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Assessment of surface water minor irrigation schemes using performance indicators

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Abstract

Performance of two surface water minor irrigation schemes namely Munippara and Poolani of Thrissur district of Kerala were assessed using the performance indicators of Relative Water Supply (RWS), Relative Irrigation Supply (RIS), Standardized Gross value of Production (SGVP), SGVP per cropped area and SGVP per unit irrigation supply. High Relative Water Supply (RWS) values of both schemes indicate that water is abundant for crop production in both minor irrigation schemes. Relative irrigation supply (RIS) values show that the distribution of water is better in Poolani scheme compared to Munippara scheme. In the command areas of both schemes along with irrigation, well recharge also is taking place and sustains the drinking water availability. Better participation of beneficiaries in irrigation water management activities of Poolani scheme ensures adequate and timely water availability compared to Munippara scheme. Further scope for improvements in the performance of the schemes is observed through careful planning of the water distribution of the schemes so that more area can be brought under irrigation. This has to be implemented through beneficiary participation approach.

Keywords: Minor irrigation scheme, Relative water supply, Relative irrigation supply, Standardized gross value of production

Introduction

India supports 17 per cent of the population and 15 per cent of the livestock population of the world with only 2.4 per cent of the land and 4.0 percent of the water resources (Dhawan, 2017). The utilizable water resources of the country have been assessed as 1123 BCM, of which 690 BCM is from surface water and 433 BCM is from groundwater sources. The National Commission for Integrated Water Resources Development Plan (Government of India, 1999) has projected that the total demand for water by the year 2050 is 1180 BCM under high demand scenario, of which 826 BCM will be for agriculture alone. This increased demand for water compounded by climate change would further deteriorate the situation. Since the total projected demand will be more than the present level of utilizable water resources, the challenge will be to produce more from less water by efficient use of utilizable water resources in irrigated areas. The main challenge facing the irrigation sector in India is the growing gap between irrigation potential created, irrigation potential utilised and uneven distribution of water over the length of the canal system. The overall irrigation efficiency of the major and medium irrigation projects is estimated to be around 38 per cent only. The ultimate irrigation potential estimated for the country is 139.89 Mha, out of which the assessed potential through major and medium irrigation projects is 58.47 Mha and minor irrigation projects is 81.43 Mha. Of the total irrigation potential of India, 58.19 per cent is the share of minor irrigation schemes (Planning Commission, 2011). Minor irrigation plays a considerable role in the economy of Kerala state

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and it is important to maintain sufficient levels of performance to achieve maximum output. As per the 5th census of Minor irrigation schemes, Kerala has 1,03,657 schemes which consists of 82,464 ground water schemes (79.5%) and 21,189 (20.50%) surface water schemes. Out of the surface water schemes, 65% are surface lift schemes and 35% are surface flow schemes.

Irrigation water management for agriculture has to be more efficient in terms of the required quantity of water at the right time with equitable distribution. Performance assessment of the irrigation schemes is essential with respect to the objectives of service delivery and efficient use of limited resources. The performance of irrigation schemes can be assessed using external performance indicators developed by the International Water Management Institute, IWMI (Moiden et al., 1998). Madhava and Ambili (2016) stated that the efficiency of minor irrigation schemes could be improved by careful operation and planning of delivery systems and by farmer participatory activities in system management. The study on the performance of Khapa minor irrigation project indicated that the resources created were not fully utilized and there are ways to increase productivity and farm income (Mahesh et al., 2018). The present study was carried out to assess the performance of two surface lift minor irrigation schemes using indicators developed by IWMI and water availability in the command area.

Materials and Methods

Munippara minor irrigation scheme located at Pariyaram Panchayath in Thrissur district of Kerala is under the Minor Irrigation Division of Water Resources Department, Kerala. The scheme became operational in the year 1983. The command area of the scheme is about 30.58 ha. Two pump sets of 75 hp and 100 hp are operating alternately with a suction head of 5 m and delivery head of 17 m, lifting water from Chalakudy river. Two wells located in the command area and recharged by the minor irrigation scheme sustain drinking water schemes 'Ganga' and 'Sheethal' which are part of the 'Jalanidhi' project. Almost 100 families/ households meet their domestic water requirements from these schemes.

Poolani minor irrigation scheme is located at Meloor panchayath in Thrissur district. The scheme started in the year 1984. The potential irrigated area under the scheme is around 74 ha. Pumping systems of 75 hp are operating alternately for meeting the water requirement of the command area.

