Sustain. Water Resour. Manag. (2016) 2:431–437
DOI 10.1007/s40899-016-0074-3

ORIGINAL ARTICLE

Evaluation of minor irrigation schemes using performance indicators: case studies from South India

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Received: 19 August 2015 / Accepted: 9 September 2016 / Published online: 20 September 2016

Abstract Food security challenge in India can be addressed to a considerable extent by improving the performance of irrigation systems. Two minor irrigation schemes in the Kozhikode district of Kerala in South India, namely, Kanniparamba and Vellannur, were assessed for their performance in terms of technical and social components. Water availability constraint in crop growth does not exist, as denoted by the high Relative Water Supply values. Irrigation delivery service in Vellannur is better, compared to Kanniparamba, when their relative irrigation supply values are taken into account. The canal system in Vellannur scheme also shows better maintenance, and hence, conveys water more effectively to the farms. Opportunity for saving water exists in the schemes through careful operation of the system and planning the water delivery by considering effective rainfall and crop water requirements. The relevance of initiating farmer participatory activities for management/distribution of the required quantity of water for crops to enable farmers to change from the practice of excess water use and for better water management is evident. This can be achieved by introducing suitable measures to institutionalize farmers' participation under the minor irrigation schemes, which do not presently exist under the minor irrigation sector in Kerala State of India.

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Keywords Minor irrigation · Water productivity · Relative water supply · Relative irrigation supply · Farmers' participation

Introduction

It is estimated that by 2050, 30 % of the geographical area and 16 % of the population in India will face absolute water scarcity, with water availability reduced to less than 500 m^3/year per capita (INCID 2002). Currently, irrigation accounts for the major share in water use in the country, utilizing about 80 % of the total usable water resource. This will continue to predominate for a long time. For meeting the country's requirement for food grains, National Commission for Integrated Water Resources Development Plan (Government of India 1999) has estimated the irrigation water demand for 2050 to be about 628 MCM for low demand and 807 MCM for high demand conditions. Despite the fact that productivity in irrigated areas has increased, when compared to rain fed areas, it is still below world standards, and that of developing countries like China. This is mainly due to sub-optimal water management, including low irrigation efficiency. Studies carried out by Ministry of Water Resources, Government of India in 30 completed projects have determined the average overall water use efficiency to be 38 %. The variation is also large, ranging from 14 % to 62 %. National Water Mission has targeted an increase in irrigation water use efficiency by 20 % for irrigation projects in India and a reduction in the gap between irrigation potential created and utilized to 15 % (Planning Commission 2011). Hence, water management for agriculture has to undergo a paradigm shift toward efficient use in terms of the required quantity of water at the right time and with

greater equity. This indicates the requirement to evaluate irrigation projects to identify the draw backs, and accordingly, apply corrective measures to improve their performance.

Minor irrigation plays a major role in the creation of overall irrigation potential in India. Of the ultimate irrigation potential of 139.95 million ha, the minor irrigation potential is 81.43 million ha, i.e., 58.19 %. Hence, to bridge the gap between irrigation potential created and utilized, emphasis needs to be given to minor irrigation (Planning Commission 2011). Cost and time overruns of major irrigation projects have also led to a shift in interest from major to medium and minor irrigation projects. For Kerala State located in south of India, since the average farm size is relatively small, minor irrigation is given considerable thrust. In 2012–2013, 21.4 % of the total budgeted outlay of irrigation sector has been allocated to minor irrigation. The expenditure for minor irrigation during the year was INR. 750.6 million, as against the expenditure of INR. 527.5 million for major and medium irrigation (Economic Review 2013). Surface lift irrigation is the prominent type, constituting around 64 % of the surface minor irrigation schemes in the State (4th Minor Irrigation Census, Government of Kerala). Considering the substantial role played by minor irrigation in the irrigation economy of the State, it is important to maintain sufficient levels of performance by these schemes for achieving maximum output from them, both in economic and productivity terms. An essential pre-requirement for performance management is performance assessment, which gives an idea of where the system stands with respect to its stated objective of service delivery and efficient use of its limited resources. In this context, a study was undertaken to evaluate the performance of two minor irrigation schemes located in Kozhikode district of Kerala State.

Performance of an irrigation system can be assessed using various tools, but the most commonly used is employing external performance indicators developed by the International Water Management Institute (Molden et al. 1998). These indicators are developed on the premise that land, water, finances, and crop production are the key attributes describing the performance of an irrigation system. These external indicators relate outputs to inputs of agriculture, without being referenced to a standard or target values. Such external performance indicators help in comparing irrigation schemes across national, regional, and international scales (Kloezen and Garcés-Restrepo 1998; Sakthivadivel et al. 1999; Jebellie 2000; Jayatillake 2004; Cornish 2005). The present study employs the external indicators developed by IWMI as well as the perception of farmers, to assess the performance of the selected MI schemes.

