Bangladesh J. Agric. Econs. XVI, 1 (June 1993): 77-88

Research Note

PRODUCTIVITY AND EQUITY PERFORMANCE OF DEEP TUBEWELL IRRIGATION UNDER DIFFERENT MANAGEMENT SYSTEMS IN CHANDINA THANA OF CQMILLA DISTRICT

M. Akteruzzaman, M.A.S. Mandal and M.T.H. Miah

ABSTRACT

This study compares productivity and equity performance of deep tubewells (DTWs) under different management systems (rental, KSS and private). Results show that the command area per MW, and output and gross return per unit of land were significantly higher under private management than under KSS and rental management. However, farmers' gross margin, return over cash cost and full cost of HYV Boro paddy produced under rented DTW schemes appeared to be higher than those under KSSDTWs and private DTWs. As regards the equity issue, it was observed that the produced benefits from irrigation were relatively more equally distributed to the farmers under KSS-D'IWs• compared to private D'IWs and rented DTWs. It revealed that private DTWs showed somewhat better performance from the view point of DTW managers/owners, while rented DTWs showed somewhat better performance from the view point of farmers. It is also concluded that KSS managed DTWs showed a little better performance with respect to farmers access to produced benefits from irrigation schemes.

I. INTRODUCTION

There has been a significant expansion of groundwater irrigation in Bangladesh both in terms of the number of tubewells and area ii7•itlated. According to the fourth five year plan (1990-95), 1.8 million hectares were irrigated by Deep Tubewells (DTWs), Shallow Tubewells (STWs) and Hand Tubewells (HTWs) in 1989-90. The plan has a target to expand groundwater uTioation to 3 million hectares, which will cover about 63 per cent of the targeted area under total surface water and groundwater itrigation. These tv¯gets are expected to be achieved mainly through the operation of 35,000 DTWs, which will mean an additional installation of 10,000 new DTWs and 222,000 new STWs during the plan period (Planning Commission, 1990)

Significant hanges in government polices with respect to minor irritation development took place in recent years. The most remarkable policy changes are the large-scale privatization of minor irrigation and the promotion of competition in the distribution and

The authors are respectively Lecturer, Professor and Associate Professor in the Department of Agricultural Economics, Bangladesh Agricultural University, Mymensingh 2202, Bangladesh. This paper is a revised version of an earlier draft based on the first author's M.Sc. Ag. Econ. thesis (Akteruzzaman 1990). The authors are grateful to the anonymous referees of the Journal for their valuable suggestions on an earlier draft.

utilization of irrigation equipment, which prompted the rapid sale of old DTWs, new DTWs and STWs since the early eighties.

Keeping in view the argument in favour of privatization, a large number of DTWs have been sold to either Krishak Samabav Samity (KSS) groups through Bangladesh Agricultural Development Corporation (BADC) with credit facilities from Bangladesh Rural Development Board (BRDB) or to informal groups, i.e., non-KSS groups through private dealers either with cash or with credit facilities from commercial banks.

Deep tubewells are powered with diesel or electricity and are operated under different forms of management. The major forms of management are informal group management of DTWs under the rental programme of BADC, formal co-operative group management of DTWs under BRDB sponsored KSS progr~nune, and private ownership and management of DTWs. There are also specialized programmes for DTWs management such as landless irrigation programme of PROSIIIKA and Bangladesh Rural Advancement Committee (BRAC), Grame.en Bank DTW management progiaunme, and DTW management programme of BADC and Banaladesh Water Development Board (BWDB) in the northern districts of Ban-ladesh.

Recent studies show that the different agencies involved in DTW management have different levels of control over and supports for the farmers participating in irrigation schemes under different management systems (Mandal, 1987, Palmer-Jones and Mandal, 1987). There are also variations amongst DTW schemes with respect to physical and technical parameters such as land class, farming system, cropping patterns and intensity, tubcwell discharges and cropwater requirements (BAU, 1986; Morton, 1989). These largely explain the variations in the performance of tubewells.

