J. Agr. Sci. Tech. (2017) Vol. 19: 1197-1208

Physical Performance in Irrigation Minors Area under Different WUAs

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ABSTRACT

Irrigated agriculture plays a vital and important role in economic development of many countries around the world. In this research, performance assessment of Water User Associations (WUAs) was undertaken over canal water management in irrigation command area. WUAs in canal irrigation network were characterised and evaluation of irrigation performance was evaluated using different performance indicators. The water delivery indicator in tail-end supply ratio was 0.67, area uniformity ratio was 0.79 and delivery timeliness ratio was 1 in Govindgarh WUA. Satisfactory performance was observed in Govindgarh WUA in the comparison of Bijori WUA and Bauchhar WUA. The carrying capacity ratio was 0.96, and poor structure ratio was 0.5 in Govindgarh WUA. This indicator was also satisfactory in Govindgarh WUA as compared to Bijori WUA and Bauchhar WUA. In financials, fee collection performance (0.75), personnel cost ratio (0.56) and manpower number ratio (0.009) in Govindgarh WUA make it satisfactory. Sustainability of irrigated area was 0.88 which was satisfactory in Bijori WUA. Area/infrastructure ratio was 139.27 in Govindgarh WUA.

Keywords: Command area, Discharge variation, Farmer participation, Performance indicator, Water user association.

INTRODUCTION

Agricultural sector plays a vital role in eradicating poverty plummeting in many regions of the world. The performance of irrigation systems has a major role in producing more food and making irrigated agriculture cost-effective. The superior irrigation management can improve the performance of irrigation system. According to Saravanan (2010), emphasis should focus on laying out broad principles in policy statements for participatory irrigation which may allow multiple actors to debate and share the principles for comprehensive assessment of water management decisions. He has suggested offering diverse forums for actors to debate and share available information. There are several other studies, addressing irrigation and agricultural issues (Batt and Merkley, 2010; Hye and Siddiqui, 2010; Lecina *et al*., 2010; Frija *et al*., 2010,) depending on the nature of issue in several areas which need further work. Sanjay *et al.* (2010) concluded that participatory approach is a key to success of developmental schemes in water sector and to protect environment and maximize benefits of schemes. Real changes in irrigation water use can be achieved through improving the productivity of existing available water resources. Therefore, institutional interventions to improve irrigation water management are a pre-requisite for increasing the productivity of limited water resources. A WUA is a group of farmers along a lateral canal who establish their own cooperative non-profit organization with a set of rules to manage water deliveries within their area (Lohmar *et al.*, 2003). Farmer participation plays an

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[DOR: 20.1001.1.16807073.2017.19.5.19.2]

important role in irrigation command. Many have studied in evaluation of WUA's and farmers participation (Cakmak *et al.*, 2009; Chandran *et al.*, 2001; Gosh *et al.*, 2011; Yavuz *et al.*, 2006). Madhya Pradesh was the second Indian state to complete elections of 1470 WUAs in April 2000 and to 90 Distributary Committees in February 2001. WUA's main aim is to increase water productivity in command area development (Hooja, 2005). Physical water productivity is the quantity of product in kg per m^3 water use of unit volume of water (m^3) (Molden *et al.*, 2003). WUA was constituted in the year 2008 in the state of Madhya Pradesh for different irrigation projects which are working to achieve the productivity improvement of the water applied (Puranic, 2008).

The task of WUA is a mixed one, which includes social, technical, economical and emotional aspects. The performance of WUA, if assessed through evaluation parameters of irrigation in command area, 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. Keeping the above perspectives in view, the present study was aimed at characterizing and evaluating the working of selected Water User Association (WUA) in irrigation command and determining water productivity in working areas under different Water User Associations.

MATERIALS AND METHODS

Study Area

The area selected for the present study is the command area under three WUAs at their locations in Madhya Pradesh in India, which are Bijori, Bouchhar and Govindgarh. WUA Command area is 2,082, 1,531 and 1,840 ha in Jabalpur, Narsinghpur and Rewa district which is shown in Figure 1.

