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Full Length Research Paper

Performance evaluation of the rubber dam project for irrigation development

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Rubber dam irrigation system for impounding surface water is a new technology in Bangladesh. It is important and priority in agricultural sector for sustainable irrigation water management due to scarcity of groundwater. The rubber dam project was evaluated to facilitate irrigation through proper use of water resources in the project area by conserving water for rabi crops. This study was evaluated by obtaining the values of some technical parameters like command area efficiency, management performance ratio, yield efficiency and benefit cost ratio and also the performance was evaluated the constraints to efficient water utilization and their remedy for irrigation development in the rubber dam project area at Nalitabari, Bangladesh. The rubber dam irrigation project was carried out by means of low lift pumps (LLPs) during the dry seasons. It was observed that water crisis was minimized during the dry seasons due to increased LLPs. It was found in the project area that command area efficiency ranged from 58.45 to 85.34% with an average value of 63.91%. Management performance ratio ranged from 0.012 to 0.114 with an average value of 0.028. Yield efficiency ranged 33 to 54 kg m^{-3} with an average value of 41.8 kg m^{-3}. Agricultural benefit was increased. Benefit-cost ratio ranged from 1.26 to 1.39 with an average value of 1.34. It was also found in the study area that a considerable number of performance constraints of the rubber dam irrigation project were identified to achieve the targeted successful output such as, lack of supply of electricity, improper management, lack of farmer's co-ordination and lack of technician and lack of farmers' participation during the implementation of the project.

Key words: Irrigation development, performance evaluation and rubber dam.

INTRODUCTION

Bangladesh is a riverine country. Small and big rivers, Haors, Baors, Canals, Bill and Marshy lands are found here and they all over the country. The contribution of surface water to the total irrigated area (3.8 million ha) was about 30% in the 1997 to 1998 dry season (NMIDP, 1999). Since availability of surface and groundwater is decreasing and rainfall distribution over the year and over the whole country is not uniform, sustainable agricultural water management is becoming a vital issue to ensure food security for the next vast population. The twin problems of shortage water during the dry season and its abundance in the rainy season are to development and management of water resources in Bangladesh. Under Bangladesh conditions, especially during the dry season, crop production is very much dependent on irrigation (Sarker et al., 2006). Rubber dam for impounding surface water for irrigation are a comparatively new technology and were introduced in Bangladesh by the Local Government Engineering Department (LGED) with technical assistance from the institute of Water conservancy and Hydroelectric Power Research, China in 1995. Considering technical and economical viability, First two rubber dams (Bakkhali and Idgaon) were constructed in 1995 and the third rubber dam was

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constructed on the Bhogai river, Nalitabari, Sherpur, Bangladesh (Saleh and Mondal, 2001). The rubber dam irrigation project on Bhogai river under Nalitabari at Sherpur district was proposed originally in 1996 but actually completed in 1997 to 1998. This project has been conceived on the basis of experience of the rubber dam projects built in Cox's Bazar in the year 1995 which already gave targeted successful output. The rubber dam on the Bhogai river which flows from hill (Assam Pradesh of India) and small and medium streams flow through the river a roundly all over the year, is being used to conserve water for the principle purpose of irrigation and also used for environmental, improvement, recreation purposes, increasing agricultural production, increasing employment opportunities, improving the institution strength and improving the living condition for the people within the project area (LGED, 1997**)**. The government of Bangladesh encourages farmers to cultivate their land many times irrigation is receiving top priority in the agricultural sector and emphasis has been given on the development of small scale tube well irrigation schemes. To feed the over increasing population of the country, it needs a high rate of food production. This increasing food problem may be faced by extensive, intensive and modern mechanized cultivation of our limited land throughout the year. The climate hazards such as cyclones, floods, tornadoes destroy a considerable amount of crops in kharif season or monsoon (from June/July to September/October). The government is thinking to grow agricultural production in rabi season (from October/November to February/March) which is comparatively safe from natural calamities. But insufficient rainfall in rabi season is the main obstacle of agricultural production. Systematic and modern irrigation practices might be adopted by utilizing of surface water with the help of low lift power pumps for increasing the winter crop production avoiding all the possible devastations. Water is vital and costly input for crop production. The average yield efficiency was found to be 0.23 kg of rice per cu meter of water applied at the farmers' field in the Philippines (Moya and rust, 1985). Miranda (1988) observed that the acceptable range of management performance ratio was found from 0.75 to 1.50 in irrigation management for crop diversification project in Indonesia and Philippine. The major resources available in this rubber dam project area are cultivable land, water and rural people. The productivity of the land and labor is low due to lack of control on water resources causing drought during dry season. Increased productivity is a major tangent in this project, which will improve economy and facilitate job opportunity in the project periphery. To extent possible ways and means of surface water retention and conservation which are cost effective and suitable for the low cost and flat physiographic. Rubber dam is one of such means of promise to retain and conserve water in reservoirs, lakes and canal storages of small and medium rivers. Surface water irrigation is of also basic importance due to the current rate of population growth, raising the present stage of food production up to the level of self-sufficiency, saving the currency, increasing yield, free from salinity and less input cost. Therefore, keeping in mind the importance of irrigation through small scale irrigation schemes in Bangladesh, the specific objectives of the study were to (i) find out the command area efficiency, (ii) evaluate the management performance ratio, (iii) determine the yield efficiency, (iv) find out the benefit cost ratio and (v) find out the different constraints and remedies of the rubber dam for irrigation development