The above studies mainly focussed on the command area and output performance of tubewells, which had wide regional diversities. A few studies dealt with the economic viability (Islam, 1991) and equity impact (IDA DTW, 1990) of KSS-mvna-ed DTWs. There is still need for more comparative studies of tubwells under different management systems. Furthermore, very little is known about the impact of DTW privatization on rural income distribution.

The major objective of this study was to assess the productivity and equity performance of DTWs on the basis of empirical data. The specific objectives of the study were: i. to identify the nature and functions of different management systems of DTW irrigation: ii. to measure and compare DTW productivity performance with respect to command area, yield and output under different irrigation management systems; iii. to estimate returns accrued to DTW owners/managers and water users operating under different management systems; iv to assess the equity performance of DTWs with respect to the access of the different categories of farmers to ownership of DTWs and to produced benefits under different management systems: and v. to suggest policy implications on the basis of the results of the analysis.

This paper consists of five sections. Section II describes research methods followed in the study. In section III, productivity performances of DTWs under different management

systems are measured. Returns from DTW irrigation are discussed in this section, while equity performance is discussed in section IV. Conclusions and policy implications are given in section V.

II. METHODOLOGY

Keeping in view the ultimate aim of the study and resource constraints, three unions namely Chandina (East), Chandina (West) and Maizkhar in Chandina Thana of Comilla district were purposively selected for the study. Two levels of information were used in this study. Firstly , a series of field surveys were conducted on technical, socio-economic and management aspects of DTWs. Secondly, indepth surveys of irrigation users were undertaken during 1990 irrigation season for collecting input-output data relating to l IYV Boro paddy.

Three mainstrem management systems such as (i) BADC-rental DTW programme, (ii) BRDB-KSS DTW programme, and (iii) private management of DTWs were considered for comparison. In order to obtain the information on management aspects of DTWs, 30 out of a total of 43 DTWs in the study area were randomly selected, taking 10 from each management system to find out the operational and management activities of DTWs. For BADC-rental management system 10 DTWs, 5 diesel operated and 5 electrically operated, were selected. For KSS management system, 10 DTWs, 7 diesel operated and 3 electrically operated, were chosen. Out of 10 DTWs under private management, 3 were diesel operated and 7 were electrically operated. For the purpose of selecting farmers, a two stage sampling procedure was adopted. In the first stage, 15 DTWs, taking 6 from each DTW under each management system were randomly selected. Each of these 6 farmers selected from each DTW included 2 small farmers (Below 0.4 ha), 2 medium farmers (0.4- 1.0 ha), and 21arge farmers (above 1.0 ha). Thus, a total of 90 farmers were selected for the farm survey.

The collected data were analysed and presented manily in tabular forms. In addition, some statistical analyses were also applied to test the validity of the findings. The analysis of variance was applied to find the significance of variation of productivity criteria among management systems. Duncan Multiple Range Test (DMRT) was applied to confirm the significance of the differences. A correlation test was also applied to test the correlation between command area and water charge.

III. PRODUCTIVITY PERFORMANCE OF DTWS

Producitivity performance of DTWs was measured in terms of command area, yield and gross output of HYV boro paddy under different management systems. Cost and return of DTW schemes from managers/owneres point of view and the cost and return of HYV boro paddy from farmers point of view were calculated and compared between management systems.

Command Area

This study showed that average command area was the highest for private DTWs and lowest for rented DTWs. Command areas were 13. 63, 14, 03 and 21. 05 hectares for rented

DTWs, KSS-DTW and private DTWs respectively (Table 1). When the F-test was employed on command area under different management systems by power sources, the result showed that command areas of DTWs under different management system were significantly different at 1 per cent level of significance, but there was no significant difference in command areas of electrically operated DTWs and diesel operated DTWs. The results of Duncan Multiple Range Test (DMRT) showed that command area of private DTW were significantly different from rented DTWs and KSS-DTWs but command areas of rented DTWs and KSS-DTWs were not significantly different from each other. The field data showed that many STWs were installed around the studied DTWs. It was also reported that the number of newly installed S'lVs per affected MW was hiaher for rented DTWs (1.0) and KSS-DTWs (0.7) than for private DTWs (0.3).