The command area of Bijori WUA lies between the 23° 2` 27`` to 23° 4` 45`` N latitude and 79° 41` 35`` to 79° 42` 5`` E longitude, command area of Bauchhar WUA lies between the 22° 94` 73`` to 22° 98` 75``

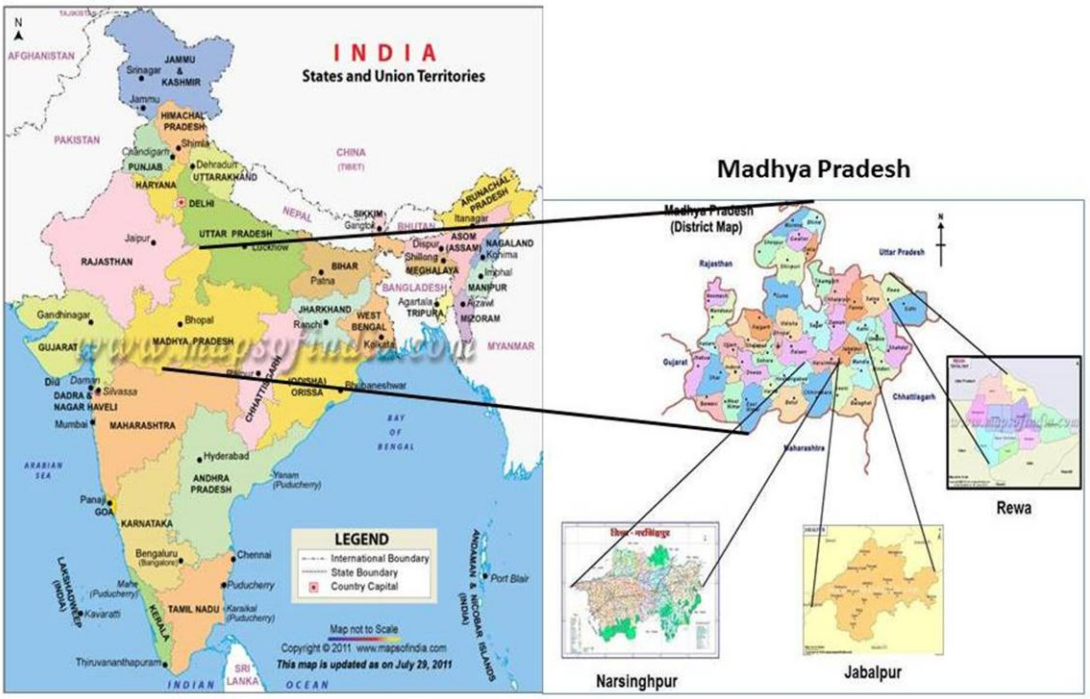

Figure 1. In India study areas are located in Madhya Pradesh state.

[DOR: 20.1001.1.16807073.2017.19.5.19.2]

N latitude and 79° 35` 54`` to 79° 28` 63`` E longitude and Govindgarh WUA command area lies between 24o38`15`` to 24o41`24`` N latitude and 81° 28 `0`` to 81° 28` 43`` E longitude. Bijori and Bauchhar WUAs are a part of Left Bank Canal of Rani Awanti bai Sagar Irrigation Project and Govindgarh WUA is under Govindgarh tank. The total number of minors are in Bijori WUA in nine minors, Govindgarh WUA in eight minors and Bauchhar WUA in six minors.

Table 1 shows land holding pattern of selected farmers under different WUAs. In Bijori WUA, numbers of farmers are highest in marginal category and lowest in large category as compared to the other category. Area coverage under the category of small farmers is highest and under medium farmers is the lowest. In Govindgarh WUA, the total number of farmers is highest in marginal category and lowest in large category. Total area covered in command is highest in small category and lowest in marginal category. In Bauchhar WUA, numbers of farmers are highest in marginal category and small farmers are dominating for area coverage. Govindgarh WUA has the maximum (407) number of farmers among three WUAs, whereas, Bijori WUA has maximum small, medium and large category farmers. Small category farmers with land holding of 1 to 2 ha cover the highest area under all the WUA's.

Survey of Water User Association

A survey of water user association was conducted in three basins namely Narmada, Betwa and Tones basin. The districts covered were Jabalpur, Narsinghpur, Katni, Vidisha, Sager, Tikamgarh, Panna and Satna. 40 farmers distributed over 10 WUAs covered different irrigation projects in the above districts where they were interviewed for knowing their working status, their operation and management of irrigation. The information was also collected regarding agitation of farmers, cooperation received by the farmers by different department, cooperation among the farmers, exposure of the farmers to modern crop technologies, awareness of the farmers for irrigation technics, working of WUAs in their commands and rights of the farmers about irrigation management (Chouhan *et al.*, 2015). Based on the information provided by farmers and the approach for the study area, cooperation was expected from Water Resources Department, Agriculture Department and responsive nature of the farmers. Bijori WUA near Gangai on Chargawan road under LBC command on Bargi Project in Jabalpur district, Bauchhar WUA near Karakbel in Narsinghpur district and Govindgarh WUA near Govindgarh Tank Project in Rewa district, were selected for conducting the project study for

Table 1. Details of the land holding pattern in the command area.