Methodology

Performance evaluation was carried out in two minor irrigation schemes in Kozhikode district in Kerala State of India, namely, Kanniparamba and Vellannur using performance indicators. These indicators include relative water supply (RWS), relative irrigation supply (RIS), standardized gross value of production (SGVP), SGVP per cropped area, and SGVP per unit irrigation supply (Molden et al. 1998). Relative water supply (RWS) is calculated as the ratio of total water supply to the crop water requirement (Levine 1999). Effective rainfall is used for calculations. Relative irrigation supply (RIS) is calculated as the ratio of total irrigation supply to irrigation demand. This indicator has a focus on irrigation alone and does not include the contribution of rainfall. For those indicators involving value of production, SGVP, with banana as the base crop, was calculated as follows:

$$\mathrm{SGVP} = \left(\sum (A_i Y_i)\left(\frac{P_i}{P_\mathrm{b}}\right)\right) P_\mathrm{bm},$$

where A_i area under crop i, Y_i yield of crop i, P_i price of crop i, P_b price of base crop (banana), P_bm market price of base crop in the state.

These indicators were also compared with social indicators such as farmers' perceptions on adequacy and timeliness of water availability, water loss from canals and extent of participation through farmers' associations.

Data on these indicators were collected using a structured interview schedule from a sample of 20 % of the farmers, who are getting irrigation water through the respective minor irrigation scheme. Discussion was also carried out with key informants (office bearers of farmers' association). Discharge measurements were done in head, mid, and tail sections of the canal. Crop water requirements were calculated using CROPWAT 8.0. Analysis of data has been carried out as percentages and through t test.

Study area

Kanniparamba Minor Irrigation Scheme located in Mavoor Panchayath in Kozhikode district of Kerala is under the Minor Irrigation Division of Water Resources Department, Kerala. The scheme became operational in the year 1981, with a command area of about 54 ha. Major crops in the command area are banana, paddy, and vegetables. The scheme has 2700 m length of canal network and two 25 Hp motors and pump operating alternately, with a suction head of 4.50 m, lifting water from the Cherupuzha river, one of the tributaries of the Chaliyar river. Banana is the major crop grown in the area and the cultivation is mostly irrigated. Of the total cultivated area, 90 % is irrigated using

water from the minor irrigation scheme. Around 89 % of the cultivated land is occupied by banana plantation.

Vellannur Minor Irrigation scheme is located in Chathamangalam Panchayath of Kozhikode district. The scheme became operational in 1976. The potential irrigated area under the system is around 120 ha, with major crops banana, areca nut, and vegetables. The total length of the canal system is 2410 m. The scheme runs on two 30 Hp motors and pump with a suction head of 5.51 m and delivery head of 1 m and a pipe of diameter 200 mm. Agriculture in the area is mainly dependent on this minor irrigation source; only 9 % of the farmers depend on other sources for irrigation. Before the start of the scheme, much of the land was left fallow. Now, about 85 % of the cultivated land is occupied by banana and the cultivation is mostly irrigated. Intercropping is also done with vegetables, pulses, paddy, coconut, tapioca, and areca nut in the command area.

Results and discussion

Water availability

Adequacy of water for crop growth was examined by computing the relative water supply. Effective rainfall is used for calculations. Water requirement calculated for the crops grown in head, mid, and tail reaches of the canals in the two schemes under study are given in Table 1. RWS of both the schemes are more than one, indicating abundance in water supplied. When the value of RWS is greater than or equal to 2.5, as in the case of middle and tail reaches in Vellannur, irrigation performance will not be affected by water stress (Levine 1999). Values much closer to one in mid and tail reaches of Kanniparamba are not indicative of water abundance, but suggest that water supplied is sufficient in meeting the crop water demand. Since calculations were done based on water supplied at the field level, losses due to non-uniformity also should be accounted for. Hence, values of RWS in the range of 1.3–1.5 are still acceptable (Abernethy 1990). Even crop development and higher yields are possible by improving the uniformity (Pereira 2005). Inappropriate water management in Vellannur scheme by supplying more than what is needed by the crops lead to water logging in its command area.