Yield of HYV Boro paddy

The result showed that average yield of IIYV boro paddy was the highest in the private DTW schemes and lowest in the KSS-DTWs schemes. The estimated yields were 4. 54, 4.18 and 4. 64 MT per hectares under rented DTW, KSS-DTW and private DTW schemes, respectively (Table 1). When F-test was employed on yield of boro paddy with respect to different management systems and power sources, the result showed that there was no significant variation in Boro yields between tubewell management system and power sources. It was also observed that the per hectare yield of Boro paddy of farmers and of managers were 4.30 and 4.42 MT respectively. However, no significant difference was observed in the yield levels.

Gross output of the DTW Schemes

Gross output of DTW scheme is estimated as the product of average yield of HYV Boro paddy and command area of the DTW schemes. The result showed that gross output was the highest for private MW (97.67 MT) and lowest for KSS DTWs (58.52 MT). When F-test was employed, the result showed that gross output were statistically different between management systems. DMRT confirmed that gross output of private DTWs were statistically different from gross output of rented DTW and KSS DTW schemes. But die gross output of rented DTW and KSS-DTWs were not statistically different from each other.

Cost and return of the DTW Scheme

The cost of DTW scheme included operation and maintenance (0 and M) cost. The size and nature of 0 and M cost varied with the management systems of DTW schemes (Table 2). The evidence showed that 0 and M cost per DTW per season were Taha 49, 466 for rented DTWs, Taka 55, 121 for KSS-and Taka 57, 206 for private DTWs, respectively. The 0 and M costs of diesel operated DTWs (Taka 57, 580 per DTW) were found to be 14 per cent higher than that of electrically operated DTWs (Taka 50, 531 per DTW). The average return over 0 and M cost was the highest for private DTWs (Taka 35, 083) and lowest for rented DTWs (7, 763). When F- test was employed, it was found that returns over 0 and M cost of private DTWs were significantly higher than that of rented DTWs, KSS-DTW, and the difference was statistically significant at 1 per cent level. However, there was no significant

difference between electrically operated DTWs and diesel operated DTWs, DMRT showed that the return over 0 and M costs of private DTW scheme was stastically different from return of KSS-DTW and rented DTW schemes, but the difference between KSS-DTW and rented DTW was statistically insignificant. The main reason for the highest return to private DTW scheme was that both command area and water charge were higher for private DTWs than for other management type of DTWs.

Cost and Return of HYV Boro Paddy production

The total variable costs and total cash costs for producing HYV Boro paddy were lower for farmers under KSS-DTWs than for farmers under rented DTWs and private DTWs. Total costs were higher for farmers under rented DTWs. The result showed that gross return of private DTW farmers from HYV Boro paddy, which constituted the value of main product (paddy) and the value of by-product (straw), were 6 and 2 per cent higher than gross returns under KSS DTWs, and rented DTWs respectively (Table 3).

Some partial measures of efficiency of producing HYV viz., gross margin, return over cash cost, and return over total cost were adopted. It was found that in every case the fu¯ms under rented DTWs had higher returns, compared to the farms under KSS-DTWs (Table 4). The explanation is that the costs of HYV Boro paddy production under rented DTW schemes were 9 and 4 per cent lower than under the KSS-DTW and private DTW schemes, respectively. Water charge for rented DTWs was 4 percent lower than for private DTWs, but similar to KSS-DTWs.

IV. EQUITY PERFORMANCE OF DTWs

In the present study, the equity performance of DTW irrigation under different management systems was measured in terms of the access of the different categories of farms to DTW ownership, access of farmers to irrigation water, access of different categories of farmers to the produced benefits, and also in terms of distribution of returns from irrigation to different factors of production.

Access to Tubewell Ownership/Management

A tubewell in Bangladesh can be owned by individuals or by formal or informal groups. Field evidence showed that 60 per cent of DTWs were owned/controlled by large farmers in the study area. It can be seen that 80 per cent of private DTW owners and 40 per cent of managers of rented DTWs were large farmers, respectively. As regUds share of command area, the study revealed that the land irrigated by owners/managers of DTWs constituted only about 4 per cent of conunand area irrespective of management systems, which runs counter to the popular belief that tubewell owners/managers have the most land in the command area.