The total length of the canal system of Munippara minor irrigation scheme is 700 m and nine outlets are provided in the main canal. The entire 700 m canal system is lined. Poolani minor irrigation scheme canal network system is 3000 m long. The dimension of the canal is 0.75m in width and 0.50m in depth. Supply channels of both minor irrigation schemes are unlined. Water is diverted to the supply channel through outlets provided along the main canal. The unlined field channels receive water from the unlined supply channels. Water is diverted to the field through the unlined field channels. In Munippara minor irrigation scheme the canal reach is divided into head, middle and tail parts/reach. Water is conveyed and distributed to every reach once a week rotationally, whereas in Poolani minor irrigation scheme the command area is divided into four zones and water is conveyed and distributed to the respective command area zones rotationally once in a week

Performance evaluation of two minor irrigation schemes namely Munippara and Poolani of Thrissur District was assessed using performance indicators. The performance indicators used were Relative Water Supply (RWS), Relative Irrigation Supply (RIS), Standardized Gross value of Production (SGVP), SGVP per cropped area and SGVP per unit irrigation supply. Relative Water Supply is the ratio of total water supply to crop water demand. Total water supply includes canal water supply and rainfall. Crop demand is the potential evapotranspiration. Relative Irrigation Supply (RIS)

was calculated as total irrigation supply to irrigation demand. RIS does not include the contribution of rainfall.

SGVP with nutmeg as the base crop was calculated using the equation below:

$$SGVP = \left(\sum A_i Y_i \frac{P_i}{P_b}\right) P_w$$

Where A_i is the cropped area with crop i (ha), Y_i is the yield of crop i (t/ha), P_i is the local price of crop i (Rs/ha), P_b is the local price of the base crop (Rs/ha), P_w market price of the base crop in the state. Also, social indicators like beneficiaries' insights on adequacy and timeliness of water availability and extent of participation through beneficiaries' association also were studied.

A survey was conducted based on a questionnaire prepared and data for the calculation of performance indicators were collected from 30 % of beneficiaries of minor irrigation schemes. For a better understanding of water availability and groundwater recharge, water table observations were taken by measuring the water table in selected observation wells in the command area of the minor irrigation schemes. Data was collected through discussion with the key stakeholders of the beneficiaries' association. Information regarding hours of operation of pump was collected from the Minor Irrigation Sub Division Office. Discharge was measured in head, middle and tail reach of the main canal. Crop water requirements for six months period (December to May) was calculated using CROPWAT 8.0 software.

The command area of the minor irrigation scheme was demarcated using Arc GIS 10.8. Latitude and longitude of the starting and end point of the canal, canal outlets and supply channel were taken using GPS. Using Google Earth Pro and Arc GIS 10.8 land use maps of minor irrigation schemes were prepared. Observation wells at the head, middle and tail reach, were selected based on the geographical features and length of the canal. Observations of water table depth were taken on a weekly basis two weeks prior to the pumping of water and during the entire period of operation of the minor irrigation schemes. The coordinates of the selected wells were taken using GPS.

Results and Discussion

Command area and land use

Using the latitude and longitude data, the canal system of the minor irrigation schemes was plotted and shown in Figures 1 and 2. The gross command area estimated from the plot is 31.74 ha for Munippara minor irrigation scheme and 77.3 ha for Poolani minor irrigation scheme. The coordinates of the observation wells were taken using GPS and are shown in the base map of the area (Figures 1 and 2).

The land use maps of minor irrigation schemes were prepared using Google Earth Pro and Arc GIS 10.8 as shown in Figures 3 and 4. The area covered by each land use pattern is given in Table 1 for Munippara and Poolani minor irrigation schemes. The whole area is classified into five land use patterns for Munippara minor irrigation scheme. The main crops grown in the mixed cropping system in