Relative irrigation supply also provides a measure of whether irrigation supply matches demand. This gives an idea of whether the scheme is able to provide the portion of water requirement which is not met by rainfall. In Kanniparamba, water supply is less than the crop irrigation demand, especially in middle and tail reaches (Table 1). Only 21 % of the irrigation demand is being met by water supplied through canals in middle region. Such lower values of RIS can lead to water stress condition for the crops grown. However, since the RWS values are on the higher side, it can be inferred that the water distribution through the canals is not done taking into account the contribution by rainfall. On the other hand, there is a condition of over irrigation in Vellannur scheme in all the three canal reaches. Low RIS values in the mid and tail reaches of canals in Kanniparamba, when compared with that in the head reaches, highlight inequitable water distribution (vanLoon et al. 2005).

Farmers' responses with respect to the availability of irrigation water contradict this (Table 2). 98 % of farmers report always and sometimes adequate water availability in Kanniparamba, while 78 % of farmers report this in Vellannur. Only 2 % of Kanniparamba farmers face never adequate water availability problem, while the figure is 22 % farmers in Vellannur. This contradiction may be due to the fact that the temporal variation in water availability within a particular season was not captured by the performance indicator RWS. *t* test of these data between the two minor irrigation schemes is significant (Table 2). Upon enquiry with key informants at Vellannur minor irrigation scheme, they attribute the deficiency in water availability to occasional problems in pumping of water under the scheme.

The study reveals that only 17 % of the physical system in Vellannur shows lack of maintenance, when compared to 93 % in Kanniaparamaba minor irrigation scheme. Proper maintenance of canals in Vellannur ensures that conveyance losses are reduced. This is also supported by the fact that while 71 % farmers in Kanniparamba report

Table 1 Crop water requirement, relative water supply, and relative irrigation supply

Details	Minor irrigation scheme	Canal reaches		
		Head	Middle	Tail
Crop water requirement (m^3)	Kanniparamba	19,994	19,803	12,195
	Vellannur	20,611	7051	6509
Relative water supply (RWS)	Kanniparamba	1.66	1.16	1.15
	Vellannur	1.93	2.34	2.32
Relative irrigation supply (RIS)	Kanniparamba	0.85	0.21	0.34
	Vellannur	2.37	3.36	3.30

Table 2 Test of significance for never adequate water availability reported by farmers

Details	Never adequate water availability in minor irrigation schemes	
	Kanniparamba	Velllanur
Farmers (%) reporting	02	22
t statistic	−6.429 (significant at 0.01 probability)	

Table 3 Adequate water availability reported by farmers

Details	Kanniparamba	Vellannur
Farmers (%) reporting	Always adequate water availability under MI schemes	
	79	45
	Sometimes adequate water availability under MI schemes	
	19	33
	Never adequate water availability under MI schemes	
	02	22

high to medium water loss from canals, only 27 % farmers report this in Vellannur minor irrigation scheme. Since more water than the crop water requirement is supplied through the canals in Vellannur, the lack of maintenance is not reflected in water availability (Table 3), as reported by the farmers.

This indicates the requirement to implement suitable strategies under minor irrigation schemes to reduce the number of farmers who face deficiency in water availability. Adoption of volumetric irrigation scheduling on a scientific basis, considering factors such as the extent of area under various crops, crop water requirement, conveyance losses in the water distribution network, etc., along with decentralization of operation and management of irrigation projects through Participatory Irrigation Management program would go a long way in achieving this objective. This is especially relevant, since such a practice is not being adopted under many irrigation projects in India. The water adequacy objective of individual farmers should not collide with the relative water supply objective at the field level.

It may be inferred from the data presented in Table 4 that the proportion of farmers reporting both adequacy and timeliness of water availability is 41 and 44 % for Kanniparamba and Vellannur schemes, respectively, which is less than farmers reporting water adequacy (Table 3) under these schemes. This is not a healthy trend for irrigation schemes, which are expected to deliver the required quantity of water in a timely manner to farmers.

Water productivity

Farmers are interested in increasing crop yield, and thereby, their economic returns out of agricultural production. If this is achieved with less use of resources, (in this case, water) water productivity gains can be achieved. Productivity of crops grown in both the schemes under study is given in Table 5. In Kanniparamba, head reach farmers obtain maximum value out of crop production, whereas, in Vellannur, farmers in the middle reach get the maximum value. High SGVP values correspond to high RWS values in both the schemes. High RWS indicates that there is increased reliability of water. This is translated into timely farming operations and use of other inputs like labor and fertilizers, influencing the yield. Non-availability of water during critical stages of crop growth will reduce the yield considerably. There exists a strong positive correlation between SGVP and irrigation supply in both Kanniparamba and Vellannur (Fig. 1) as indicated by the *r* values of 0.907 and 0.767, respectively.

