Benchmarking Performance Assessment of Irrigation Water Management in Initial Reach of Left Bank Canal Network of Rani Avanti Bai Sagar Irrigation Project

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Abstract— Irrigation water management is facing organizational changes worldwide. Beginning in the 1980's, there have been a large scale programs to turn over irrigation management from Government Agencies to organized Water User Associations in a number of countries such as Philippines, Indonesia, Senegal, Madagascar, Columbia and Mexico. This trend has been seen as the convergence of a number of policy trends including decentralization, privatization, participation and democratization. This study aims to benchmarking performance assessment of water user's association (WUAs) taken over irrigation water management in the Initial Reach of Left Bank Canal Network of *Rani Avanti Bai Sagar* Irrigation Project (RABSP), Jabalpur, India. For this purpose, the indicators of Water Deliveries, Maintenance, Financial and Sustainability were used. The study was carried out in *rabi* season of year 2008 on four minors from initial reach of Left Bank Canal Network of Rani Avanti Bai Sagar Irrigation Project to evaluate irrigation performance by different performance indicators In this study, the tail-end supply ratio is varied between 0.20 to 0.58 which is less than the reference range of 0.50-0.70 which indicate the poor scheduling of irrigation water and poor maintenance of canal strictures which result in water logging in head reach of minor. The delivery timeliness ratio was found to be 1 which is ideal condition. Carrying capacity ratio under maintenance indicator varied between 0.81 to 0.99 which indicate siltation of the minor. Poor structure ratio is varied in between 0.53 to 0.65 which is much more than the reference range of 0.01 to 0.20 indicates poor maintenance of the strictures both by government and WUA. Water fee collection rates were generally good on the all organizations in the command area. The collection rate was found to be average 87%. This ratio shows that the cost of irrigation water was generally paid by farmers with reference to satisfaction with the irrigation water service delivery. In general, *Pipariya* WUA was of the most successful farmers' organization among all four WUA in the study area. This water user association can be used as benchmarks against which the other WUA can be assess their performance. The study results showed that the benchmarking indicators provided the WUA in the basin to see where they were placed in comparison with others. As a result, performance assessment and benchmarking can help to improve performance of irrigation water management in a canal command area.

Keywords— Benchmarking, Performance indicator, Canal irrigation performance, Water management, Water user association.
introduction

Introduction—Poor water management is certainly one of the most important factor for poor performance of irrigation system. Irrigation, the single largest user of the water resources accounts for about 84% of all withdrawals in India [1]. Further, with increasing municipal and industrial needs; agriculture's share of water is likely to go down. Therefore, water management in the canal command area is very essential to improve the performance of irrigation project and thus calls for a through diagnostic analysis and evaluation of the system as a whole [2]. The performance evaluation studies are envisaged as an auditing exercise not only to assess the actual performance as compared to what envisaged at the formulation stage, but also to draw lessons for devising appropriate steps for future projects.

Recent decades have seen increasing emphasis on change as a critical driver of organizational success [3] [4]. Irrigated agriculture is facing organizational changes worldwide. There is a growing recognition worldwide that irrigation water management is a service provided to customers with better results when operated by decentralized organizations: this leads to irrigation management transfer [5].

Beginning in the 1980's, there have been a large scale programs to turn over irrigation management from Government Agencies to organized Water User Associations in a number of countries such as Philippines, Indonesia, Senegal, Madagascar, Columbia and Mexico [6]. This trend has been seen as the convergence of a number of policy trends including decentralization, privatization, participation and democratization. A result of this has been 'rolling back of the boundaries of the state' within the irrigation sector. Participatory irrigation management refers to the programs that seek to increase farmers direct involvement in system management, either as a compliment or as a substitute for the state role.

The acceptance of Participatory Irrigation Management (PIM) was powered by the dismal state of irrigation systems itself. Non-irrigated fields because of undependable water flows, indiscriminate use of water by head-enders depriving the same to the tail enders, inequitable distribution and resulting conflicts created a situation where the WU A ensures greater water control by farmers and fairness in water distributions [7]. Greater water control by farmers permits less water to be used per unit of production, which translates into reduced energy consumption, water logging and salinity [8].