Access of the Farmers to Water Use

For this part of study, irrigators of 13 DTW schemes were investigated. The current list of farmers participating in 2 DTWs were not available. The total number of irrigators in the 13 DTWs were 1387. Out of them, 59 per cent were small farm (0-0.4 ha), 29 per cent of them were medium farm (0.4-1.0 ha), and the large farm (above 1.0 ha) were 12 per cent,

respectively. It was found that the participation of the small farmers were 66 per cent under private DTWs, but their cultivated Boro land constituted 16 percent of total command area. Under the KSS-DTWs 56 per cent were small farmers, but their cultivated Boro land accounted for 37 per cent of command area (Table 5).

Share of Produced Benefits

In the study 90 farmers from 15 DTWs (2 small, 2 medium and 2 large farmers from each of the DTWs) were selected for investigation. It was observed that the bottom one third irrigators of rented DTW KSS-DTW and private DTW schemes received 20, 19 and 18 per cent of the produced benefits (net benefits from irrigated HYV Boro paddy production), respectively. On the other hand, top one third section of the irrigators under rented DTW, KSS and private DTW schemes received 54, 42 and 46 per cent of produced benefits, respectively (Table 6). The gini concentration ratios of income for irrigators under rented DTWs, KSSDTWs and private DTWs were 0.23, 0.16 and 0.17, respectively. These imply that the pattern of income distribution was a little better for KSS-DTWs and private DTWs than for rented DTW schemes.

Distribution of Irrigation Returns to Factors of Production

The study examines how the returns from irrigation is distributed amongst the factors of production. Thirty-seven and 36 per cent of the total return from irrigation accrue to land and labour, respectively. It was found that 16 per cent of gross value of output were distributed for irrigation water. The residual is negative or losses for all types of management but the losses are less for rented DTWs than KSS-DTWs and Private DTWs (Table 7).

V. CONCLUSIONS AND POLICY INIPLICATIONS

This study was conducted to make a comparative analysis of performance of deep tubewells under different management systems.

The private DTWs owners were able to start operating their engines at right time which was a significant effect on development of command areas than those started operating later. The fixed amount of cash per unit of irrigated land was charged irrespective of quantity of water to the field. The water charge and command area were not significantly correlated and the water charge was higher for cash purchased DTWs than loan purchased DTWs. It is also noted that for all types of DTWs, 28 per cent water charge was overdue from farmers and the unpaid amount would be paid in the next irrigation period.

Command areas and gross output of privately owned DTWs were higher than those of rented DTWs and KSS-DTWs and the difference was statistically signifciant. Yield of HYV boro paddy did not vary with management systems of DTWs, although it was nominally higher for privated DTWs than for rented DTWs and KSS-DTWs.

On the basis of gross margin, return over cash cost, and return over full cost of HYV Boro paddy, the rented DTW schemes showed better performance, compared to private DTW and KSS DTW schemes. The better performance of rented DTWs in this case, due to lower cost of production of HYV Boro and lower water charge.

The evidence showed that most of the managers (60 per cent) had large farms and enjoyed higher benefits from DTW schemes. The percentage of irrigated to total cultivable area of the managers was found to be much higher than that of irrigated farmers participating in the scheme. The study revealed that the land irrigated by the DTW owners/ managers accounted for only 4 per cent of DTW command area, the remainder being irrigated by other farmers.

Evidence showed that 66 per cent of irrigators under privately managed DTWs were small farmers, while their irrigated Boro land accounted for only 46 per cent of the command area under the KSS managed DTWs, only 56 per cent of irrigators were small farmers and their irrigated boro land within the command area was only 37 per cent.

The investigation showed that bottom one third irrigator were enjoyed 40 per cent lower benefits than that of top one third sections to the irrigators. It is near about same for all types of DTW management.

The study revealed that 37 and 36 per cent of total returns from irrigation were distributed for land and labour, respectively, the remainder being distributed to water and other variable inputs.

