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EVALUATION OF FOUR FARMER-MANAGED DEEP TUBEWELL IRRIGATION SCHEMES : CASE STUDIES

M. H. Rashid and R. K. Das[1]

Irrigation and Water Management Division
Bangladesh Agricultural Research Institute
Gazipur-1701, Bangladesh

Abstract

A base-line study was undertaken in 1988-89 irrigation season on the four deep tubewell schemes in Dhaka and Manikganj districts to identify the problems constraining the command area development. Plausible solutions to the priority problems that are technically feasible and economically viable were developed and implemented.

Pump discharges were 51 to 62 lps against the design discharge of 56 lps and drawdown observed varied from 5.06 to 7.21 m. Pumping hour (14.7 to 17.5 hrs / day) was good. But pump operation per unit area (89.9 to 99.5 hrs/ ha) channel density (91 to 153 m/ha) and area occupied by the channels (1.84 to 3.9%) were considerably high).

Channels were constructed with inadequate capacity, insufficient freeboard, uncompacted channel banks and irregular channel bed slope at all schemes.

Irrigation application was not based on crop water requirement at any of the sites. Over irrigation (mostly at the head end) as well as under irrigation (mostly at tail end) were observed existing together in each scheme. At none of the sites block rotational irrigation was practiced. Daily crop water use was found 8 to 12 mm at the peak period. Rainfall varied from 70 to 140 mm during the boro season. Lower aile heights (4 to 11cm) were observed which were insufficient for ponding water. Night irrigation was practiced at all sites with insufficient supervision and care.

Command area per unit of pump discharge varied from 0.31 to 0.41 ha (about 57 to 75% of the potential command area). Conveyance losses were found 7 to 11 lps/100m of channel length and conveyance efficiency ranged from 43 to 68 percent.

Inequity of water distribution was observed at all schemes (1.7 to 2.3) and adequacy of water supply varied from 0.86 to 2.35.

Key words: Command area, Potential command area, Conveyance loss, Conveyance efficiency, Equity and Adequacy.

Introduction

Irrigation is recognized as a leading input for enhancing agricultural production in Bangladesh and accordingly it has been given a very high priority in the national plans of the country. The Government of Bangladesh (GOB) has established an objective of foodgrain self-sufficiency as soon as possible.

1 *Mott MacDonald International Ltd., 87, Motijheel C/A, Dhaka, Bangladesh.*

This will require a significant increase in crop production. But, there is hardly any additional land to bring under cultivation. Hence, the increased food must come from intensifying the production through irrigation expansion, its effective utilization, and improved production practices. With this view, more and more irrigation equipment are being installed every year throughout the country. So far, about 30,000 deep tubewells (DTW), 3,00,000 shallow tubewells (STW), 56,000 low-lift pumps (LLP) and more than, 1,00,000 MOSTIs are working in the field (Rashid, 1993). Of these equipment deep tubewells are the most expensive ones. A 2 cusec DTW costs more than Tk. 6 lacs, but unfortunately it commands only around 20 ha against a potential of about 30-35 ha (Rashid and Das, 1991).

In the recent years, the scarcity of the surface water during the rabi season is severely experienced; alternatively there are increased interests in the exploration of groundwater for irrigation (Biswas, 1991). However, the availability of groundwater resources has also become an alarming situation for further installation of pumping units in certain regions. Under this situation, action should be taken, to maximize utilization of the available water resources as well as pumps. Many authors (Bhuiyan and Nishat, 1977; Biswas, *et al.*, 1978; Miah, 1979, MacDonald and Partners Ltd., 1980; Keller *et al.*, 1981; Satter, 1983, Biswas, 1985; Chowdhury, 1985, Motton, 1989) had mentioned about the poor performance of irrigation schemes in Bangladesh but none of them were based on specific and thorough case studies. Thus, four deep tubewell irrigation schemes in Dhaka and Manikganj districts were selected for specific studies to identify the factors responsible for poor performance of these schemes. These schemes were Ukiara at Manikganj thana, Baparipara at Ghior thana, Gorjona-1 at Saturia thana and Khatra -2 at Dhamrai thana. This study covered all the three aspects of irrigated cropping- engineering, agronomic and socio-economic. However, the major parameters are only described here in brief with emphasis in engineering. The main objective of this programme was to study the farmers' practices, the performance of the schemes and to identify the constraints.