MATERIALS AND METHODS

The study was conducted at rubber-dam irrigation project site in Nalitabari Upazila at Sherpur district under Bangladesh during the rabi season, 1999 to 2000.

Study area

The location of the Rubber dam irrigation project area was situated approximately between the latitude 25°1/ N and 25° N and between the longitude 90°8/ E and 90°17/ E. This study was situated about 35 km north of Sherpur town and rubber dam cum bridge was situated about 5.5 km south of Nalitabari Upazila. The study area was bounded by the Bhogai River. The Bhogai River had come from Garo-hill (Assam Prodesh) of India and flows to the middle of the Nalitabari Upazila. The project embodies potential area for Boro rice cultivation was taken 67% of the total cultivable area and 58% of the gross area of the union (9 unions in Nalitabari and 1 union in Nakla). Total irrigable land (target) area for irrigation facilities in 2800 ha (7000 acres) under Rubber dam irrigation project. But actually 8 nos. unions, that is,1,223 ha (3,022.84 acres) were presently provided with irrigation facilities. Local farmers are being able to utilize the small flow of Bhogai River either by gravity flow or by using low lift pumps to the cultivation of Boro rice, Wheat and other crops.

Topography

Nalitabari and some part of the Nakla upazila felt under the lower Bhogai river flood plain. The topography of the study area was mainly felt which was consisted of 25% highland, 60% medium land, 10% medium low land and 5% low land.

Soil characteristics

The Bhogai River in the western and eastern part of the study area was composed of sandy sediments, elsewhere the deposits are mainly clay and sandy loam with pH ranges from 4.5 to 5.7. The reaction of the soil was highly acidic to low acidic.

Climate and crop

In the study area was cool, rainy and cool summer. The study area was laid in the Northern Meghalay. Generally, farmers cultivate High Yielding Variety (HYV) of Boro rice and some HYV of wheat and some vegetables were cultivated under the schemes of the rubber dam irrigation project. Sometimes aggravated high local