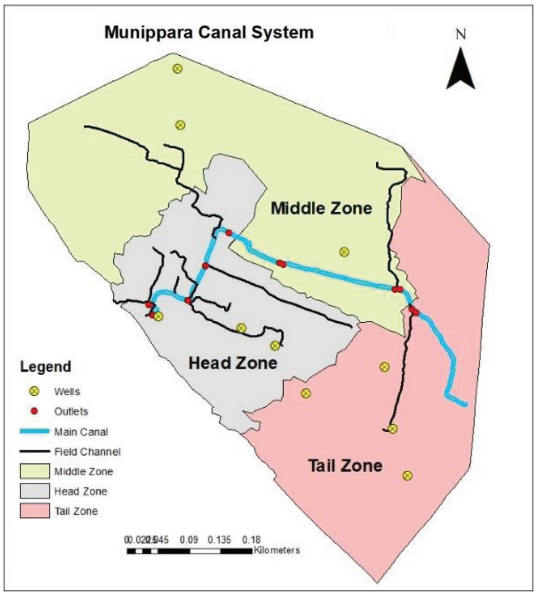

Figure 1. Canal system and command area of Munippara minor irrigation scheme

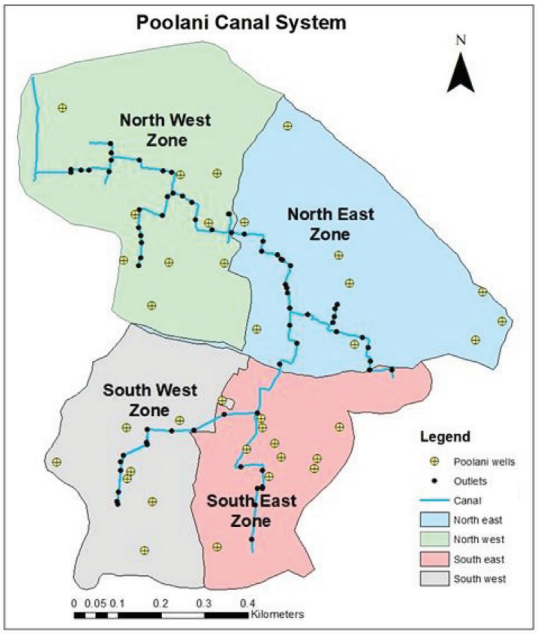

Figure 2. Canal system and command area of Poolani minor irrigation scheme

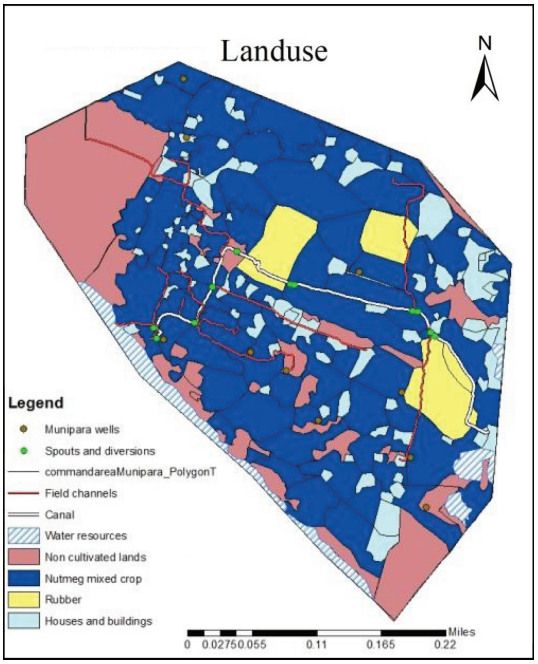

Figure 3. Land use map of Munippara minor irrigation scheme

Munippara minor irrigation scheme are nutmeg, banana, coconut and fruit crops namely rambutan and mangosteen. Rubber is cultivated in 2.08 ha as a rainfed crop. In Poolani minor irrigation scheme,

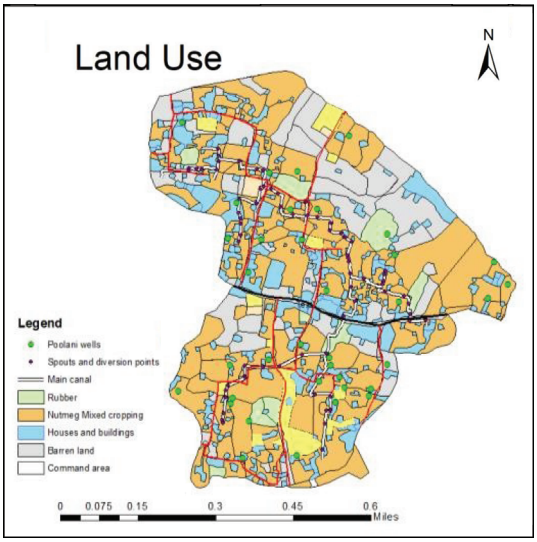

Figure 4. Land use map of Poolani minor irrigation scheme

Table 1. Land use patterns and extent of command area of Munippara and Poolani minor irrigation schemes