Irrigation performance assessment is an important management tool to aid in providing sound water service delivery. Performance assessment in irrigation and drainage can be defined as the systematic observation, documentation and interpretation of activities related to irrigated agriculture with the objective of continuous improvement [9]. There is a clear relationship between performance assessment and organizational excellence. The latter can be defined as "Organizational excellence an outstanding practice in managing organizations and delivering value for all stakeholders" [10]. Recently, academicians, practitioners and researchers have debated on development of new approaches, looking for better ways to measure and determine organizational performance more rapidly and reliably.

Performance indicators are a powerful tool for identifying deficiencies in irrigation district management [11]. A set of performance indicators was developed by the International Water Management Institute (IWMI) and likewise a new set of performance indicators called ''benchmarking indicators'' was developed by International Program Technology and Research in Irrigation and Drainage (IPTRID) to assess the performance of irrigation organizations [12] [13].

Benchmarking can be defined as a systematic process for securing continual improvement through comparison, using indicators, with relevant and achievable internal and/external norms and standards. It can compare past and present performance, as well as the performance of (otherwise similar) entities, and/or compare a performance against a relevant set of 'best practices'. Benchmarking is a very powerful management tool widely accepted all over the world for analyzing and improving the performance of water resources projects [14] [15]. The benchmarking indicators cover a range of process service delivery, financial and environmental management. Also, the productive efficiency are essentially for comparison of scheme outputs against key inputs (land, water) and allow organizations to see where they are placed in comparison with others. The process indicators can then be used to investigate which processes are contributing well or poorly to this output relative to similar process on other schemes [16].

Performance assessment through key indicators has become a standard practice in the irrigation water management sector in many countries. Dozens of irrigation performance indicators have been proposed over the years. But they still receive relatively little use, and that use is mostly by researchers and agencies rather than managers. David E. Nelson describes performance indicators which can be applied within the limited time, money, and information resources available to the typical manager or water users association [17]. Indicators are oriented toward items that directly or indirectly affect water deliveries, rather than indicators like crop yields that are also affected by other factors. These indicators are also oriented toward the existing system, aspects which do not require major modification of the infrastructure.

Materials and Methods—The area selected for the present study is a part of Left Bank Canal of RABSP. Command of *Dhulakheda*, *Pipariya*, *Jhansi* and *Jamuniya* Minor of Left Bank Canal (LBC) was considered for this study. Command area lies between latitude 23^0 02' 21" to 23^0 04' 53"N and longitude 79^0 41' 14" to 79^0 43' 19"E in the Jabalpur district of Madhya Pradesh.

The Dhulakheda, Pipariya, Jhansi and Jamuniya minor starts at 47.62km, 45.50km, 51km, 52km on LBC respectively and commanded about 1058 ha. The climate of the study area is subtropical monsonic characterized by an oppressive hot summer, high humidity and chilly winter. The temperature beings to rise rapidly from about March till May, which is generally the hottest month. The average annual temperature of the study area is 25.7º C. The mean maximum temperature ranges between 42.2º C and 25.8º C and mean minimum temperature ranges between 26.7º C and 9.2º C. As the project area lies in hot zone, the variation in humidity is quite large. Most of the land in the study area comes under class-II of land capability classification and as per land irritability classification the area falls under class-B. The water holding capacity in the study area is 16.0 cm, which is favorable for plant growth. The major crops grown in the area during *rabi* season are Wheat, Gram, Lentil, Pea, Arhar and some Vegetables crops and in *kharif* season the main crops are paddy. Information of sowing and harvesting of different crops, their duration and the cropping pattern of the study area were collected from the different sources including contacts with the local farmers and revenue records of the village. The soil of the study area is clay-loam. The details of soil characteristics were collected from Soil Testing Department of M.P. govt. In the testing of 763 soil samples they observed that soil of the study area have low phosphorous, medium Nitrogen and medium potassium.