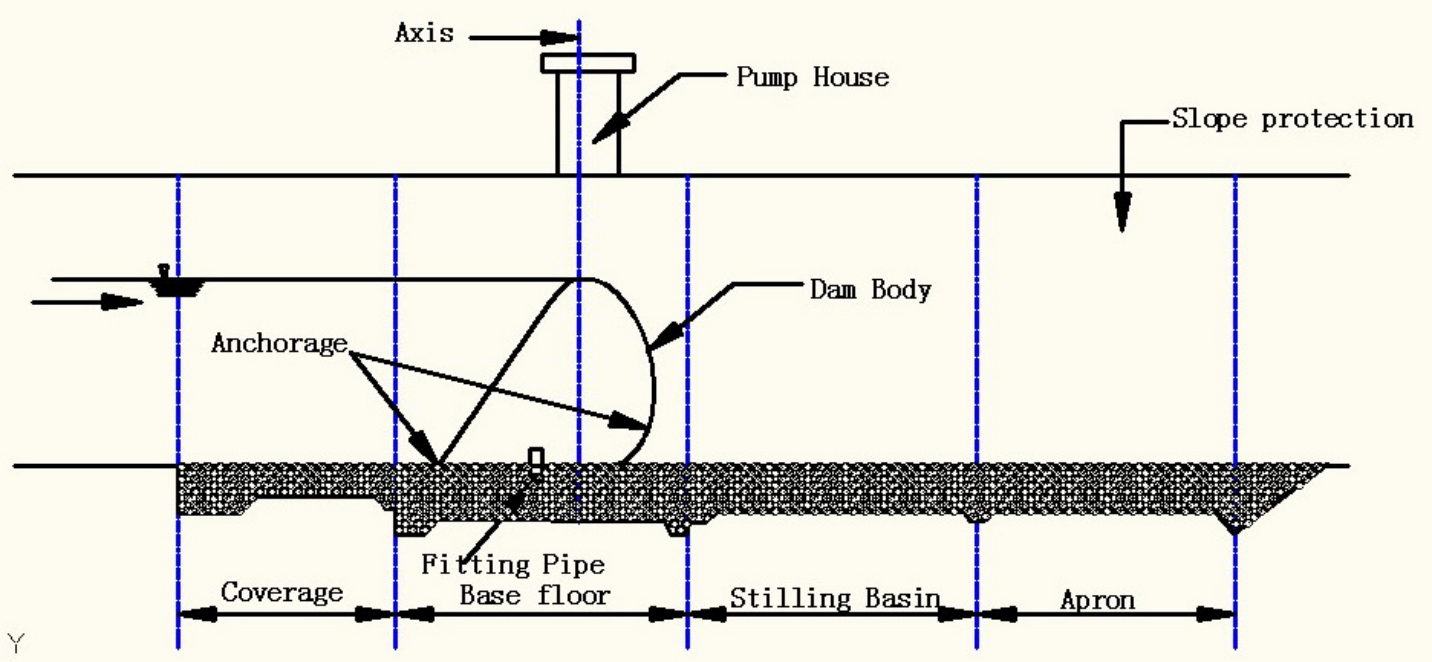

Figure 1. A typical cross section of the rubber dam. i. Rubber dam length: 100 m, ii. Dam height: 4 m, iii. Maximum retention depth: 4 m, iv. Inflated height: 2 m, v. Length of concrete floor: 54 m, vi. Protective works, upstream: 5.7 m, downstream: 10.7 m, vii. Dam body. Material: reinforcement rubber, shell thickness: 8 mm, viii. Irrigated area: (a) targeted area: 2800 ha (7000 acres), ix. Total volume of water available at dam site during January to April months: 45.49 Mm^3, x. Release downstream (30% available accumulation): 13.78 Mm^3 (spill over), xi. Usable volume of water: 32.15 Mm^3, xii. Bridge : 100 m, xiii. Dam site electrification: 6 km (electric line), xiv. West bank guide bandth: Earth work 50 MT, xv. Approach road: 6 km, xvi. West Bank Sluice gate: 2 nos.,(a) Simulatali Sluice gate and(b) Kapashia near dam site. xvii. Growth centre development: 6 nos. (a) Kalakuma Bazar, Nalitabari, (b) Fakirpara Bazar, Nalitabari, (c) Bankura Bazar, Nalitabar, (d) Baromasha Bazar, Nakla, (e) Gourdawar Bazar, Nakla and (f) Dhakusha Bazar, Nalitabari. xviii. Pump house: 1 no. (for filling and emptying dam bag)

rainfall entailed severe damage to the crops particularly in the early and the monsoon.

Salient feature of the rubber dam on Bhogai River

A typical cross section of the rubber dam (Figure 1) and the salient features and a typical cross section of the rubber are given in Figure 1.

The rubber dam structure was composed of four parts, such as; rubber bag, anchorage, filling and emptying system (pump house and foundation). Water was imposed by inflating the rubber bag with water. When deflated, the body of the rubber dam lied flat on the river bottom without causing and obstruction to the river flow. The operation and maintenance of the dam were very simple and cheap.

Distribution of LLP

The study area covered 14 nos. of 2 cusec, 93 nos. of 1 cusec, 40 nos. of 0.75 cusec and 20 Nos. of 0.5 cusec LLPs to distribute water during irrigation period 51 no LLP on the east bank and 31 no LLP on the west bank of the Bhogai river and 85 no LLP on the canal (Dodhuar khal) were installed.

Water management committee association condition (WMCA)

The irrigation scheme was executed by WMCA. WMCA was formed consisting 12 execute members such as chairman, Vice chairman, secretary, joint secretary treasurer and seven directors for different affairs. 167 nos. block committee have been formed under WMCA. Water tax was fixed Tk. 30 (BDT) per acre by the opinion in a general meeting by the committee on the basis of total cost.

