

iii) To suggest measures of improving system performance.

RESEARCH SITES

The Bangladesh Rice Research Institute (BRRI) and the International Irrigation Management Institute (IIMI) research group selected a number of tubewells in the Rajshahi region under BIADP. These tubewells were Amtali-1 and -2, Sarengpur-1 and -2, Fazilpur-2, Ramnagar-2 and Sarmangla-1. Another six tubewells rented by BADC to farmer groups were also selected for the study. These tubewells were Mahabathpur-2, Buckshimal, Darshanpara, Shakua, Haridagachi and Dural-3. In three of these six wells the farmer groups were provided with production costs (including irrigation costs) by RAKUB. These tubewells are Shakua, Haridagachi and Dural-3. In the same area three additional wells owned by farmer group were also selected. These tubewells are Palasha, Moheskondi and Bakshail.

METHODOLOGY AND MEASUREMENTS

Relevant data/information for the study were collected from both primary and secondary sources including farmers, farmer leaders, agency officials, official records, studies and research reports and farmer group records. Methods included were participant observation, discussions with officials, farmers and farmer leaders, and maintenance of weekly records of DTW performance, etc.

The research project was initiated with the measurements of rainfall, seepage and percolation, evaporation, water adequacy and water distribution equity, and monitoring of discharge and duration. In addition to the above water management parameters, crop production aspects were researched through field trials and monitoring of farmer management practices, yield and input use.

Rainfall

In Barind and Mohanpur, rainfall was measured by True-Check rain gauges in the research site.

Irrigation Water Flow Measurement

Irrigation water flow was measured at deep tubewell discharge boxes to quantify the water available in each of the DTW areas. Measurement was made by the use of cutthroat flume, V-notches and pitot tubes.

Measurement of Conveyance Losses

Conveyance losses at tertiary, secondary and main canals of the DTWs were measured by the inflow-outflow method.

Evapotranspiration

Evaporation (EV) was measured from a United States Weather Bureau class A pan. In this study, potential evapotranspiration (ET) rate for rice was considered equal to the class A pan evaporation rate for the same day. Review of literature suggests that for rice, ET equals EV over the growing season more or less close to unity when water is not a limiting factor (Bhuiyan 1982; Kampen and Levine 1970; and Sevendsen 1983). Daily measured evaporation data were used to compute weekly and seasonal evapotranspiration values.

Seepage and Percolation

Seepage and percolation was measured by using the water subsidence technique (Giroan and Wickam 1976). In this method the water loss from a rice field takes place as evapotranspiration (ET), surface drainage (DR), and seepage and percolation (S&P). If no water is added to or drained from the field, then the total water used would be due to ET plus S&P and would be reflected by a corresponding subsidence or loss of head of water on the rice field surface. Assuming that daily evapotranspiration is computed from evaporation pan data and subtracted from this head loss fall in depth of water, the remainder of the daily fall in water level is equal to the S&P rate provided there is no surface water flow into or out of the rice field.

Water Use

Water used in the project area was either from irrigation sources or from rainfall. Water use status was evaluated in terms of, water used for land soaking and land preparation up to transplanting, seasonal water use and nonbeneficial water supplies prior to seedbed preparation.

Yield Assessment

Yields were assessed on the basis of crop cuts taken in each season in the 30 selected plots, one from each deep tubewell area. Crop-cut samples were taken in each season to estimate yields. For crop-cut samples, a five square meter (m^2) sample area was harvested from each plot taking 1 m^2 harvests from five different locations of the plot. The harvest was threshed and the grain yield measured. Moisture content of the grain was determined by a moisture meter. Yield was adjusted to 14 percent moisture content and expressed in kilogram per hectare (kg/ha).

RESULTS AND DISCUSSION

Characteristics of System Management

For attaining the objectives of irrigation, all systems of management have to perform certain irrigation management tasks which have been categorized and listed by various authors in different ways. Uphoff (1986) identifies twelve irrigation management activities which he has grouped into three broad categories i.e., (i) organization and management activities, (ii) physical system activities, and (iii) water use activities. Svendsen and Small (1990) categorized the activities of an irrigation system into six (which they called) "primary irrigation processes," i.e., planning, designing, construction, operation of facilities, maintenance, and application of water to the land.