Policy Implications

i) Privatization of DTWs appears to have made some improvement in irrigation performance with respect to command area, gross output and return cover O and M cost, and access of farmers to water use. Therefore, all kinds of institutional rigidities with respect to privatization of DTW management should be removed for increasing efficiency. The major actions are needed in regards to turn over of public DTWs to private management, loan sanction for new DTW sales, repair and spare parts supplies for DTWs. Grameen Bank management or landless management of DTWs, which are special forms of private management of DTWs, should also be allowed and monitored in search of improvement in DTW performance.

ii) KSS managed DTWs showed somewhat better performance with respect to distribution of irrigation benefits. So, KSS management of DTWs should also be allowed to continue in competitive with private management of DTWs. But KSS should not be given any monopoly right to acquire and operate DTWs, as has been the case in the past. Rather, the KSS-DTWs must operate in a competitive environment with private or other forms of DTW management.

iii) Because of low O and M costs (14 per cent lower) and large command area (23 per cent higher) of electrically operated DTWs more and more tubewells should get electricity connections. This necessitates the promotion of rural electrification programme.

iv) There was a common feature of non-repayment of loan instalments and rental charges in the study area. This can be improved through strict measures towards repayment of loan instalments and payment of arrear rental charges before the rented DTWs are sold out.

REFERENCES

Akteruzzaman, M. (1990). *A Comparative Economic Study on Productivity and Equity Performance of Deep Tubewell Irrigation under Different Management systems in a Selected Area of Comilla District,* M. Sc. Ag. Econ. Thesis, Department of Agricultural Economics, BAU, Mymensingh.

BAU, (1986): *Water market in Bangladesh : Inefficient and Inequitable?* Workshop Proceedings, IWM-12 Department of Irrigation and Water Management Mymensingh Bangladesh Agricultural University.

IDA DTW (1990): *Equity Impact of Deep Tubewells,* Working paper no, 54, IDA Deep Tubewell II Project, GOB/Mott Mac Donald International Limited.

Islam, N. (1991). "An Economic Analysis of Deep Tubewell Privatization in Bangladesh", *Farm Economy,* 8:61-81.

Mandal, M.A.S. (1087). "Imperfect Institutional Innovation for Irrigation Management in Bangladesh, "Irrigation *and Drainage Systems,* 3: 239-258.

Morton, James (1989). "Tubewell Irrigation in Bangladesh", *Irrigation Management Network Paper No. 89/2d,* London Overseas Development Institute.

Palmer-Jones, R.W. and Mandal, M.A.S. (1987): Irrigation Groups in Bangladesh, *ODI-IIMT Irrigation Management Network Paper no. 87/2d.*

Planning Commission (1990): *The Fourth Five Vear Plan, 1990-95.* Ministry of Planning, Government of the People's Republic of Bangladesh, Dhaka.

Table 1 : Performance of DTW by Management Systems.

Management systems	Command Area (hectare)	Yield (metric tons/ha)	Output (metric tons/scheme)
Rented DTWs	13.63	4.54	61.88
KSS DTWs	14.00	4.18	58.52
Private DTWs	21.05	4.64	97.67
All DTWs	16.24	4.48	72.76
Electric DTWs	19.49	4.54	88.48
Diesel DTWs	15.01	4.37	65.65

Source: Field Survey, 1990.

Table 2: Returns to DTW owner/manager by Management Systems.

Management Systems	: Amount water : charge : (Taka)*		: Operation and : maintenance cost : (Taka)		: Return over operation : and maintenance cost : (Taka)	
	: Per DTW : scheme : (Tk '000) :	: Per : hectare : :	: Per DTW : scheme : (Tk '1000) :	: Per : hectare :	: Per DTW : scheme : (Tk. '000) :	: Per : hectare : :
Rented DTWs	56.875	4075	49.467	3475	7.763	568
KSS DTWs	60.176	4199	55.221	3942	10.755	766
Private DTWs	92.540	4280	57.409	2732	35.083	1667
All DTWs	69.690	4186	54.056	3330	17.867	1099
Electric DTWs	75.694	4226	50.532	2896	26.062	1492
Diesel DTWs	63.670	4145	57.560	3836	9.672	643

*Excluding depreciation cost of DTWs.

Source : Field survey, 1990.