Methodology

Base- Line Study

A base-line study was conducted of the farmers' existing practices of pump operation, crop husbandry and scheme management to see the operational performance and identify the problems that constrained improved performance. Measurements and estimations were done as follows:

i) fortnightly pump discharges by cutthroat flumes at the steady state condition;
ii) static water levels (SWL) and pumping water levels (PWL) by depth gauge (well dipper) at the time of discharge measurement;
iii) RPM of the prime mover by tachometer at the time of discharge measurement;
iv) pump operating hours by noting the time of start and stop of each day in log book;
v) irrigation channel characteristics such as length, density wetted perimeter, area occupied by the channels and compaction by direct field measurements;
vi) field water requirement(FWR) by two sets double ring infiltrometers at each scheme;
vii) water distribution system by direct field observations;
viii) aile heights by field measurements;
ix) command area estimation from records of block registers;
x) conveyance loss by inflow-outflow method at operational flow depth using the following formula (3 to 4 observations at each scheme):

$$Cl = \frac{Q_1 - Q_2}{L} \times 100$$

Where CL = steady state conveyance loss in lps /100 m,

Q_1 & Q_2 = flow rate in the upstream and downstream flumes in lps, respectively and

L = length of the channel section in meter.

xi) night irrigation practices by direct field visits;

xii) agronomic and socio-economic data were collected by interviewing the farmers.

Evaluation of the system

Farmers' water management practices were evaluated using the following parameters:

1) Command area: Area covered per unit of pump discharge i. e. hectare per litre per second (ha/lps).

ii) Potential command area: The potential command area was calculated based on the gross water used by the crop during the peak time (say April) and the available discharge of the pump. It was assumed that all area was cropped with rice, water use by crops includes both crop evapotranspiration and seepage and percolation losses, and the pump can be operated 20 hours a day and 30 days a month. Overall water use efficiency was assumed to be 70 percent. Thus :

a) Irrigation water available for peak period (m^2) , say April

$$V = \frac{Q \times 60 \times 60 \times 20 \times 30}{1000}$$

b) Potential command area, PCA (ha/lps)

$$PCA = \frac{V \times 0.7}{d \times 10000 \times Q}$$

where Q is the well discharge in litres per second and d is the gross water use by crop in meters during April, which was found to be 0.25 to 0.36 m with an average of 30 m.

iii) Pumping hours: Pumping hours by total hours operated per season and percent of potential. Potential means maximum possible which is considered here 20 hours a day and 130 days in the whole boro season.

iv) Channel conditions: Size, shape, alignment, compaction, gradient etc.

v) Conveyance loss: Scheme average conveyance losses in lps/100m of channel length and lps/m^2 of wetted channel area.

vi) Conveyance Efficiency : Ratio of water available at field inlet to that at supply point.

vii) Equity: Determined by the inter-quartile ratios when arranged in descending orders (Abernathy, 1986).

$$\text{Inter-quartile Ratio} = \frac{\text{Upper quartile (upper 25\%)}}{\text{Lower quartile (lower 25\%)}}$$

viii) Adequacy: supply- demand ratio (supply/demand=R)

Water supply = total irrigation water delivered to field plus effective rainfall, m/season.

Demand = Water needed for land preparation, seasonal crop water need and percolation, m/season.

Results and Discussion

Scheme Information

The basic information of the schemes are shown in Table 1. The seasonal average discharges of the pumps are shown in Table 2. Low water level fluctuation (difference between static and pumping water levels (Table 2) and low specific drawdown (<15 ft/cfs) describe the aquifer (s) to be of good quality.

Farmers practices

i) Channel Construction and Operation

Table 1. Summary of basic information of the deep tubewell schemes.

Parameters	Scheme			
	Ukiara	Baparipara	Gorjona-1	Khatra-2
Thana	Manikganj	Ghior	Saturia	Dhamrai
Commissioning date	26-3-86	26-3-86	10-7-85	20-12-87
Operated by	Electric Motor	Electric Motor	Diesel Engine	Diesel Engine
HP of prime mover	20	30	25	31.5
RPM of prime mover (design)	1455	1470	2250	1500
DTW capacity (cfs)	2	2	2	2
Soil type	Clay	Clay & Clay loam	Clay and Sandy clay loam	Clay

The schemes have 2-4 feeder channels and several field channels covering the entire command area. Usually tubewell discharge is diverted two or three directions from the discharge box/ stilling basin. The layout of the channels had to follow the field boundaries of highly fragmented plots, resulting in a meandering path, longer channels, more exposed wetted areas and insufficient free-board. These caused high leakage, seepage, percolation and overtopping losses (conveyance loss 7.08 to 10.64 lps/100 m, Table 2); and high channel density (91 to 153 m/ ha, Table 2). The area occupied by the channels varied from1.8 to 3.5 percent (Table 2).

Channels were constructed at all sites, by the farmers themselves without following any engineering design and procedures. As a result most of the channels were of poor quality due to uncompacted bed and banks, irregular bed slope, no control and division structures, inadequate size and irregular shapes. Beds of field channels were mostly lower than the field elevations. However, most of the feeder channels have three beds higher than the adjacent fields. Non-uniform bed slope caused dead storage losses in many places and retarded the flow causing back water effects and either overtopping of the banks at flatter and upward sloping points or increased the flow velocity at the steeper slope points causing bank erosion. Farmers took water by cutting the channel banks (bunds) thus making them weaker. It was also observed that most of the field channels were constructed temporarily and during the season.