In this section of the paper, the main focus was on the identification of salient characteristics of the four DTW management systems under study, with reference to some of the management tasks identified by different authors as noted above. As background material, certain general attributes of the tubewell systems include the following:

Pump and Well Attributes

There was wide variation in the ages of the DTWs of the different management systems. The oldest DTWs belong to the rental and rental-RAKUB systems, their average age is 15 years. The most recently installed DTWs are privately owned. All of the sample DTWs of the latter category were commissioned in 1989. The BIADP DTWs are relatively new, their average age being 4.7 years. All the sample DTWs utilize turbine pumps, and are operated with diesel.

Command Areas

The majority of the DTWs were installed in suitable locations for achieving maximum command area. The topography with reference to the command areas of DTWs of rental and rental-RAKUB systems are sloped, while those of private DTWs are medium sloped, and those of BIADP DTWs are medium sloped and terraced. The canal networks of rental, rental-RAKUB and BIADP DTWs are simple in the sense that they have a few branch channels. In contrast, in the private DTWs, the canal network consists of a large number of main and subsidiary canals and channels.

Water Allocation

In Bangladesh, if a farmer has land under the command area of an irrigation system, he is entitled to get water from the system provided he pays irrigation fees and abides by the rules and norms decided by the system management in the common interest of the irrigators.

In case of DTW irrigation, a farmer's perceived entitlement to water is strongest if the DTW is rented and managed by a group of farmers of which he is a member, and the entitlement is weakest if the DTW is owned and managed by a few farmers not including himself. In a system when a DTW is owned by a public agency and managed jointly by a farmer group and a public agency, and where water is delivered on payment of a specified irrigation fee, a farmer's entitlement to water becomes strong but not as strong as in the case of a rental DTW managed by his own group.

Farmer Organizations for Managing the Systems

All sample DTWs except those under private management have farmer irrigation organizations. These organizations are informal in the sense that they are not registered groups or cooperatives.

All of the DTWs, however, have irrigation management committees consisting of nine-to-eleven members. When there are irrigation groups, the managing committees (MCs) of such groups automatically become the irrigation management committees (IMCs). One observation of the research team is that the irrigation groups in all management systems under study are defunct for all practical purposes. They seem to exist mainly on paper. The IMCs/MCs too, are not very active. Irrigation tasks are managed primarily by the manager of a group in collaboration with one or two other persons.

Water Distribution

Mostly, DTWs followed a rotational distribution of water under which system the management divided the entire command area into blocks. The number of blocks in the rental system ranged from 3 to 6, in the rental-RAKUB from 3 to 4, in private tubewells from 2 to 4, and in the BIADP System from 2 to 5. The blocks were divided in two ways: (i) in terms of head, middle and tail, and (ii) in terms of rotational sector.

Operation, Repair and Maintenance of DTWs

In each of the systems, DTW had an operator who is under the direct control and supervision of the manager. In the private system, repair and maintenance of DTWs is the responsibility of the tubewell owners. BADC, which is the supplier of DTWs, is under agreement to supply the services of mechanics up to five years from the date of sale of a DTW. In the rental, rental-RAKUB and BIADP systems, repair and maintenance responsibilities lie with the BADC which owns the DTWs. In rental and rental-RAKUB, the farmer groups are required to pay Tk 1,000 (approximately US$27.03) per year for free supply of some spares. The groups included in the study did not pay this amount but decided to purchase their spares from local markets. In the BIADP System, the cost of spare parts in excess of one third of the fee paid by farmers to the BIADP authority, was borne by farmer groups.

Water Availability and Utilization

The designed discharge of each tubewell was 56.6 lps but actual discharge was less than the designed. Among Barind tubewells the maximum discharge of 51 lps was recorded at Amtoli-1 which was 8 percent less than the designed and the minimum of 28.3 lps at Sarengpur-2 which was 50 percent less than the designed discharge. In Mohanpur area the maximum discharge of 50.2 lps was recorded at Buckshimul which was 11 percent less than the designed, and the minimum of 26.6 lps at Mohabatpur-2 which was 53 percent less than the designed discharge (Table 9.1).

In terms of the area irrigated during *kharif*-1 season, in 1990, it was found that the private DTWs performed best followed by the rental DTWs. On the average, for each cusec discharge, a private tubewell irrigated 15 ha and a rental tubewell irrigated 13.23 ha (Table 9.1). The performance of rental with RAKUB DTW was 12.81 ha while the BIADP DTWs covered only 10.3 ha. The performance in 1991 followed the same trend as in 1990. Area per cusec discharge under private, rental and BIADP were 13.2, 10.3 and 8.1 ha, respectively. However, none of the systems was able to achieve a practicable command area.