Sl. No	Land use pattern	Munippara Minor Irrigation Scheme Area (ha)	Poolani Minor Irrigation Scheme Area (ha)
1	Mixed cropping	18.52	50.74
2	Rubber	02.08	3.74
3	Fallow land	06.58	5.35
4	Houses and buildings	03.48	17.55
5	Water source	01.08	-
	Total	31.74	77.38

the main crop cultivated is nutmeg and the other crops cultivated in the mixed cropping system are coconuts, arecanut, banana and fruit crops.

Water availability

The seasonal crop water demand and irrigation water demand of the major crops of the both minor irrigation scheme estimated by CROPWAT model and are given in Table 2. The sufficiency of water for crop production was studied by estimating the Relative Water Supply (RWS). The RWS and RIS calculated for the Munippara and Poolani minor irrigation schemes are given in Table 2. The RWS is more than 2.5 in the case of head reach of Munippara scheme showing that irrigation performance is not affected by water stress. RWS value is more than one in the middle reach which indicates that the water supplied is sufficient in

Table 2. Canal water supply crop water demand irrigation demand, relative water supply and relative irrigation supply of Munippara and Poolani minor irrigation schemes

Sl No	Parameters	Munippara Minor Irrigation Scheme Canal reach			Poolani Minor Irrigation Scheme Canal reach			
		Head	Middle	Tail	Zone 1 (north east)	Zone 2 (north west)	Zone 3 (south east)	Zone 4 (south west)
1	Cropped area (ha)	5.49	7.5	5.53	11.08	11.65	10.97	11.33
2	Canal water supply(M^3)	174432.00	130824.00	87216.00	196107.03	196107.03	196107.03	196107.03
3	Effective rainfall (M^3)	10121.34	13821.14	10175.92	20422.67	21480.39	20227.20	21132.24
4	Crop water demand(M^3)	39101.72	53390.62	39335.41	70461.00	80841.38	75817.44	77888.20
5	Drinking water demand (M^3)	14400.00	0.00	0.00	0.00	0.00	0.00	0.00
6	Irrigation demand (M^3)	28980.38	39569.48	29159.49	50038.33	59360.99	55590.24	56755.96
7	Relative Water Supply (RWS)	3.45	2.71	2.48	3.07	2.69	2.85	2.79
8	Relative Irrigation Supply (RIS)	4.02	3.31	2.99	3.92	3.30	3.53	3.46

meeting the crop demand. The RWS of both schemes is more than 2.5 which indicates that the water supply is adequate for irrigation. High values of RWS of Poolani minor irrigation scheme denote that water is supplied in abundance. Relative irrigation supply (RIS) indicates whether irrigation supply meets crop demand. Observing the values of RIS in both minor irrigation schemes, it can be concluded that over irrigation is there in Poolani minor irrigation scheme compared to Munippara minor irrigation scheme. The study on Munippara and Poolani minor irrigation schemes in terms of RWS and RIS also reveals that the equitable water distribution in the command area is more for Poolani when compared to Munippara as depicted in Table 2. For Poolani scheme, the RIS values vary from 3.05 to 3.66 only whereas in Munippara the RIS values vary from 1.14 to 3.89 in the canal reaches.

The wells in the command area of the Munippara minor irrigation scheme are recharged during the water supply period. The water table rises in the observation wells of head, middle and tail reach of the canal are shown in Figures 5,6 and 7 respectively. For the wells in the command area, the rise in the water table is from 90 to 120 cm at the head end. The rise in the water table of the tail end of the canal is less compared to the head and middle reaches. This is because the water reaches the tail end command area through longer unlined supply channels.

