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The performance evaluation of water users association: A case study of Shree Datta water user association Mirewadi

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Abstract
The study was conducted on "The Performance Evaluation of Water Users Association: A Case Study of Shree Datta Water User Association Mirewadi". Under this study, the performance indicators in Shree Datta WUA were determined for year 2020-21. WUA in canal irrigation network were characterized and evaluation of irrigation performance was evaluated using different performance indicators. The water delivery indicator in tail-end supply ratio was found 0.24, and poor structure ratio was found 0.5 in Shree Datta WUA. In financials, fee collection performance was found (0.4) and manpower number ratio was found (0.01) in Shree Datta WUA which make it not satisfactory. The analysis of financial indicators showed that the scheme had a serious problem about the collection of water fees i.e. revenue or irrigation charges collected from scheme were less than that of total operation and maintenance expenditure. The analysis of agricultural performance indicators showed that the production value of different crops grown in command area were lower than that of the recommended package of practices. The Water Delivery Capacity (WDC) for whole Shree Datta WUA command area was calculated as 2.25 which represents the canal capacity was sufficient to meet the peak consumptive requirement.

Keywords: Water users association, performance indicators, command area, discharge variation, farmers participation

Introduction
Water is the necessity for the human, animal and agricultural life. Agriculture is becoming more constrained & less productive without valuable irrigation. Irrigation development in India is mainly from three sources viz. Canals, wells and tanks as per demand for irrigation as well as technologies developed for storing, transporting and lifting of water. It is necessary to achieve maximum returns per unit of water used from cropping activities. An important factor in the effective use of water resources is the involvement of farmers in the management of the operation, maintenance, and collection of water charges from the areas under the control of water user associations (WUA). A WUA is a group of farmers who live near a lateral canal and create their own non-profit cooperative organisation with a set of regulations to control water delivery in their region (Lohmar *et al.*, 2003) [4]. WUA constituted in the year 2005 in the state of Maharashtra for different irrigation projects are working to achieve the productivity improvement of water applied. WUA's main aim is to increase water productivity in command area development (Hooja, 2005) [10]. Physical water productivity is the quantity of product in kg / m^3 water use of unit volume of water (m^3) (Molden *et al.*, 2003) [15]. The performance of WUA, if assessed through evaluation parameters of irrigation in command area, it may indicate the success of these bodies and may also suggest the necessary changes to achieve the goal of higher productivity per unit of water used in the system. The study on performance indicators showed that evaluation of actual irrigation system performance should rely on an accurate hydrologic water balance over the area considered. They provided equations, procedures and examples for making these calculations and recommended that confidence intervals be included in all reporting of irrigation performance parameters. The main aim of the study is to improve the system performance with an efficient use of water in command area.

Materials and Methods
Study area: The area selected is the command area of Shree Datta Water Users Association, located in Mirewadi village Phaltan tahasil Satara district of Maharashtra state In India shown in Fig.1.