Land productivity is found to be very less in the middle and tail reaches of Kanniparamba minor irrigation scheme. Each hectare of cropped area in head and mid reaches of Vellannur yields INR 0.14 Lakhs. Output per irrigation water supplied is found to be higher in the tail reaches of Kanniparamba. Comparatively, lesser area is cultivated in the tail region, and hence, more uniformity could be achieved. The responses of farmers also indicate the same. More farmers in tail reaches have reacted affirmatively to equitable supply of irrigation water, compared to those from the head reaches. Water productivity variations are different from the land productivity variations, showing that crop yield is not the major driving factor for changes in water productivity of the schemes (Karimi et al. 2011). Since irrigation water supply is not a constraint in Vellannur scheme, as indicated by the high RIS values, SGVP per unit cropped area is much more significant than SGVP per unit irrigation supply, similar to what has been reported by Molden et al. (1998). High RIS values in Vellannur also suggest that opportunities exist for increasing the SGVP per irrigation supply by reducing the quantity of water supplied. SGVP per unit water consumed also does not

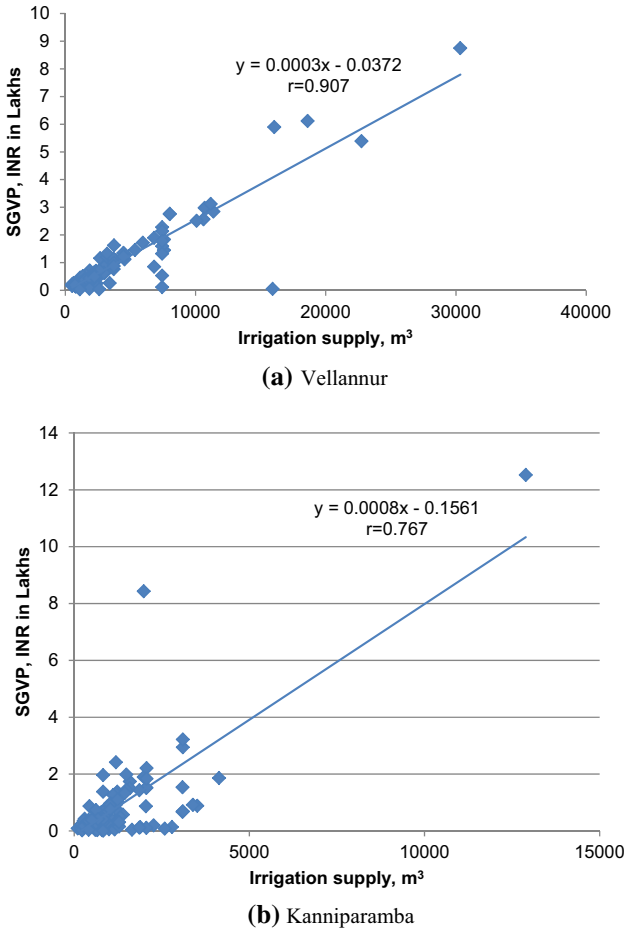
Table 4 Adequate and timely water availability reported by farmers

Details	Kanniparamba	Vellannur
Farmers (%) reporting	Always adequate and timely water availability under minor irrigation schemes	
	41	44

Table 5 Indicators for assessing value of production

Canal reaches	SGVP (INR in Lakhs)		SGVP per cropped area (INR in Lakhs/ha)		SGVP per irrigation supply (INR/m^3)		SGVP per water consumed (INR/m^3)	
	Kanniparamba	Vellannur	Kanniparamba	Vellannur	Kanniparamba	Vellannur	Kanniparamba	Vellannur
Head	1.2	0.94	0.13	0.14	9.32	4.62	4.62	5.93
Mid	0.57	1.22	0.07	0.14	19.12	12.38	2.21	22.49
Tail	0.77	0.95	0.08	0.10	26.55	10.64	4.86	18.97

INR Indian Rupees (1 INR = 0.0156 US$)



(a) Vellannur

(b) Kanniparamba

Fig. 1 Relation between SGVP and irrigation supply. **a** Vellannur; **b** Kanniparamba

follow land productivity. Highest value of land productivity is observed in the middle reaches of Vellannur scheme. Range is also on the higher side (20.28), when compared with SGVP per irrigation supply.