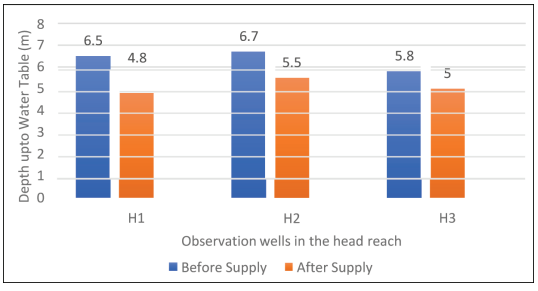

Figure 5. Depth to water table for wells at head end of Munippara minor irrigation scheme

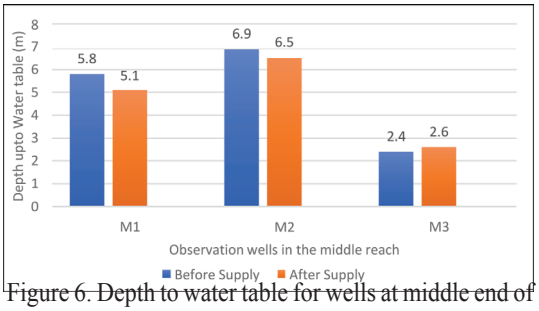

Figure 6. Depth to water table for wells at middle end of Munippara minor irrigation scheme

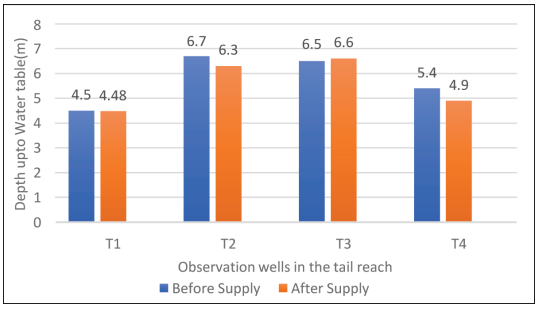

Figure 7. Depth to water table for wells at tail end of Munippara minor irrigation scheme

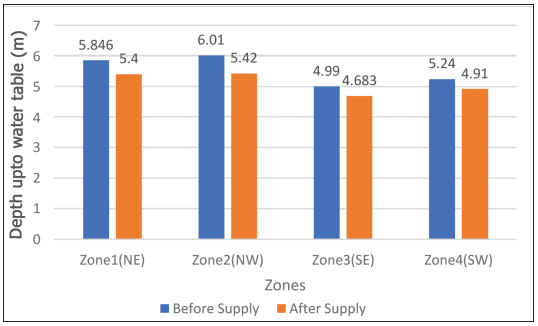

Figure 8. Depth to water table for different zones of Poolani minor irrigation scheme

The water table rise in wells located in the command area of Poolani minor irrigation scheme is shown in Figure 8. Wells in the command area of both schemes are recharged by canal supply. The beneficiaries of the scheme depend on the canal system for the adequate supply of water in their wells. Hence, the existence of the scheme is well correlated to crop production as well as the continuous availability of water in the wells.

Beneficiaries' response to the availability of irrigation water supply is given in Table 3 and matches with the high value of RWS and RIS. About 85 % of beneficiaries agree that always adequate water is available in Poolani scheme. For Munippara scheme about 75 % of beneficiaries report adequate water availability, and the remaining 25% face problems that the quantity of water supplied to them is not adequate. The majority of this 10% is in the tail end and if the unlined supply channels of the tail end are lined and extended, adequacy for the water supply for the tail end can be achieved. The farmers' association is taking keen interest in the maintenance of the canal system and distribution of water to all beneficiaries as per the schedule maintained by them. It is observed from the data presented in Table 3 that 75% of the beneficiaries of Munippara scheme and 85 % of Poolani scheme are getting adequate water supply. When the adequacy and timeliness of the water supply are considered, the above figures are 60% and 80% only. This is due to the reason that in its original mandate, these minor irrigation systems are intended mainly for cash crops that need irrigation once in a week. Later annual crops like bananas and vegetables are introduced which need irrigation twice in a week. The present rotational system of irrigation once in a week is focused on cash crops. Observation done during the field survey revealed that irrigation water for bananas can be stored in a pond or tank from the canal during the supply period and this water can be pumped to the banana field to meet the requirement.