Data collection and presentation

Data were collected from Local Government Engineering Department (LGED, 2000), Sherpur and Directorate of Agriculture Extension (DAE, 2000), Nalitabari, regarding assessment and the management of schemes. Then, information's were justified through non-formal field inspections and interviews with block organizers, Chairman of the WMCA, Friends and farmers. The data were presented in Tables 1, 2 and 3.

Theoretical consideration

The theoretical considerations were reviewed by Molden and Gates (1990) and Molden et al. (1998).

Command area (CA) efficiency

It was the ratio of actual command area to potential command area and expressed in percent. The actual command area was determined directly through the study area inspections and interviews with farmers, technicians and scheme managers. The

Table 1. Achievements of irrigation during dry season (1998 to 1999).

Name of Scheme	Water lifting device, LLP	Command area(CA) ha	Achievement of irrigated cropped area (ha)			Water charge (average) *Tkha^{-1}
			Rice	Wheat	Others	
Jogania irrigation scheme	26	158.09	134.4	15.85	8.03	1.852
Marichpuran irrigation scheme	18	180.99	154.08	19.0	8.19	1.976
Nalitabari sadar irrigation scheme	25	198.27	167.78	21.27	9.22	1.927
Nalitabari Purasabha irrigation scheme	4	269.6	228.94	29.22	11.45	1.951
Baghbar irrigation scheme	44	287.48	244.87	31.88	10.73	1.976
Nayanbill irrigation scheme	6	76.02	84.78	8.06	3.14	1.815
Ramchandrakrira irrigation scheme	4	34.48	28.75	3.6	5.15	1.877
Kalaspara irrigation scheme	3	18.63	15.9	2.06	0.75	1.939
Total	167	1.223.82	1039.5	131.04	53.4	

Source: LGED, Nalitabari, Block organizers Survey, *In 2000 prices 1 US$ = 53 TK (BDT).

potential command area were determined considering certain assumptions, such as, potential hours, pumping conditions and its efficiency, cropping practices and its time, quantity of water supply, topographic limitation, operation water distribution systems, water use efficiency, the cropping field and management practices, etc.

Management performance ratio

It was the ratio of the total volume water supply to total volume of water demand:

Total vol. of water supply = Actual discharge capacity × total operating time

Total vol. of water demand = Irrigation water requirement for corps ×Actual command area.

Total irrigation water requirement for crops was taken considering some assumptions, such as total seasonal water requirement for boro rice, wheat and others were 1153, 300 and 320 mm, respectively(LGED and DAE, 2000).

Yield efficiency

It was expressed as the ratio of production per cubic meter water per ha.

Benefit cost ratio

It was the ratio of gross return to total cost. Total cost included seed/seedling, fertilizer, ploughs, labor charges, irrigation, insecticides, tax and O and M in Tk.ha^{-1} and gross return includes the value of crops and straws Tk.ha^{-1}.

Net return = Gross return – total cost

RESULTS AND DISCUSSION

In order to study the performance of the selected irrigation schemes of the rubber dam, necessary data were collected and analyzed.

Command area efficiency

Command area efficiency of scheme of the rubber dam ranged from 58.45 to 85.34% with an average value of 63.91% (Table 4). Similar findings have been reported in Bangladesh by BRRI (1998). The results indicated that Nayabill irrigation scheme was performed best of all others. The variation of the results also indicated that increasing command area could be increased the command area efficiency. As a result, more income to the farmer and employment opportunity would be ensured. Command area efficiency depends on irrigated area and potential command area. Actual command area depends on farmer's participation with their irrigated land interest for cultivation, regular maintenance of water conveyance system, favorable soil conditions and installation of the water lifting device. The lower command area efficiency had occurred due to low operating hour per day, lower discharge capacity of the LLPs, faulty site election of the water lifting device, neglecting the repair and maintenance of equipments.

Management performance ratio

The management performance ratio (MPR) of irrigation schemes under rubber dam ranged from 0.012 to 0.114 (Table 5) with an average value of 0.028 (Miranda, 1988). The results indicated that all of irrigation schemes were poor performed due to lower operating times, higher farm canals density, irrigation activity could not be started with properly, poor relationship between farmers and block organizers and WMCA and manager of the involving STWs. The variation of MRP denoted that there was great opportunity to improve water management on these existing schemes of the rubber dam.

Yield efficiency

The yield efficiency of schemes under the rubber dam

Table 2. Discharge capacity of LLP and operating hours.