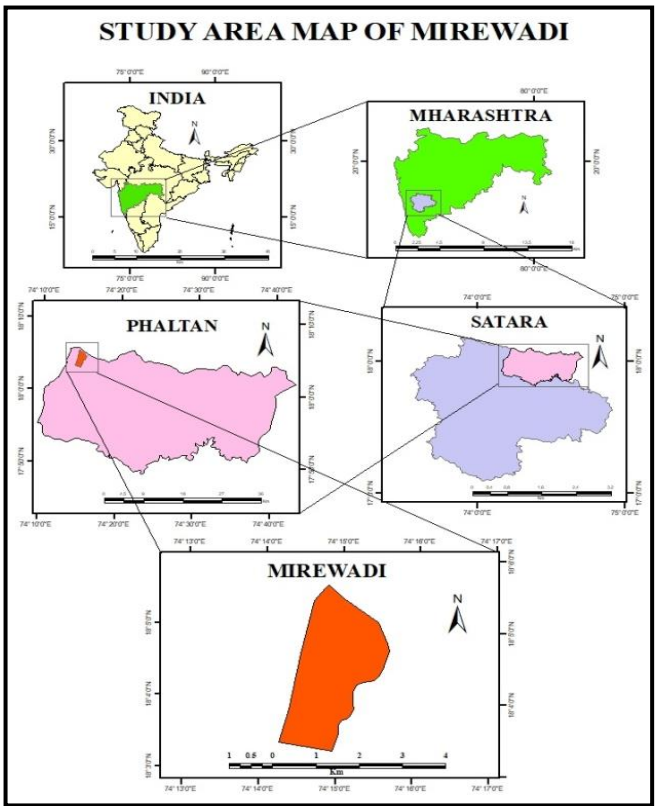

Fig 1: Location map of study area

It lies between 18º4'12"N latitude and 74º15'1"E longitude at altitude of 550 m above mean sea level. The primary and secondary data were collected from Shree Datta WUA Mirewadi has gross command area (G. C. A.) of 84.21 ha out of which 80.91 ha (96.1% of G.C.A.) area is under C.C.A. and 71.54 ha area is I.C.A. At present 69.30 ha is being irrigated, amounting to (85.65%) of culturable command area. The present command area comes under second transition zone of agro-climatic zone of Maharashtra. The textural class of soil in study area was clay soil. The normal annual rainfall in study area is 521 mm and the average annual temperature is 25.1 ºC, which maximum 33.5 ºC and minimum 18.8 ºC. (Jacob and Rajvanshi, 2006) [16].

Existing cropping pattern: The area under irrigation during 2020-21 in Shree Datta WUA command area is 68.30 ha. The major crops of Shree Datta WUA command area, which are sugarcane (65 ha), sapota (0.40 ha) and sorghum (2.90 ha) are irrigated with canal water and other resources.

Methodology: From the survey of WUA it was observed that the actual area under perennial crops was more and the area under cereals is very less. The main output considered is crop yield and foremost inputs are water and land. The different performance indicators namely water deliveries, maintenance, financial, output per unit irrigated crop area, output per unit water delivered, WDC and bio-economical indicator were computed.

Survey of Water User Association: A survey of Shree Datta water user association was conducted in Mirewadi village and 10 farmers were selected and interviewed for knowing their working status, their operation and management of irrigation. The information was also collected regarding agitation of farmers, cooperation received from the different departments, cooperation among the farmers etc.

Data Collection from Government Officers: The data required for calculation of these performance indicators was collected from Irrigation Department Phaltan, Sub- Division office Vathar Vasahat and Sub-Division office Padegoan.

Farmer's survey: In order to assess the impact of introduction of canal irrigation on cropping pattern, method of irrigation, land use and agricultural production, farmers were contacted personally to collect the desired information using a questionnaire survey. For calculation procedure, personal interview among farmers using a schedule and group discussions with farmers includes some important points such as modern crop technologies, awareness of the farmers for irrigation techniques, working of WUA in their commands and rights of the farmers about irrigation management.

Field Observations

Table 1: Average cross section details, flow depth and velocity in Shree Datta WUA (Minor-5)

Shree Datta WUA	Bottom width, m	Side Slope (H:V)	Top width, m	Depth of flow,	Velocity (m/s)
Head	0.30	1:1.5	0.90	0.20	0.81
Middle	0.30	1:1.5	0.84	0.17	0.75
Tail	0.30	1:1.5	0.75	0.15	0.68

Field observations were recorded to determine the discharge of minor and field channel at different reach. Discharge of minors was estimated by velocity area method. Cross sectional area, velocity of flow and depth of flow were measured in the minor-5. Cross sectional area was measured at three locations and averaged for head, middle and tail reach of each minor. The depth and velocity of flow was measured by standard method in minor and field channels. The details regarding the area of cross section, depth of flow and velocity in minors and field channel obtained from the measurement along with the location are presented in Tables 1. The bottom width of minors is 0.3 in all reach locations and depth of flow change from 0.15 to 0.20 m and velocity is ranges from 0.68 - 0.81 m/s in various reaches of minor.

Performance Indicators

The performance of WUA was evaluated based on following performance indicators.

Water deliveries indicators

Tail-end Supply Ratio (TSR)

$$\text{Tail} - \text{end Supply Ratio (TSR)} = \frac{Ns}{Nt} \quad \text{… Eq. (3.1)}$$

Ns = the no. of days that sufficient water reached the end of canal system.
Nt = the total no. of days the canal system was delivering water.