WUA name	Farmers category	Total farmer	Total area (ha)
Bijori WUA	Marginal	450	321
	Small	423	843
	Medium	184	270
	Large	78	415
Govindgarh WUA	Marginal	414	368
	Small	231	784
	Medium	161	242
	Large	24	88
Bauchhar WUA	Marginal	147	47
	Small	84	132
	Medium	22	53
	Large	16	68

[DOR: 20.1001.1.16807073.2017.19.5.19.2]

evaluation of Water User Associations.

Selected WUA's were surveyed and information was collected on Gross command area, cultivable command area, total number of structures, total number of damaged structures, water charges collection, expected water charges collection, total number of minors, total length of canal, total number of day water available in canal, total number of staff working in WUA, canal irrigated area, tube well irrigated area. This information which was tabulated and analyzed characterizes the WUA. All the information was collected with the help of questionnaires.

Data Collection

The data collection was carried out with the help of water resources department, district revenue department and meteorological department of JNKVV, Jabalpur. Few farmers and WUA precedents were consulted about the general condition of WUA's and irrigation project. Three WUAs were selected for study and four farmers field were selected from the head, middle and tail water users of WUA command area, respectively to get the desired information. It included the following: (Salient information pointwise)

- Observations were made to record and investigate the method of application.
- Measurement of canal water discharge at head regulator and discharge from different outlets of head, middle and tail reach respectively.
- Measurement of canal water flow at different sections of the main canal.
- The farmers under study area were divided into four groups i.e. marginal, small, medium and large. A questionnaire was prepared and WUA and farmers from different reaches were interviewed.

Table 2 shows the number of minors and their length in different WUAs. Bijori WUA has nine minors in which Dulakheda minor has the highest length of 3.21 km and Dabola minor has the lowest which is 1.21 km. Bauchhar WUA has six minors with the highest length in Karakbel minor (3.66 km) and the lowest length in Basanpani minor (0.75 km). Govindgarh WUA with eight numbers of minors has Mohini minor with a length of 2.45 km and Nakta minor with the lowest length of 0.90 km.

Farmer's Survey

In order to assess the impact of introduction of canal irrigation on cropping pattern, intensity of cropping, land use and agricultural production, farmers were contacted personally to collect the desired information in proforma using a questionnaire survey. (A) Personal interview among farmers using a schedule and (B) group discussions with farmers and

Table 2. Length of minors in WUA.

Bijouri WUA		Bauchhar WUA		Govindghgarh WUA	
Name of minor	Canal length (km)	Name of minor	Canal length (km)	Name of minor	Canal length (km)
Dabola	1.21	Basanpani	0.75	Govindhgarh	0.87
Bicuva	2.41	Bauchhar-1	3.46	Parsiya	1.25
Nunpur	2.51	Bauchhar-2	1.34	Kapurhai	1.21
Chapra	1.22	Mekh	2.55	Nakta	0.90
Dulakheda	3.21	Karakbel	3.66	Mohani	2.45
Pipariya	2.21	Devri	2.64	Amin	1.46
Jhanshi	2.18			Dhobat	1.22
Jamuniya	3.19			Hardishankar	1.31
Badayakheda	2.32				

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CADA officials were carried out (Sreehari *et al.*, 2012; Chandran *et al*., 2001). Representative farmers from within the WUA command area as well as in the immediate vicinity were selected under different categories namely marginal, small, medium and large. Farmers were selected using stratified random sampling technique. Three farmers in each of four categories were selected in head, middle and tail reach of minors. Thus a total of 36 farmers were surveyed in each WUA area. The selected farmers were interviewed and the information on their agricultural practices, land use, crops grown, irrigation sources and irrigation practices were obtained. This information was tabulated and analyzed to determine the status of canal water use.

Field Observation

Field observations were recorded to determine the discharge of minor and field channel in different minors 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 minors and canal.