Channel conveyance efficiency varied from 43 to 68 percent (Table 2). Higher conveyance efficiency (68 %) at Ukiara was probably due to the lower wetted perimeter and the use of shorter channel length. Use of larger perimeter and longer channel length in the other three schemes might be the reasons for lower efficiencies. At Gorjona, the low pump discharge might be the another reason.

ii) Pump Operation and Water Distribution

Operating hours of the pumps per day were

Table 2. Performance evaluation of the deep tubewell irrigation schemes.

Parameters	Scheme			
	Ukiara	Baparipara	Gorjona-1	Khatra-2
Pump discharge (lps)	61.5	61.1	56.0	55.2
Pumping hours				
i) Hours/day	16.8	17.5	15.7	14.7
ii) Hours /ha	99.5	94.4	89.9	98.2
Static water level (m)				
i) Range	4.00-5.90	3.50-5.62	2.90-5.63	3.40-4.62
ii) Mean	5.26	4.89	4.78	3.86
Pumping water level (m)				
i) Range	11.20-13.32	9.70-10.60	10.20-13.10	9.20-11.30
ii) Mean	12.47	9.95	11.95	10.40
Measured pump RPM	1400	1320	1340	1340
Total length of the channel (Feeder & Field),m	2668	2272	2489	2657
Channel density (m/ha)	132	91	143	153
Area occupied by channels				
i) Hectare	0.47	0.46	0.67	0.54
ii) Percentage (%)	2.32	1.84	3.90	3.16
Average wetted perimeter (m)				
i) Feeder channel	1.16	1.24	1.64	1.29
ii) Field channel	0.81	0.76	1.08	0.68
Conveyance loss				
i) lps/100 m	7.08	8.80	10.64	8.08
ii) lps/m^2	0.074	0.068	0.066	0.074
Conveyance efficiency (%)	68	56	43	53
Water supplied (m/season)				
i) Range	0.86-1.56	1.01-1.97	0.49-1.27	0.43-1.31
ii) Mean	1.36	1.54	0.77	0.81
Water use (mm/day)				
1) Evapotranspiration (ET)	3	4	4	4
ii) Seepage & percolation (S&P)	6	6	8	4
Land preparation (mm/season)	226	207	267	213
Aile heights (cm)				
i) Range	4-9	6-8	4-8	6-11
ii) Mean	6	6	5	8
Equity of water distribution	1.70	1.75	1.98	2.30
Adequacy of water supply	1.71	1.16	0.86	2.35
(Command area (ha/lps)				
i) Actual	0.33	0.41	0.31	0.32
ii) Potential	0.57	0./53	0.45	0.63

reasonably good (13.5 to 17.25 hrs/ day), however number of days operated was low. Rashid *et al.* (1986) mentioned that a pump can be operated at its rated load for 20 hours a day and up to 30 days a month without causing any harm to the machine provided that proper maintenance is done. This shows that pumping hours can further be increased to cover more areas.

All the study schemes were under the Irrigation Management Programme (IMP) where block rotational irrigation system had to be followed. But unfortunately, block rotation was practised at none of the schemes. Water was supplied either following the semi-demand method or some sort of rotation among the water users. The present study revealed that several feeder channels were used at a time (simultaneously) to irrigate plots scattered over the command area, leading to excessive conveyance losses. Rotational system was not practised due to organizational weaknesses and lack of motivation.

iii) Irrigation practices

Rashid and Das (1991) mentioned that following "line rotational system" either command area could be increased or pumping cost could be reduced by 20 percent. Water was applied using continuous flooding method and application was not based on the crop water requirement. Over applications as well as under applications were observed at the same time in the same scheme. Over irrigation was reported at Baparipara and Ukiara and under irrigation for same farmers at Gorjona-1 and Khatra-2 (Table 2).

Night irrigation was practised in all the schemes. For night irrigation, both the pump operator and the lineman stayed awakened up to 10 or 11 p.m. and thus fell asleep at late night when water distribution was unattended resulting over-watering in some plots and under-watering in others.