Maintenance indicators

Poor Structure Ratio (PSR)

$$\text{Poor Structure Ratio (PSR)} = \frac{NP}{NT} \quad \text{… Eq. (3.2)}$$

NP= is the number of structures in poor condition (not functioning adequately or at risk of failure) as per observation during survey.

NT = is the total number of structures on the system as per WUA record.

Financial indicators
Fee Collection Performance

$$\text{Fee collection performance} = \frac{Fc}{Fa} \quad \ldots \text{Eq. (3.3)}$$

Fc = the annual amount of water charges collected as per WUA records.
Fa = the annual amount of water charges assessed as per WUA records.

Manpower Numbers Ratio

$$\text{Manpower Numbers Ratio} = \frac{Ns}{At} \quad \ldots \text{Eq. (3.4)}$$

Ns = is number of staff (full-time equivalent) as per WUA records.
At = is total irrigated area as per WUA records.

Output per unit irrigated crop area

$$\text{Output per unit irrigated crop area (Rs/mm)} = \frac{\text{Production (Rs)}}{\text{Irrigated crop area}} \text{..Eq. (3.5)}$$

Output per unit water delivered

$$\text{Output per unit water consumed (Rs/mm)} = \frac{\text{Production (Rs)}}{\text{Water delivered by crop (mm)}} \text{..Eq. (3.6)}$$

Water Delivery capacity (WDC)

$$\text{Water Delivery capacity} = \frac{\text{Canal capacity to deliver water at system head}}{\text{Peak consumptive demand}} \text{.Eq. (3.7)}$$

Estimation of Bio-economical Indicator
Water Productivity

$$\text{Water Productivity} = \frac{Y}{Wq} \quad \ldots \text{Eq. (3.8)}$$

Y = Yield per ha, kg as per surveyed
Wq = Quantity of water use per ha, m^3 as per farmers survey and field observation.

Land Productivity

$$\text{Land Productivity} = \frac{P}{CA} \quad \ldots \text{Eq. (3.9)}$$

P = Production obtained from land in kg as per surveyed
CA = crop area in ha

Strategic planning of WUA: Micro-irrigation is introduced primarily to save water and increase the water use efficiency in command area. However, it also delivers many other economic and social benefits to the farmers. Reduction in water consumption due to drip method of irrigation over the surface method of irrigation varies from 30 to 70 percent for different crops. According to data available from research stations, productivity gain due to use of micro-irrigation is estimated to be in the range of 20 to 90 per cent for different crops. While increasing the productivity of crops significantly, it also reduces weed problems, soil erosion and cost of cultivation substantially, especially in labor-intensive operations. The cropping pattern was also proposed in enhance output. The performance of Shree Datta Water Users Association was based on the strategic planning of cropping pattern. The proposed cropping pattern, number of crops to be proposed, area allotment for different crops, water productivity, land productivity and net returns from proposed crops were discussed in depth under the section of results and discussion.

Result and Discussion
Discharge Variation in Minor-5

Table 2: Discharge measurement in minor-5 under Shree Datta WUA

Shree Datta WUA	Bottom width m	Side Slope (H:V)	Top width m	Depth of flow m	Velocity (m/s)	Observed discharge (m^3/s)	Designed discharge (m^3/s)	% Variation
Head	0.30	1:1.5	0.90	0.20	0.81	0.096	1.44	93
Middle	0.30	1:1.5	0.84	0.17	0.75	0.072	0.864	91
Tail	0.30	1:1.5	0.75	0.15	0.68	0.053	0.227	76

From table 2 it shows the discharge measured in head, middle and tail reach of minors-5 in Shree Datta WUA. In head reach highest discharge was observed at head in minor-5 is 0.096 m^3/s which decreases to (55.20%) in tail reach is 0.053 m^3/s. The depth of water flow was also found reduced from 0.20 m - 0.15 m from head to tail reach. The velocity of water flow can also reduced while moving from head to tail reach. The reduction in discharge is due to seepage, percolation and evaporation occurred at head to middle reach of minor-5.