Cross sectional area was measured at three locations and averaged for head, middle and tail reach of each minor. Depth of flow was measured directly by depth gauge in the stream. Velocity of flow was measured with the help of current meter in main canal and minors, whereas float area method was applied in 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 3 to 5. Bottom width of minors is 0.3 and side slopes are 1:1.1 to 1:1.5, depth of flow change from 0.11 to 0.43 m. Accordingly velocity is recorded as 0.27 to 1.15 m s^{-1} in various minors.

Performance Indicators

Performance indicators as proposed by Nelson (2002) were used for evaluating the irrigation project commanded by WUA.

Water Deliveries

$$\text{Tail} - \text{end Supply Ratio} = \frac{\text{Ns}}{\text{Ntd}} \qquad (1)$$

Ns= The Number of days sufficient water

Table 3. Average cross section details, flow depth and velocity in Bijori WUA.

Bijori WUA	Bottom width (m)	Side: Slope (H:V)	Top width (m)	Depth of flow (m)	Velocity of flow (m s^{-1})
Head	0.30	1:1.5	1.06	0.38	0.99
Middle	0.30	1:1.5	1.05	0.33	0.56
Tail	0.30	1:1.5	0.91	0.29	0.27

Table 4. Average cross section details, flow depth and velocity in Govindgarh WUA.

Govindhgarh WUA	Bottom width (m)	Side: Slope (H:V)	Top width (m)	Depth of flow (m)	Velocity of flow (m s^{-1})
Head	0.30	1:1.5	1.14	0.43	1.15
Middle	0.30	1:1.5	1.12	0.37	0.90
Tail	0.30	1:1.5	0.99	0.34	0.49

Table 5. Average cross section details, flow depth and velocity in Bauchhar WUA.

Bauchhar WUA	Bottom width (m)	Side: Slope (H:V)	Top width (m)	Depth of flow (m)	Velocity of flow (m s^{-1})
Head	0.30	1:1.1	1.11	0.36	1.14
Middle	0.30	1:1.1	1.01	0.26	0.89
Tail	0.30	1:1.1	0.73	0.11	0.45

[DOR: 20.1001.1.16807073.2017.19.5.19.2]

reached the end of the canal system.

Nt= The total Number of days the canal system was delivering water.

$$\text{Area Uniformity} = \frac{\text{Dw}}{\text{Davg}} \quad (2)$$

Dw= The water Depth (volume/irrigated area) for the worst supplied area in the system. (Which was tail end in all the cases.)

Davg= The average water Depth supplied to the whole system during the same time period.

$$\text{Delivery Timeliness Ratio} = \frac{\text{Nto}}{\text{NTo}} \quad (3)$$

Nto= Is the Number of orders where water was delivered within the target time. It was assumed that all the farmers have ordered five irrigations in wheat, two in gram etc.

NTo= Is the Total Number of orders (from the individual water order records). All 36 farmers were considered as total number of orders.

Maintenance

$$1.\ \text{Carrying Capacity Ratio} = \frac{\text{Ca}}{\text{Cd}}$$

Ca= Is the actual canal Capacity for the selected canal (measured at designed head) during observantions.

Cd= is the designed canal Capacity for the selected canal as per WUA record.

$$2.\ \text{Poor Structure Ratio} = \frac{\text{NPs}}{\text{NTs}}$$

NPs= Is the Number of structures in Poor condition (not functioning adequately or at risk of failure) as per observation during survey.

NTs= Is the Total Number of structures on the system as per WUA record.

2.6.3 Financial

$$1.\ \text{Fee Collection Performance} = \frac{\text{Fc}}{\text{Fa}}$$

Fc= The annual amount of water charges collected as per WUA records.

Fa= The annual amount of water charges assessed as per WUA records.

$$2.\ \text{Maintenance Budget Ratio} = \frac{\text{Em}}{\text{Eo\&}\ m}$$

Em= Average annual Expenditures for maintenance as per WUA records.

Eo&m= Average annual Expenditures for both operations and maintenance as per WUA records.

$$3.\ \text{Personnel Cost Ratio} = \frac{\text{Ep}}{\text{Et}}$$

Ep= Annual Expenditures on personnel (wages, fringe benefits, training, etc.) as per WUA records.

Et= Total annual Expenditures as per WUA records.

$$4.\ \text{Manpower Number Ratio} = \frac{\text{Ns}}{\text{At}}$$

Ns= Is the Number of staff (full-time equivalent) as per WUA records.

At= Is the total irrigated Area as per WUA records.