Table 9.1. Designed and actual discharges, command areas, and irrigated areas of the selected tubewells (boro seasons 1990 and 1991).

Location	Designed discharge (lps)	Command area (ha)	Actual discharge (lps)		Irrigated area (ha)	
			1990	1991	1990	1991
BIADP Rental DTW						
Sharangpur-1	56.6	24.3	26.9	39.9	17.5	18.2
Sharangpur-2	34.0	18.2	28.0	28.3	10.7	8.9
Sharmongla-1	56.6	24.3	37.1	33.1	4.4	2.0
Fazilpur-2	56.6	24.3	34.0	45.6	14.8	9.7
Amtoli-1*	56.6	24.3	49.3	51.0	–	–
Amtoli-2**	51.0	21.9	28.0	33.0	6.8	–
Ramnagar-2	56.6	24.3	34.2	37.1	14.2	14.0
IFAD DTW, Mohanpur						
Shakua**	56.6	24.3	52.1	–	13.5	–
Haridagachi**	56.6	24.3	40.0	–	18.4	–
Durail-3	56.6	24.3	45.3	47.5	30.4	20.0
Rental DTW, Mohanpur						
Mohabathpur-2	56.6	24.3	53.2	48.1	23.6	20.9
Bakshimul	56.6	24.3	48.1	50.2	28.3	15.0
Darshanpara**	56.6	24.3	36.8	–	12.8	–
Private DTW, Mohanpur						
Palsa	56.6	24.3	49.3	45.5	27.1	22.3
Moheskondi	56.6	24.3	51.0	41.6	27.7	24.3
Bakshail	56.6	24.3	47.3	44.5	23.7	14.7

* There was no boro rice crop in 1990 and 1991.

** There was no boro rice crop in 1991.

Notes: DTW = Deep tubewell.
BIAD = Barind Integrated Area Development Project.
IFAD = International Fund for Agricultural Development.

Water Productivity

On the average, water productivity for private and rental with RAKUB were 7.63 and 5.73 kilogram per hectare-millimeter (kg/ha-mm), respectively. The performance of rental tubewells was 5.40 kg/ha-mm, while the BIADP tubewells had 5.10 kg/ha-mm (see Table 9.2). The performance in 1991 was not similar to 1990. Productivity of water in 1991 under private, rental and BIADP were 6.63, 6.6 and 4.2 kg/ha-mm, respectively (Table 9.3).

Table 9.2. Water availability and productivity of selected tubewells (boro season 1990).

Location	Actual discharge (lps)	Total operating hours	Water depth (mm)	Rainfall (mm)	Total water (mm)	Yield (kg/ha)	Water productivity (kg/ha-mm)
BIADP Rental DTW							
Sharengpur-1	26.9	977	540	171	711	5,000	7.0
Sharangpur-2	28.0	1,108	1,045	171	1,216	5,420	4.4
Sharmongla-1	37.1	300	890	171	1,061	5,230	4.9
Fazilpur-2	34.0	1,207	984	171	1,155	5,320	4.6
Amtoli-2	28.0	632	938	171	1,109	5,600	5.0
Ramnagar-2	34.2	1,133	989	171	1,160	5,425	4.7
IFAD DTW, Mohanpur							
Shakua	56.6	548	613	171	784	3,610	4.6
Haridagachi	56.6	790	617	171	788	3,606	4.6
Durail-3	56.6	750	402	171	573	4,590	8.0
Rental DTW, Mohanpur							
Mohabathpur-2	56.4	677	550	171	721	4,453	6.1
Bukshimul	56.6	877	537	171	708	3,000	4.2
Darshanpara	56.6	471	480	171	651	3,833	5.9
Private DTW, Mohanpur							
Palsa	56.6	690	451	171	622	5,566	8.9
Moheshkondi	56.6	599	397	171	568	5,233	9.2
Bakshail	56.6	590	546	171	717	3,446	4.8

Notes: DTW = Deep tubewell.
BIAD = Barind Integrated Area Development Project.
IFAD = International Fund for Agricultural Development.

Field-Level Water Use Efficiency

Water use efficiency was 92 percent for Barind tubewells and 76 percent for the Mohanpur area (Table 9.4). The soil type of Barind was silty clay and it was loamy in Mohanpur. A low water use efficiency which may be attributed to light soil type was observed in Mohanpur. Table 9.5 gives the seepage and percolation rates for the Barind and Mohanpur areas.