Serial No.	Name of scheme	Discharge capacity of LLP (cusec)	No. of LLP	Daily operating hours (average)
01	Jogania irrigation scheme	2	1	11
		1	14	13
		0.75	7	12
		0.5	4	11
02	Marichpuran scheme irrigation	2	3	11
		1	13	13
		0.75	1	12
		0.5	-	-
03	Nalitabari sadar irrigation scheme	2	3	12
		1	11	12
		0.75	8	11
		0.5	3	9
04	Nalitabri pourasabha irrigation scheme	2	4	11
		1	20	12
		0.75	11	10
		0.5	6	11
05	Baghbar irrigation scheme	2	2	12
		1	26	12
		0.75	11	10
		0.5	5	11
06	Nayabill irrigation scheme	2	1	12
		1	4	12
		0.75	2	10
		0.5	-	-
07	Ramchandrakira irrigation scheme	2	-	-
		1	3	12
		0.75	-	-
		0.5	1	8
08	Kalaspara irrigation scheme	2	1	8
		1	2	12
		0.75	-	-
		0.5	1	11

Source: LGED (2000)

Table 3. Information on low lift pumps (LLPs) used for irrigation.

Serial No.	Item	Pre-project period (before,1998 to1999)	Post-project (1998 to1999)
01	LLPs	120	167
02	Irrigated area (under LLP),ha	819.1	1,223.82
03	HYV extension condition	50%	70%
04	Agricultural benefit	* Tk 31,500,000	Tk 71,400,000

*In 2000 prices 1 US$ = 53 TK (BDT)

Table 4. Performance of command area (CA) efficiency of irrigation schemes.

Serial No.	Name of irrigation scheme	LLP	Actual CA (ha)	Potential CA (ha)	CA Efficiency (%)
1	Jogania irrigation scheme	26	158.09	270.47	58.45
2	Marichpuran irrigation scheme	18	180.99	263.19	68.69
3	Nalitabari sadar irrigation scheme	25	198.27	285.9	69.36
4	Nalitabari Purasabha irrigation scheme	41	269.6	458.3	58.82
5	Baghbar irrigation scheme	44	287.48	477.8	60.17
6	Nayanbill irrigation scheme	06	76.02	89.08	85.34
7	Ramchandrakrira irrigation scheme	04	34.48	41.3	83.48
8	Kalaspara irrigation scheme	03	18.63	29.15	63.89
Average					63.91

Table 5. Water management performance ratio of irrigation schemes.

Serial No	Name of irrigation schemes	LLP	Water supplied (m^3)	Water demand (m^3)	Management performance ratio
1	Jogania irrigation scheme	26	29443.3	162,022.6	0.018
2	Marichpuran irrigation scheme	18	24858.7	1,857,795.5	0.0133
3	Nalitabari sadar irrigation scheme	25	30003.7	2,025,588.3	0.0148
4	Nalitabari Purasabha irrigation scheme	41	45183.8	2,083,978.7	0.022
5	Baghbar irrigation scheme	44	47883.6	2,950,016.2	0.016
6	Nayanbill irrigation scheme	06	8863.6	780,416.8	0.114
7	Ramchandrakrira irrigation scheme	04	4075.2	348,675.9	0.012
8	Kalaspara irrigation scheme	03	3005.5	191,836.7	0.016
Average					0.028

Table 6. Performance of yield efficiency of the irrigation schemes.

Serial No.	Name of scheme	LLP	Actual CA (ha)	Average yield ($kgha^{-1}$)	Water supplied (m^3)	Yield efficiency ($kg\ m^{-3}$)
1	Jogania irrigation scheme	26	158.09	6,131	29,443.3	33
2	Marichpuran irrigation scheme	18	180.99	6,039	24,858.7	44
3	Nalitabari sadar irrigation scheme	25	198.27	6,217	30,003.7	40
4	Nalitabari Purasabha irrigation scheme	41	269.6	6,144	45,183.8	37
5	Baghbar irrigation scheme	44	287.48	6,183	47,883.6	37
6	Nayanbill irrigation scheme	06	76.02	6,263	8,863.6	54
7	Ramchandrakrira irrigation scheme	04	34.48	6,003	4,075.2	51
8	Kalaspara irrigation scheme	03	18.63	6,101	3005.5	38
	Average		41.8			

ranged from 33 to 54 kg m^{-3} (Table 6) with an average value of 41.8 kg m^{-3} (Moya and Rust, 1985). The results indicated that the comparatively higher yield efficiency could be attained by providing training, to the technical knowledge of production, introduced to the profitability cropping pattern and effective irrigation planning and improved water management practices to the block organizers and farmers.