Sustainability

$$1.\ \text{Sustanability of Irrigated Area} = \frac{\text{Ac}}{\text{Ai}}$$

Ac= Is the current total irrigated Area as per WUA records.

Ai= Is the total irrigated Area when system development was completed as per WUA records.

$$2.\ \text{Area Infrastructure Ratio} = \frac{\text{At}}{\text{Lc}}$$

At= Is the total irrigated Area as per records of WUA's.

Lc= Is the total Length of canals and laterals on the system as per records of WUA's.

RESULTS AND DISCUSSION

The information collected on different parameters shown in Table 9 was converted in terms of performance indicators which are water delivery, maintenance, financial and sustainability in Table 10.

Discharge Variation in All Minors

Discharge measured at different fields in all the minors is shown in tables 6 to8. In table 6 the discharge was measured in the head, middle and tail reach of all nine minors under Bijori WUA. In head reach the highest discharge was observed in Nunpur minor 0.443 $m^3\ s^{-1}$ which decreased to 21.7% in tail reach (0.096 $m^3\ s^{-1}$). The lowest discharge was measured in Badayakheda minor being 0.025 $m^3\ s^{-1}$ which

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Table 6. Discharge measurement in different minors under Bijori WUA.

Name of Minor	Measured discharge ($m^3 s^{-1}$) at different reaches		
	Head	Middle	Tail
Dabola	0.328	0.140	0.055
Bichuva	0.299	0.142	0.059
Nunpur	0.443	0.178	0.096
Chapra	0.200	0.144	0.083
Dulakheda	0.285	0.107	0.042
Pipariya	0.347	0.209	0.068
Jhanshi	0.287	0.139	0.060
Jamuniya	0.266	0.094	0.016
Badayakheda	0.025	0.018	0.004

Table 7. Discharge measurement in different minors under Govindgarh WUA.

Name of Minor	Measured discharge ($m^3 s^{-1}$) at different reaches		
	Head	Middle	Tail
Govindgarh	0.572	0.324	0.213
Parsiya	0.467	0.365	0.174
Kapurhai	0.434	0.312	0.151
Nakta	0.331	0.276	0.106
Mohani	0.325	0.244	0.078
Amin	0.246	0.163	0.080
Dhobet	0.255	0.124	0.062
Hardi Sankar	0.246	0.138	0.048

Table 8. Discharge measurement in different minors under Bauchhar WUA.

Name of Minor	Measured discharge ($m^3 s^{-1}$) at different reaches		
	Head	Middle	Tail
Basanpani	0.189	0.104	0.075
Bauchhar - 1	0.408	0.301	0.053
Bauchhar - 2	0.310	0.125	0.002
Mekh	0.250	0.122	0.016
Karakbel	0.342	0.146	0.024
Devri	0.274	0.132	0.018

decreased to 16% in tail reach (0.004 $m^3 s^{-1}$). In general tail end recieved less water ranging from 6.02 to 41.5%. The discharge measurement of Govindgarh WUA is show in Table 7. In head reach the highest discharge was obtained in Govindgarh minor (0.572 $m^3 s^{-1}$) which decreased by 62.76% in tail reach (0.213 $m^3 s^{-1}$). The lowest discharge was in Amin and Hardisankar minor which was 0.246 $m^3 s^{-1}$. It decreased by 67.48 and 80.49% in tail reach (0.08 and 0.048 $m^3 s^{-1}$ respectively).

The Bauchhar WUA is presented in Table 8. In head reach, the highest discharge was 0.408 $m^3 s^{-1}$ in Bauchhar-1 minor which had an 87.01% decrease in tail reach and reached to 0.053 m^3/s. The lowest discharge was measured in Basanpani minor at 0.189 $m^3 s^{-1}$ which decreased in tail reach (0.075 $m^3 s^{-1}$).

Water Deliveries

The tail-end supply ratio was highest in Govindgarh WUA because sufficient canal water was available for irrigation in tail reach. The area uniformity ratio in Bijori WUA was less because in this WUA tail reach water users had their land holding size is sufficient water available for irrigation in the field and in Bauchhar WUA this ratio was lowest therefore, tail end water user

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Table 9. Computation parameters for evaluating performance of irrigation project.