In this study Data comprising Water Deliveries, Maintenance, Financial and Sustainability of irrigation command area were collected through the methods of measurements, survey and estimation. Some of the recommended performance indicators were not considered due to irregular and unavailability of reliable data. The indicator were calculate as follows:

Water Deliveries

1. Tail-end Supply Ratio: The simplest indicator of water delivery performance is whether adequate water is reaching the farmers at the end of the canal system. The Tail-end Supply Ratio is the number of days that sufficient water reached the end of the canal system, divided by the total number of days. Ideally, this ratio would be close to one. TSR is simple and inexpensive, but is only a qualitative indicator. It is based on the common situation that irrigators at the end of the canal are usually the ones shorted.

$$TSR = Ns / Nt$$

Where,

Ns is the number of days that sufficient water reached the end of the canal system
Nt is the total number of days the canal system was delivering water.

2. Delivery Timeliness Ratio: If water is delivered on request, an analysis of timeliness may be possible from the individual water order records. The Delivery Timeliness Ratio is the number of orders where water was delivered within the target time of the requested date, divided by the total number of orders. Ideally, this ratio would equal one. If there is a difference in DTR between the upper part of the canal system and the lower end or DTR is low, or lower than normal, this may be occur due to reasons like, if demand exceed the canal capacities, if demand exceed the available water supply, or the water supply itself miss-managed or it could also be caused by poor maintenance or management of the diversion dam, pump stations, or canals.

$$DTR = Nt/NT$$

Where,

Nt is the number of orders where water was delivered within the target time.
NT is the total number of orders (from the individual water order records).

Maintenance

1. Carrying Capacity Ratio: Canal capacity can indicate problems related to sediment deposits, erosion, vegetation, or possibly inadequate capacity of some structures. The Carrying Capacity Ratio is the actual capacity for the selected canal, divided by its designed capacity [18]. The ideal ratio would be one. In applying this indicator, flow should be measured at the designed water level or head. It is possible to operate a canal at a higher flow than its actual capacity, by operating the canal too full and reducing canal freeboard to an unsafe margin.

$$CCR = Ca/Cd$$

Where,

Ca is actual canal capacity for the selected canal (measured at designed head)
Cd is the designed canal capacity for the selected canal.

2. Poor Structure Ratio: The Poor Structure Ratio is the number of structures in poor condition, divided by the total number of structures. Poor can be defined as a structure not functioning adequately, or at risk of failing during the coming year. Ideally, this ratio should be zero [19].

$$PSR = NP/NT$$

Where,

NP is the number of structures in poor condition (not functioning adequately or at risk of failure)
NT is the total number of structures on the system.

Financial:

1. Fee Collection Performance: Fee Collection Performance is the annual irrigation fees collected, divided by the total annual fees assessed. This indicates the effectiveness of the collection program, but it can also be affected by the economic condition of the irrigators and the degree to which the irrigators feel the system is worth supporting. Values greater than 1 are possible if some delinquent assessments from previous years are collected.

$$FCP = Fc / Fa$$

Where,

Fc is the annual amount of water charges collected.
Fa is the annual amount of water charges assessed.

2. Manpower Numbers Ratio: The Manpower Numbers Ratio, which is the number of staff (full-time equivalent) divided by the total irrigated area. The optimum value for this indicator may vary widely among different regions of the world, because of differences in labor productivity and irrigation intensity [20].

$$MNR = Ns/At$$

Where,

Ns is number of staff (full-time equivalent)
At is total irrigated area

Sustainability:

1. Sustainability of Irrigated Area: Sustainability of Irrigated Area is the current irrigated area, divided by the initial irrigated area when the system was first fully developed. A trend toward reduced area generally indicates that the system is not sustainable (for water supply, environmental, or economic reasons). If area has increased significantly from the designed area, it may indicate that the water supply is now distributed over too much land, or delivery capacities are being exceeded.

$$SIA = Ac/Ai$$

Where,

Ac is current total irrigated area.
Ai is total irrigated area when system development was completed.