Performance Indicators

Table 3: Performance of Shree Datta Water Users Association

Sr. No.	Parameter	Performance Indicator	Basic Input	Input Value	Value	Reference Range
1	Water Delivers	Tail-end supply ratio	Ns	22	0.24	0.50-0.70
			Nt	90		
2	Maintenance	Poor structure ratio	Np	2	0.5	0.01-0.20
			Nt	4		
		Fee collection performance	Fc	23178	0.4	0.62-1.0
			Fa	50000		
3	Financial	Manpower number ratio	Na	1	0.01	0.0004-0.001
			At	69.30		

Water Delivers

Tail end supply ratio: The tail-end supply ratio in Shree Datta WUA was found to be 0.24 which is less than reference range and hence it cannot be satisfactory in WUA.

Maintenance

Poor structure ratio: The poor structure ratio was found to be 0.5 is not satisfactory in WUA shows maximum structures of minor-5 are not proper working conditions.

Financial

Fee collection performance: The fee collection performance was found 0.4 which is less than reference range shows not satisfactory in WUA i.e. The charges collected from WUA were not sufficient for operation and maintain ace of the project.

Manpower number ratio: The manpower number ratio was found to be 0.014 is less than reference range shows working staff is less in WUA.

Output per unit irrigated crop area

Table 4: Output per unit irrigated crop area

Sr. No.	Crop	Existing yield (kg)	Selling Price (Rs/kg)	Gross Returns (Rs)	Irrigated crop area (ha)	Output per unit irrigated crop area (Rs/ha)
A	Perennial crop					
1	Sugarcane	5291723	2.85	1,50,81,410	68.30	2,21,178
2	Sapota	835	30	25050		
	Total			15106460		
B	Cereals					
	Sorghum	2057	28	57596	68.30	844
Gross Total				15164056	68.30	222022

The ICA of Shree Datta WUA during year 2020-21 is 68.30; it is observed that total gross returns from existing area was Rs. 1,51,64,056 during summer season. Hence the O/P per unit ICA for whole command area was Rs. 2, 22,022 ha^{-1}.

Output per unit water delivered

Table 5: Output per unit water delivered

Sr. No.	Crop	Gross Returns (Rs)	Volume of water delivered by crop (mm)	Output per unit water delivered (Rs/mm)
A	Perennial crop			
1	Sugarcane	1,50,81,410	118382	127
2	Sapota	25050	345	73
B	Cereals			
1	Sorghum	57596	622	93
Gross Total		1,50,71,808	119349	126

It is calculated from the ratio of production obtained in terms of gross returns measured at local prices to the volume of water delivered by crop. It is determined from the data collected through sample questionnaire. Hence the output per unit water delivered varies from Rs. 73 mm^{-1} for sapota to Rs. 127 mm^{-1} for sugarcane. For whole command area the indicator was obtained as Rs. 126 per mm of water.

Water Delivery Capacity

Table 5: Water use indicators

Sr. No.	Parameters	Value
1	Canal capacity to deliver at system head (m3/day)	7341
2	Peak consumptive demand (m3/day)	3252.79
3	Water delivery capacity (WDC)	2.25

The canal capacity to distribute water at system head for daily flow rate of 24 hr is 7341 m^3/day; while the peak consumptive demand is 3252.79 m^3/day. Water delivery capacity of minor-5 was 2.25, which represents the canal capacity was sufficient to meet the peak consumptive demand.

Estimation of Bio-economical Indicator

Table 6: Water productivity in different reaches of WUA

Sr. No.	Crop	Water productivity (kg/m^3)			Average
		Head	Middle	Tail	
1	Sugarcane	4.35	4.52	4.36	4.41
2	Sapota	-	0.24	-	0.24
3	Sorghum	-	-	0.11	0.11

From Table 3 it shows the water productivity of sugarcane, sapota and sorghum was found to be 4.41 kg/m^3, 0.24 kg/m^3 and 0.11 kg/m^3 in Shree Datta WUA.