S No	Parameter	Definition	Bijori	Govindgarh	Bauchhar
1	*Ns*	The Number of days that sufficient water reached the end of the canal system.	70	80	44
2	*Ntd*	The total Number of days the canal system was delivering water.	120	120	120
3	*Dw*	The water Depth (volume/irrigated area) for the worst supplied area in the system. Which was tail end in all the cases.	8556.26	4304.34	4140.9
4	*Davg*	The average water Depth supplied to the whole system during the same time period.	8942.77	5460.95	7237.5
5	*Nto*	The Number of orders where water was delivered within the target time.	4	4	3
6	*NTo*	The Total Number of orders (from the individual water order records). All 36 farmers were considered as total number of orders.	4	4	4
7	*Ca*	Actual canal Capacity for the selected canal (measured at designed head) during observations.	292	350	284
8	*Cd*	The designed canal Capacity for the selected canal as per WUA record.	318	364	318
9	*NPs*	The Number of structures in Poor condition (not functioning adequately or at risk of failure) as per observation during survey.	290	130	150
10	Nts	The total Number of structures on the system as per WUA record	395	260	180
11	Fc	The annual amount of water charges collected as per WUA records	288000	280200	40600
12	Fa	The annual amount of water charges assessed as per WUA records	431614	373100	70500
13	Em	Average annual Expenditures for maintenance as per WUA records	55000	45000	25000
14	Eo&m	Average annual Expenditures for both operations and maintenance as per WUA records.	90000	72000	60000
15	Ep	Annual Expenditures on personnel (wages, fringe benefits, training, etc.) as per WUA records	45000	40000	28000
16	Et	Total annual Expenditures as per WUA records.	90000	72000	60000
17	Ns	Number of staff (full-time equivalent) as per WUA records	20	14	18
18	At	Total irrigated Area as per WUA records	1849.07	1486	300
19	Ac	Current total irrigated Area as per WUA records	1849.07	1486	300
20	Ai	Total irrigated Area when system development was completed as per WUA records	2082.08	1760	850
22	Lc	The total Length of canals and laterals on the system as per records of WUA's.	20.46	10.67	14.4

Table 10. Performance indicators and water user associations at various locations preferred range.

S No	Performance indicators		Bijori	Govindgarh	Bauchhar	Reference Range	Source
1	Water deliveries	$\text{Tail} - \text{end Supply Ratio} = \frac{\text{Ns}}{\text{Ntd}}$	0.58	0.67	0.37	0.50 – 0.70	Nelson, 2002
		$\text{Area Uniformity} = \frac{\text{Dw}}{\text{Davg}}$	0.96	0.79	0.57	0.50 – 0.9	Santhi and Pundarikanthan, 1999
		$\text{Delivery Timeliness Ratio} = \frac{\text{Nto}}{\text{NTo}}$	1	1	0.75	0.72 – 0.9	Palmer *et al.,* 1991
2	Maintenance	$\text{Carrying Capacity Ratio} = \frac{\text{Ca}}{\text{Cd}}$	0.92	0.96	0.89	0.60 – 1.36	Nelson, 2002
		$\text{Poor Structure Ratio} = \frac{\text{NPs}}{\text{NTs}}$	0.72	0.50	0.83	0.01 – 0.2	Nelson, 2002
3	Financial	$\text{Fee Collection Performance} = \frac{\text{Fc}}{\text{Fa}}$	0.67	0.75	0.58	0.62 – 1	Nelson, 2002
		$\text{Maintenance Budget Ratio} = \frac{\text{Em}}{\text{Eo\& m}}$	0.61	0.63	0.42	0.4 – 0.7	Nelson, 2002
		$\text{Personnel Cost Ratio} = \frac{\text{Ep}}{\text{Et}}$	0.50	0.56	0.47	0.5 – 0.6	Nelson, 2002
		$\text{Manpower Number Ratio} = \frac{\text{Ns}}{\text{At}}$	0.01	0.01	0.06	0.4 – 1	Nelson, 2002
4	Sustainability	$\text{Sustanability of Irrigated Area} = \frac{\text{Ac}}{\text{Ai}}$	0.89	0.84	0.35	0.5 – 1	Nelson, 2002
		$\text{Area Infrastructure Ratio} = \frac{\text{At}}{\text{Lc}}$	90.37	139.27	20.83		

with sufficient water was not available for irrigation. The delivery timeliness ratio was low in Bauchhar WUA because of sufficient canal water not being available in the irrigation time.