Table 3: Gross Return of HYV boro paddy by Management

Management systems	Gross return (Taka/hectare)		
	Main product (Tk. '000)	By-product (Tk. '000)	Total (Tk. '000)
Rented DTWs	24.712	1.181	25.893
KSS DTWs	23.334	1.245	24.986
Private DTWs	24.521	1.721	26.253
All DTWs	24.294	1.398	25.692
Electric	24.092	1.316	25.411
Diesel	24.594	1.630	26.043

Source: Field Survey, 1990.

Table 4: Returns of Irrigated Boro paddy by Management Systems.

Management systems	Gross margin (Tk. /hectare)	Return over cash cost (Tk. /hectare)	Return over total cost (Tk. /hectare)
Rented DTWs	12387	12782	-948
KSS DTWs	12014	12399	-4515
Private DTWs	12182	12642	-1768
All DTWs	12202	12612	-2322
Electric	14052	11597	-2322
Diesel	12980	13378	-2378

Source: Field Survey, 1990.

Table 5: Access of Different Categories of Farmers to water use for Boro Production by Management Systems

Farm size	Rented DTWs		KSS DTWs		Private DTWs		All DTWs	
	: Cumula-tive : % of : house-holds :	: Cumula-tive : % of : culti-vated : boro : land	: Cumula-tive : % of : house-holds :	: Cumula-tive : % of : culti-vated : boro : land	: Cumula-tive : % of : house-holds :	: Cumula-tive : % of : culti-vated : boro : land	: Cumula-tive : % of : house-holds :	: Cumula-tive : % of : culti-vated : boro : land
Small	59.71	37.81	56.22	36.69	65.53	46.42	60.82	40.36
Medium	90.05 (30.34)	76.20 (38.39)	83.78 (27.55)	66.76 (30.08)	88.18 (22.65)	72.26 (25.89)	87.49 (26.60)	71.36 (31.00)
Large	100.00 (9.95)	100.00 (23.79)	100.00 (16.22)	100.00 (33.23)	100.00(11.82)	100.00 (27.73)	100.00 (12.17)	100.00 (28.84)
Gini-Coefficient	0.25		0.24		0.22		0.24	

Figures in the parentheses indicate percentage of total farm and cultivated boro land.
Source : Field survey, 1990.

Table 6: Access of Different Categories of Farmers to Production benefits from Irrigation by Management Systems.

Farm size	Rented DTWs		KSS DTWs		Private DTWs		All DTWs	
	: Cumula-tive : % of : house-land :	: Cumula-tive : % of : income :	: Cumula-tive : % of : house-land :	: Cumula-tive : % of : income	: Cumula-tive : % of : house-hold :	: Cumula-tive : % of : income	: Cumula-tive : % of : house-land :	: Cumula-tive : % of : income
Small	33.33	20.29	33.33	19.04	33.33	18.22	33.33	13.15
Medium	66.67 (33.33)	45.78 (25.49)	66.67 (33.330)	57.56 (35.52)	66.67 (33.33)	55.74 (37.52)	66.67 (33.33))	53.00 (33.85)
Large	100.00 (33.33)	100.00 (54.22)	100.00 (33.33)	100.00 (23.33)	100.00(1 (33.33)	100.00 (46.26)	100.00 (33.33)	100.00 (47.00)

Fitures in the parentheses indicate percentage of total farms and total income.
Source : Field survey, 1990.

Table 7: Returns to Factors of Production HYV Boro Paddy

Factors	: Items of cost	:	Net return (Taka/hectare))			
	:	: Rented	:KSS : DTWs	: Private : DTWs	: All : DTWs	: % of : gross : output
Land	Opportunity Cost as bank loan basis	9309	11041	8455	9509	37
Labour	Family + Hired	8482	9416	9900	9267	36
Water	Cost payment	4093	4182	4350	4211	16
Variable inputs	Fertilizer	1971	1674	2161	1951	8
	Seed	605	494	546	551	2
	Draft power	1376	1277	1282	1312	5
	Insecticides	576	701	773	692	3
	Others	518	491	538	519	2
Residual	-	-1037	-4490	-1764	-2319	-9
Gross value of output	-	25893	24786	26241	25693	100

Source : Field survey, 1990.