Inequity of water distribution (1.7 to 2.3) was observed in all of the schemes (Table 2). Besides management problems, high land at the tail-end cracked channels at Khatra, and light soils at Gorjona-1 were responsible for the inequity of water distribution.

iv) Command Area

Table 2 reveals that on an average the actual command area was 62 percent of the potential command area. This lower command area was mainly due to shallow tubewell (STW) installations in the deep tubewell (DTW) command area (as a result of social conflicts) at Ukiara and Baparipara schemes. A drainage channel, about 40m north-east side and high land at southern part limited the command area at Khatra-2. At Gorjona-1, heterogeneous soils and undulating land restricted the command area. Improper distribution of pumped water affected the command area at all sites. Removal of STWs from the DTW command area at Ukiara and Baparipara, and installation of partial buried pipe distribution systems in the other two schemes will increase the command area.

v) Agronomic practices

The main cropping pattern of the study sites was Aman-Mustard-Boro; and only boro was irrigated. Rice occupies by far the largest area in the cropping patterns in all the schemes. Transplanting of boro started from first week of January and continued until the 2nd week of February. Sixty to ninety day old seedlings were transplanted in all the sites as against a recommended age of 35 to 45 days. To make use of natural ponding water in the low lands, depression and canal, farmers usually started seed beds earlier. This was reason of using older seedlings. Fertilizers were applied in inappropriate ratios and at inappropriate times. Mostly Urea was over used (145 to 524 kg/ha), Triple Super Phosphate (TSP) and Muriate of Potash (MP) were applied as a basal dose but not in correct amounts (42 -319 kg/ ha and 17-73 kg/ha, respectively). Gypsum, Zinc sulphate and organic manures were rarely used. Green manuring was not practised at any of the sites. A inappropriate doses of Basudin and Furadan were used to control insects and diseases. Farmers weeded upto three times with sickles and by hands. Grain yield of boro was found reasonably good in all the schemes, 3.7 to 5.9 t/ha.

vi) Scheme Management

All the four schemes were managed by a formel KSS. The management system was not found to be sound at any of the schemes. Two rival informal groups were found in each of the schemes. Generally, this groups are in power-struggle. Farmers are mostly illiterate except few who has elementary education. Misunderstanding regarding decision making and scheme management, and mistrust regarding payment of DTW installment and loan, accounting, record keeping and unbiased water supply were observed between the groups. Lack of proper education and training of the members, was one of the reasons for this misunderstanding and mistrust among the farmers. Two of the schemes followed the crop sharing (one fourth) method of water charging and the other two followed cash payment system (Tk. 18 per decimal at Khatra-2 and Tk. 20 per decimal at Gorjona-1). In the crop sharing method, the water owners (DTW Management) were interested in maximizing the yield and therefore took keen interest in delivering water timely and adequately.

Bangladesh Agricultural Development Corporation (BADC), Department of Agriculture Extension (DAE) and Bangladesh Rural Development Board (BRDB) were the three agencies responsible for the implementation for DTW-11. BADC performed the engineering aspects, DAE the agronomic aspects and BRDB looked after the socio-economic and organizational aspects. But the co-operation and co-ordination among the officers of these departments as observed in the field were not very satisfactory.

Conclusions

Low command area (0.31 to 0.41 ha/lps) was found in all of the schemes. This was mainly due to: High on-farm water losses, low pumping hours, soil/physiographical problems, social conflicts, organizational problems, lack of motivation and subsistence farming.

High conveyance losses (7 to 11 lps/100m) were found in the feeder channels. The reasons were mainly: bad channels, improper water distribution (simultaneous) system, absence of flow control & regulating facilities and unawareness of bad sides of this wastage. This resulted in inequity (1.70 to 2.30) of water supply and under (adequacy = 0.86) as well as over (adequacy= 2.35) irrigation. Management problems were also equally responsible. Pumps were operated on an average 16 hrs/day and 23 days/month. There is a scope to increase the pump operation further. Reasons for low pump operation as observed were breakdown of engine, frequent interruption of electricity (Ukiara and Baparipara Schemes), tendency of fuel saving (Gorjona-1 and Khatra-2 Schemes) and low irrigated area.

Most of the farmers planted older seedlings (60 to 90 days) and applied higher doses of urea and lower doses of TSP and MP fertilizers. Generally, farmers did not apply organic fertilizers. Yield was higher than the national average but lower than the research achievements.

Conflicts within the managements and/or between the management and the farmers were observed more or less in all the schemes. Interdepartmental co-ordination and co-operation among the service porviding agencies (BADC, DAE and BRDB) and interaction between the farmers and the agencies were not encouraging.

Recommendation

1. The design, construction, operation and maintenance of the conveyance systems need to be improved. Channels should be designed based on the soil types, topography and discharge of the deep tubewells to be constructed as per engineering design and procedures. Control Structures should be constructed at the required places.
2. Shallow tubewell within deep tubewell command should be removed for further enlargement of the DTW command supply.
3. At least line rotational water supply should be ensured for more reliable and better equitable water supply.
4. Appropriate aged seedlings (35-45 days old) are to be transplanted and proper doses of fertilizers are to be applied.
5. Interdepartmental co-ordination should be established for quick transfer of the improved crop production technology. Conflicts should also be resolved. Interaction between farmers and extension workers are very essential.

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