Land and Water Productivity

Due to the timely availability of sufficient water, beneficiaries are interested in increasing agricultural productivity and increasing their economic return on investment. If better crop productivity is obtained with less use of water, water productivity is

Table 3. Beneficiaries' feedback on adequate and timely water availability in minor irrigation schemes

Sl. No.	Beneficiaries feedback	Munippara Minor Irrigation Scheme	Poolani Minor Irrigation Scheme
1	Always adequate water available (%)	75	85
2	Sometimes adequate water available (%)	15	13
3	Never adequate water available (%)	10	2
4	Adequate and timely water availability (%)	60	80

Table 4. Indicators for assessing land and water productivity

Indicators	Munippara Minor Irrigation Scheme Canal reaches			Poolani Minor Irrigation Scheme Zones			
	Head	Middle	Tail	Zone 1 (north east)	Zone 2 (north west)	Zone 3 (south east)	Zone 4 (south west)
SGVP (INR in Lakhs)	5.29	7.23	5.33	19.53	14.12	36.55	28.8
SGVP per cropped area (INR in Lakhs/ha)	0.95	0.95	0.95	1.74	1.19	3.29	2.48
SGVP per irrigation supply (INR/m^3)	3.03	5.52	6.11	9.96	7.20	18.64	14.68

achieved. Indicators of land and water productivity of the two schemes are shown in Table 4.

In Munippara scheme, middle reach beneficiaries obtain the maximum value of production (SGVP) compared to head and tail reach beneficiaries. Zone 3 beneficiaries get the maximum value of production in the Poolani scheme. In Poolani scheme high value of Standardised Gross value of Production (SGVP) relates to the high value of RWS and RIS, whereas in Munippara scheme highest value of SGVP coincides with low values of RWS and RIS (Table 2 and 4). This shows chances prevail for increasing the SGVP for irrigation water supply by reducing the quantity of water supplied in Poolani irrigation scheme. Land productivity of Rs 0.95 lakhs/ha is the same for the head, middle and tail end reaches of Munippara minor irrigation scheme, whereas the value ranges from Rs 1.19 lakhs/ha to Rs 3.29 lakhs/ha with a maximum value of Rs 3.29 lakhs/ha in zone 3 of Poolani minor irrigation scheme.

SGVP/ Irrigation water supply (water productivity) values show that the highest value is for the tail end of Munippara minor irrigation scheme, whereas for Poolani minor irrigation scheme the highest value is obtained for zone 3. It shows that water productivity variation is different from land productivity variation in Munippara minor irrigation scheme. However, in the case of the Poolani minor irrigation scheme, the water productivity variation follows land productivity.

The farmers' participation in the operation and maintenance of the scheme is a good performance indicator for the scheme. Considering the high value of land productivity, it is evident that the farmers are interested in the operation and maintenance of the system (Table 5). Farmer's association is active and about 90-95 % of the farmers cooperate for the distribution of water at the right time. After the 2018 flood, the suction pipes were completely blocked due to the over accumulation of sand. Farmers and local people of the command area arranged workers for removal of sand. Also, a vacuum pump was purchased and the scheme was made operational. The survey has shown that the majority of the farmers of the command area are not depending completely on agriculture for their livelihood. Most of them have jobs and other means of income.

An intervention is proposed for making use of excess water available for irrigating an area of 15 acres at the tail end of the canal in zone 3. This excess water in the canal can be diverted and stored in an existing pond of size 20 m x 10.5 m x 5 m. Water can be pumped and used for irrigating the area. Apart from irrigation, wells in the surrounding area will get recharged and this will resolve the existing drinking water issues in that area.

Conclusion

Study shows that water is abundant for crop production in both Munippara and Poolani minor irrigation schemes as indicated by high relative water supply values. Relative irrigation supply values show that more equitable distribution of water is in Poolani minor irrigation scheme compared to Munippara. Along with irrigation, well recharge is also taking place and sustains the drinking water availability in the command areas of both schemes. High RWS values observed in the

Table 5. Involvement of beneficiaries association in irrigation water management activities

Sl. No.	Activity	Farmer's Participation (%)					
		Munippara Minor Irrigation Scheme			Poolani Minor Irrigation Scheme		
		A	S	N	A	S	N
1	Contributing money for the maintenance of pump/canal/structure	80	15	5	90	8	2
2	Contributing labour for the maintenanceof canal	80	15	5	90	8	2
3	Distributing water among beneficiaries	90	5	5	95	3	2

*A: Always, S: Sometimes, N: Never

minor irrigation schemes give scope for further improvement of performance by regulating water supply or by increasing the cropped area. Suitable water management measures such as water harvesting to increase recharge of well and irrigation scheduling based on area and crop water requirements are to be implemented through beneficiary participation approaches. This would empower beneficiaries to shift from the practice of over irrigation to better water management and to associate more with water management activities among themselves.

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