Land productivity

Table 7: Land productivity in different reaches of WUA:

Sr. No.	Crop	Land productivity (kg/ha)			Average
		Head	Middle	Tail	
1	Sugarcane	85933	80920	75830	80894
2	Sapota	-	2087	-	2087
3	Sorghum	-	-	709	709

From Table 4 it shows the land productivity of sugarcane, sapota and sorghum was found to be 80894 kg/ha, 2087 kg/ha and 709 kg/ha in Shree Datta WUA.

Strategic planning for WUA: Surface irrigation needs more water compared to micro irrigation and leads to water accumulation of excess water in absence of proper drainage arrangement. It is admitted fact that the yields of crops are higher under micro irrigation system. It also leads to substantial saving of water. Generally, in drip irrigation, water saving ranges from 5 to 68 percent and yield increase of the crops is in the range of 10 to 50 per cent. Though, operation and maintenance cost for energy charges of this system is more when compared to surface irrigation, it is more efficient with regard to the water use efficiency. In addition to water saving, micro irrigation also results in enhanced yield of crop with superior quality, saving in labour and energy, flexibility in operation etc. In this study the adoption of drip irrigation was also developed for 80.91 ha. The various vegetables, horticultural crops are proposed based on benefit cost ratio for command area of Shree Datta WUA. The design of micro irrigation system for command area was followed as per the standard drip irrigation design procedure. It includes selection and design of lateral, selection of dripper, Selection and design of submain, Selection and design of main, Time of operation, cost economics of installing proposed micro-irrigation in command area etc. are considered in design procedure.

Table 8: Comparative study of water and land productivity of proposed and existing crop

Sr. No.	Scenario	crop	Water productivity (kg/m^3)		Land productivity (kg/ha)	
			Existing	Proposed	Existing	Proposed
1	Existing crops	Sugarcane	4.41	12.57	80894	187750
2		Sorghum	0.11	2.36	709	5767
3		Sapota	0.24	5.23	2087	15600
4	Proposed crop	Cabbage		7.60		48692
5		Cauliflower		6.91		29510
6		Brinjal		3.0		21160
7		Watermelon		9.31		57550
8		Cucumber		8.75		24600
9		Banana		11.45		71800

From table 5 it was found that the water and land productivity of proposed crop was more than the existing crop. This is because the adopting micro irrigation system in command area. It shows the yield and water productivity of existing crops was increased due to the micro irrigation system over surface or flood irrigation.

Table 9: Comparative study of net returns of existing and proposed crops in command area

Sr. No.	Crop	Existing cropping pattern		Crop	Proposed cropping pattern	
		Area	Net Returns (Rs)		Area (ha)	Net Returns (Rs)
Rabi						
1	-	-	-	Cabbage	20.25	12807760
2	-	-	-	Sorghum	15.28	1408791
3	-	-	-	Cauliflower	12.48	9515936
4	-	-	-	Brinjal	8.35	718031
Summer						
5	Sorghum	2.90	8,722	Cabbage	23.07	14597673
6	-	-	-	Watermelon	18.14	4437267
7	-	-	-	Cucumber	15.41	1091399
Perennial						
8	-	-	-	Banana	11.04	2042225
9	Sugarcane	65	73,10,504	Sugarcane	8.02	2439532
10	Sapota	0.4	9,400	Sapota	5.21	1161830
		Total	7328626		Total	4,83,82,444

From Table 6 it was found that net returns obtained from proposed crops was maximum than the existing crops in Shree Datta WUA command area. The result shows that due to adapting micro irrigation in command area gives more area under irrigation gives maximum yield and a net return was obtained in Shree Datta WUA command area.

Conclusions

The performance indicators showed land and water was not the limitation in the command area. The existing prospective of command area was not fully utilized. This can be overcome by organizing the awareness among the farmers regarding the utilization of available land and water sources by adopting the micro irrigation system in command. Therefore. the micro irrigation system in command area with cropping pattern is proposed for total cultivable area i.e., 80.91ha. The total net returns under proposed cropping pattern are increased in large extent due to largest area was carried out under cultivation and high valued crops are introduced on large area with micro irrigation system therefore, water is efficiently used with appropriate fertilizer quantity and ultimately results in net returns under proposed crops observed as peak value.

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