Maintenance

Performance indicators Carrying Capacity Ratio (CCR) and Poor Structure Ratio (PSR) come under the maintenance parameter. Carrying capacity ratio was highest in Govindgarh WUA because actual water discharge in the canal was near to design discharge. In Bauchhar WUA poor structure ratio was highest because in this WUA numbers of structure were in a poor condition compared to other WUAs.

Financial

In this parameter four performance indicators namely Fee Collection Performance (FCP), Maintenance Budget Ratio (MBR), Personnel Cost Ratio (PCR) and Manpower Number Ratio (MNR) were evaluated. Fee collection performance of Govindgarh WUA was more than other WUAs, expenditure in maintenance was more in Govindgarh WUA thus maintenance budget ratio was more in this WUA compared to other WUAs. For Govindgarh WUA personnel cost ratio is more, due to expenditure in personnel activities like training, wages etc. The manpower number ratio was lowest in Govindgarh WUA and Bijori WUA because in this WUA the number of staff was less compared to Bouchhar WUAs.

Sustainability

Sustainability parameter includes two performance indicators namely Sustainability of Irrigated Area (SIA) and Area/Infrastructure Ratio (AIR). Sustainability of irrigated area was more in Bijori WUA because actual irrigated area was more in this WUA compared to other WUAs and Area/infrastructure ratio in Govindgarh WUA was more than other WUAs because the number of structure was less and irrigation area was more. Overall comparison of WUA establishes the fact that Govindgarh WUA is performing better than other WUA.

CONCLUSIONS

Out of the total 11 indicators evaluated for characterising WUAs, nine were in an acceptable range in WUAs. Tail end supply ratio was 0.37 in Bouchhar which is below the acceptable limit and shows poor availability in Bauchhar WUA. Bauchhar WUA had the highest manpower number ratio of 0.06 followed by 0.01 in Bijori and 0.01. Compared to Bauchhar WUA command area, in physical performance indicators Govindgarh WUA command area was better. Based on the literature (Ahmadvand and Sharifzadeh, 2010; Azizi Khalkheili and Zamani, 2009; Koc *et al.*, 2006) and empirical evidence from this study, it is possible to conclude that the most important factors influencing WUA problems are "people or human factors". According to Omid *et al.* (2012) human factors were derived from inequitable distribution of water. For instance, elite farmers were given more power thereby making other members more vulnerable in obtaining their fair share of water. In the case of farmer-owned organizations such as WUAs, research has shown that unequal distribution of power among members is the prime reason for this organization to fail. Consequently, in Bauchhar WUA performance indicators (1) Water deliveries; (2) Maintenance; (3) Financial, and (4) Sustainability are low compared to Govindgarh and Bijori WUAs

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[DOR: 20.1001.1.16807073.2017.19.5.19.2]

عملکرد فیزیکی در مناطق آبیاری زیرزمینی تحت WUA های مختلف

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چکیده

کشاورزی آبی نقش مهمی حیاتی در توسعه اقتصادی بسیاری از کشورها در سراسر جهان ایفا می کند. در این تحقیق، ارزیابی عملکرد انجمن های آب مصرفی (WUAs) بر مدیریت آب کانال در منطقه فرمان آبیاری انجام شد. WUAs در شبکه آبیاری کانال مشخص شدند و ارزیابی عملکرد آبیاری با استفاده از شاخص های عملکردی مختلف مورد ارزیابی قرار گرفت. تحویل آب در نسبت tail-end supply ۰.۶۷ ، نسبت یکنواختی منطقه ۰.۷۹ و نسبت وقوع تحویل ۱ در Govindgarh WUA بود. عملکرد مطلوب تری در WUA Govindgarh در مقایسه با Bijori WUA و Bauchhar WUA مشاهده شد. نسبت ظرفیت گنجایش ۰.۹۶ و نسبت ساختاری ضعیف ۰.۵ در Govindgarh WUA است. این شاخص در WUA Govindgarh نیز در مقایسه با WUA Bijori و Bauchhar WUA رضایت بخش تر بود. در جمع آوری مالی، هزینه جمع آوری (۰.۷۵)، نسبت هزینه پرسنل (۰.۵۶) و نسبت تعداد نیروی کار (۰.۰۰۹) در GOVINDGARH WUA آن را رضایت بخش کرده است. پایداری منطقه آبیاری در WUA Bijori ۰.۸۸ بود که رضایت بخش می باشد. نسبت منطقه / زیرساخت در GovindgarH WUA 139.27 بود.

[DOR: 20.1001.1.16807073.2017.19.5.19.2]