Benefit cost ratio

Net and gross return obtained through economic analysis

Table 7. Performance of benefit-cost ratio of irrigation schemes.

Serial No.	Name of scheme	Total cost (Tk)	Gross return (Tk)	Net return (Tk)	Benefit-cost ratio
1	Jogania irrigation scheme	15,506	20,784	5278	1.34
2	Marichpuran irrigation scheme	16,092	20,209	4117	1.26
3	Nalitabari sadar irrigation scheme	15,407	20,941	5534	1.36
4	Nalitabari Purasabha irrigation scheme	15,437	21,226	5790	1.38
5	Baghbar irrigation scheme	15,768	20,025	4257	1.27
6	Nayanbill irrigation scheme	15,629	21,703	6074	1.39
7	Ramchandrakrira irrigation scheme	15,206	20,609	5404	1.36
8	Kalaspara irrigation scheme	15,653	20,746	5093	1.33
Average					1.34

*In 2000 prices 1 US$ = 53 TK (BDT)

of irrigated crops under eight irrigation schemes (167 LLP) of the rubber dam irrigation project showed that the benefit cost ratio was ranged from1.26 to 1.38 with an average value of 1.34 (Table 7). The variation of the benefit cost ratio indicated that there was great opportunity to get benefit under the rubber dam. The effective marketing systems should be developed so that farmers could sell their produce at more attractive prices.

Performance constraints and remedies of irrigation schemes of the rubber dam

The performance constraints of all irrigation schemes of the rubber dam were identified through visiting the physical condition of the rubber dam bag, sluice gate, river, canals situation of the LLPs and cultivation of the farmer's field and assessment of some information whose were collected from executive engineer, LGED, Sherpur, agricultural engineer, DAE, Sherpur, Chairman of the WMCA of the rubber dam, Nalitabari and remedies were discussed.

Constraints

During rainy season, high velocity streams flow through the Bhogai River, as a result, site slopes and scour erosion influenced the direction of flow and sometimes causes flood.

i. There were no drainage facilities to remove excess water
ii. Site selection of the pumps was very important for water distribution and efficient conveyance to the command area. But in the field observation it was found that water lifting devices were installed in some schemes unscientifically
iii. Factional conflict among block organizers and farmers
iv. Conflicting interest of water suppliers and water users
v. Competition of multiple water suppliers for limited irrigable land
vii. Involvement of multiple water lifting devices to supply water for irrigation
viii. Late adopter about new innovation
xi. Poor maintenances, distributions, selfishness and preparation of annual reports.

Remedies

i. The characteristics of flow of the Bhogai River have changed due to erosion and siltation, therefore, siltation may be removed by proper dredging
ii. For eroding, east and west bank of the Bhogai River and Dodhuar khal(canal) should be stabilized
iii. The main and distributor canals system may be controlled by re-excavation every year for proper functioning
iv. Heavily subsidized LLP with provision of easy loan should be available with low interest so that small and medium farmers may take the advantage of the system
v. Location of the water lifting device with respect to the command area should based on scientific analysis and proper surveying of the area

CONCLUSIONS AND RECOMMENDATIONS

This study conducted some valuable information to the farmers, WMCA and block organizers regarding the performance of LLPs of irrigation schemes of the rubber dam. After completion the project, low lift pumps has increased for more transferring water to the Bhogai River and canal (Dodhuar Khal) for irrigation. Cropping intensity was increased from 150 to 230%. It was found from the study that the command area efficiency do not satisfactory except the Nayabill and Ramchandrakrira irrigation schemes of the rubber dam. The management performance ratios of irrigation schemes of the rubber

dam were not satisfactory. The management performance ratios of irrigation schemes were lower than the acceptable range of management performance ratio. The yield efficiencies of all irrigation schemes of the rubber dam were improved. The performances of the benefit cost ratio of irrigation schemes of the rubber dam were reasonable.

The following were recommended:

i. Every scheme should have the assurance of timely supply of fuel, oil, technician and necessary spare parts. As par as, possible, pumps would be operated by electricity.
ii. The farmers could be motivated to form effective co-operative societies. The interrelationships between the farmers and water management committee might be improved.
iii. Irrigation canals could be lined with stable materials to reduce seepage and percolation losses. Farmers should take care of wastage of water by filling ditches, ponds and rat holes in the canal bunds, run off in the drain, overtopping the bunds and bund breaks.
iv. Suitable crop calendars should be developed and appropriate irrigation schedules should be prepared in relation to the varying water needs of crops at different stages of growth.

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