Crop Yield

Under irrigated conditions, farmers grew only rice during the kharif-1 season. Crop-cut yield records in 1990 show that yield was highest in BIADP DTWs (5.3 t/ha) followed by private DTWs (4.75 t/ha). The lowest yield was recorded in rental DTWs (3.76 t/ha). In 1991, farms under private DTWs got the highest yield (5.6 t/ha) followed by rental and BIADP farms (Tables 9.2 and 9.3).

Table 9.3. Water availability and productivity of selected tubewells (boro season 1991).

Location	Actual discharge (lps)	Total operating hours	Water depth (mm)	Rainfall (mm)	Total water (mm)	Yield (kg/ha)	Water productivity (kg/ha-mm)
BIADP Rental DTW							
Sharangpur-1	39.9	1,046	788	39	827	4,492	5.4
Sharangpur-2	28.3	748	809	39	848	4,250	5.0
Sharmongla-1	33.1	196	1,423	39	1,162	3,925	3.4
Fazilpur-2	45.6	881	1,427	39	1,466	4,777	3.3
Amtoli-1*	–	–	–	–	–	–	–
Amtoli-2*	–	–	–	–	–	–	–
Ramnagar-2	37.1	1,273	1,148	39	1,187	4,641	3.9
IFAD DTW, Mohanpur							
Shakua*	–	–	–	–	–	–	–
Haridagachi*	–	–	–	–	–	–	–
Durail-3	47.5	740	634	59	693	5,010	7.2
Rental DTW, Mohanpur							
Mohabathpur-2	26.6	735	571	59	630	4,527	7.2
Bukshimul	56.2	650	748	59	843	4,585	5.4
Darshanpara*	–	–	–	–	–	–	–
Private DTW, Mohanpur							
Palsa	31.13	706	579	59	638	5,911	9.3
Moheshkundi	41.60	695	663	59	722	5,704	7.9
Bakshail	30.33	512	639	59	698	5,097	7.3

* There was no boro crop.

Notes: DTW = Deep tubewell.
BIAD = Barind Integrated Area Development Project.
IFAD = International Fund for Agricultural Development.

Distribution of Water Among Farmers

It has been mentioned earlier that in 1990 almost all of the sample farmers received water reasonably on time and in sufficient quantity leaving no problems of distributional equity during that year. During 1991 however, in the rental DTWs, farmers of all categories stated that they did not receive water in time and in sufficient quantity.

Table 9.4. Field-level water use efficiency for rice growing period (boro season 1991).

DTW	Irrigated area (ha)	Water applied (mm)			Water required (mm)			Water use efficiency (%)
		IR	RF	Total	EV	S&P	Total	
Sharangpur-1 (Barind)	18.2	830	39	869	579	225	804	92
Moheskundi (Mohanpur, private)	24.3	650	59	709	274	262	536	76

Notes: IR = Irrigated.
RF = Rain-fed.
EV = Evaporation.
S&P = Seepage and percolation.

Table 9.5. Seepage and percolation (S&P) rates (boro season 1991).

Month	Number of effective readings	Barind Area*	Number of effective readings	Mohanpur Area*
		Average S&P (mm/day)		Average S&P (mm/day)
March	115	2.40	125	3.60
April	130	2.30	140	3.55
May	150	2.20	170	3.45
Average		2.30		3.53

* Weighted by number of samples.

Note: S&P = Seepage and percolation.

Suggested Strategies for the Improvement of System Performance

i) Discharge capacity of a DTW is limited and there is no scope for increasing it. Presently the DTWs are operated for 8 to 10 hours a day. Irrigated area per DTW can be easily increased by increasing daily operating time to 16 to 20 hours. An increase in operating hours will supply a greater volume of water for an additional area under each DTW.

ii) Presently, the rotational system of water distribution is not practically followed; consequently a huge volume of water is misused resulting in poor area coverage. There is no hard and fast rule for water distribution by any agency though it is a key factor in improving the area coverage. Rotational water distribution should be followed on the basis of blocks as well as water requirements of particular crops.

iii) A diversified cropping plan should be adopted for maximizing the use of land and water resources while cropping schedules should be adjusted so that aman cultivation can take advantage of the maximum rainfall period.

iv) The Bangladesh Rural Development Board and co-operative societies should come forward for the management of systems.

v) The canal network should be properly designed for smooth distribution of water.

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