2. Relative Groundwater Depth: Relative Groundwater Depth is the actual groundwater depth, divided by the Critical minimum depth needed for good crop production. This ratio should be greater than one, preferably at all locations and for the whole season. If the ratio is getting closer to one over time, it may indicate a need for improved drainage. Minimum depth should be based on the most sensitive crop grown in the area; one meter is a value frequently used. Where wells are used as a source of water, increasing depth to groundwater over time usually indicates groundwater over drafting.

$$RGD = Da/Dm$$

Where,

Da is actual depth to the water table.
Dm is the minimum intended depth to the water table, based on most sensitive crop

3. Area/Infrastructure Ratio: A key variable affecting the economic sustainability of a system is the Area/Infrastructure Ratio, which can be roughly defined as the irrigated area divided by the total length of canals and laterals. The critical value for this variable is determined by the economics of the region.

$$AIR = At/Lc$$

Where,

At is the total irrigated area.
Lc is the total length of canals and laterals on the system.

Results and Discussions—These performance indicators were evaluated through field visits, analyzing survey and collecting information from water resources department, (M.P.). Table 1 shows the results obtain for the Jamuniya, Jhasi, Pipariya and Dhulakheda minors.

Table 1 Performance Indicator for Jamuniya, Jhasi, Pipariya and Dhulakheda Minors.

Parameters	Performance Indicator	Name of Command Area				Reference range
		Jamuniya	Jhansi	Pipariya	Dhulakheda	
Water Deliveries	Tail-end Supply Ratio	0.208	0.25	0.58	0.416	0.50-0.70
	Delivery Timeliness Ratio	1	1	1	1	0.72-0.90
Maintenance	Carrying Capacity Ratio	0.918	0.94	0.993	0.811	0.60-1.26
	Poor Structure Ratio	0.5357	0.647	0.622	0.645	0.01-0.20
Financial	Fee Collection Performance	0.95	0.9	0.8	0.82	0.62-1.0
	Manpower Numbers Ratio	0.0142	0.0196	0.0066	0.0083	0.0004-0.001
Sustainability	Sustainability of Irrigated Area	0.325	0.246	0.416	0.436	0.50-1.0
	Relative Ground Water Depth	1.5	1.5	1.5	1.5	>1
	Area/Infrastructure Ratio	21.53	22.66	40	27.58	35

A common practice in irrigation supply is to apply water to the root at the required time, amount and quality. In this study, the tail-end supply ratio is varied between 0.20 to 0.58 which is less than the reference range of 0.50-0.70 which indicate the poor scheduling of irrigation water and poor maintenance of canal strictures which result in water logging in head reach of minor. The delivery timeliness ratio was found to be 1 which is ideal condition.

Carrying capacity ratio under maintenance indicator varied between 0.81 to 0.99 which indicate siltation of the minor. Poor structure ratio is varied in between 0.53 to 0.65 which is much more than the reference range of 0.01 to 0.20 indicates poor maintenance of the strictures both by government and WUA.

Water fee collection rates were generally good on the all organizations in the command area. The collection rate was found to be average 87%. This ratio shows that the cost of irrigation water was generally paid by farmers with reference to satisfaction with the irrigation water service delivery. In general, Pipariya WUA was of the most successful farmers' organization among all four WUA in the study area. This water user association can be used as benchmarks against which the other WUA can be assess their performance.

Conclusion—This study provides support for literature claiming that performance of irrigation water management should be assessed in the light of integrated approach. Analyses in this study show the bench-marking performance of WUAs in canal command area and may be lead to searching for best practices, regenerative ideas and highly effective operating procedures considering the experience of others. As a result, performance assessment and benchmarking can help to improve the water delivery, financial and production performance in a canal command area.

Acknowledgement

The author expresses his deep sense of gratitude to Prof. Y.K. Tiwari, Associate Professor, Department of Soil and Water Engineering, College of Agricultural Engineering, J. N. K. V. V., Jabalpur for his valuable guidance, keen interest and encouragement rendered during the course of this study. Authors are grateful for providing necessary facilities for the experiment by College of Agricultural Engineering, JNKVV, Jabalpur, during the course of research work.

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