Farmers' participation under the minor irrigation schemes

Ways in which farmers participate in operation and maintenance of the system as well as their levels of participation serve as indicators for system performance. Table 6 reveals that the percentage of farmers who contribute money and labor for the maintenance of irrigation canals is comparatively high in Vellannur, while about 65 and 76 % farmers under Kanniparamba scheme never contribute money and labor, respectively, for maintenance of irrigation canals/structures. This may be probably because significantly more proportion of farmers (22 %) in Vellannur is experiencing never adequate water availability, when compared to only 2 % farmers in Kanniparamaba (Table 3). Hence, when compared to Kanniparamaba, more farmers under Vellannur minor irrigation scheme are interested in maintaining canals and structures, with the expectation of improvement in water availability. In Kanniparamba, even with lesser water availability in middle and tail reaches than the head reaches, farmers are getting higher monetary output per unit water supplied (Table 5). The lack of interest of Kanniparamba farmers in maintenance of canals has left the canal system in a poor condition, as evident from the visible cracks and unwanted vegetation in the canals observed during transect walk. About 76 % farmers in Vellannur do not involve in water distribution among themselves, when compared to only about 41 % in Kanniparamba. This may be one of the reasons for more farmers in Vellannur minor irrigation scheme reporting never adequate water availability. Participation by farmers in canal maintenance also increases the output, as reflected in the high land productivity observed in Vellannur scheme.

For effective water delivery and improved returns from farming, regular communication and interaction among

Table 6 Participatory activities on irrigation management undertaken through farmers' associations

Participatory activity	Farmers (%) participating					
	Kanniparamba			Vellannur		
	A	S	N	A	S	N
Contributing money for maintenance of irrigation canals/structures	1.7	32.8	65.5	11.3	64.8	23.9
Contributing labor for maintenance of irrigation canals/structures	1.7	22.4	75.9	8.5	54.9	36.6
Distributing water among farmers	3.4	55.2	41.4	2.8	21.1	76.1

A always, *S* sometimes, *N* never

farmers is necessary. Farmers in the range of 83–100 % under the minor irrigation schemes evaluated are found to discuss with other farmers on problems in cultivation and ways to improve cultivation/income. This is a positive sign of trust/social capital existing in the command area of the projects. However, this has not contributed to community-based group farming through farmers' associations in any of the minor irrigation schemes. Group farming involves adoption of a common approach among farmers in land preparation, crop variety, planting time, pest and disease control, irrigation, harvest, marketing, etc. This would lead to less pest/disease attack and cultivation costs, higher crop yields and better price for the produce, when compared to individual level farming. Group farming was tried among farmers by the Department of Agriculture in Kerala during 1980's for paddy cultivation. But, it was not successful. Factors such as small and fragmented landholdings of farmers, in ability to adopt mechanization due to opposition from the labor class having strong political support in Kerala, absence of suitable marketing mechanism, and resistance from the farmers to sacrifice their individual freedom under a group approach made it difficult to convince farmers about the benefits of a group approach. Implementation of group farming would have also helped in better water management through construction of farm channels and drainage channels with the support and involvement of majority of the farmers. This would have ultimately contributed to water saving, since the tendency of farmers to over irrigate the crops would be less, when operating at a group level. This is especially relevant for an irrigation system like Vellannur, wherein, the RIS values are very high.

The study has shown that all the farmers under Kanniparamba and Vellannur minor irrigation schemes undertake marketing of their produce (mainly banana and vegetables) through farmers' associations. This is due to the existence of a Government run institution, namely, Vegetable and Fruit Promotion Council Keralam (VFPCK) in the area coming under these two irrigation schemes. VFPCK has been found to be beneficial for farmers in different parts of Kerala for getting higher price for their produce by marketing through their farmers' associations, without the interference of middle men. Ensuring proper marketing/price for their produce can also motivate farmers to have more involvement in various farming-related activities. This is especially relevant for a State like Kerala, where agriculture, in general, is not profitable due to high cost of cultivation and low market price for crops.

Conclusion

The schemes studied are inflexible in managing irrigation supplies based on the contribution from rainfall. Excess availability of water acts as a deterrent to water savings by farmers. High RWS values reported in both the minor irrigation schemes suggest the opportunities for improving performance by regulating water supply or by increasing the cropped area. The need for maintenance of the canal system in Kanniparamba minor irrigation system is increasingly visible. If this has to be done with farmers' participation, the farmers have to be incentivized by providing reliable, timely, and equitable water supply. If a diagnostic analysis follows the performance assessment exercise, it can provide better inputs to system managers to efficiently allocate resources. Participatory activities related to management/distribution of the required quantity of water for various crops have to be initiated under the irrigation schemes studied. This would enable farmers to shift from the practice of excess water use to conservative water management and to involve more in water management among themselves. To achieve this objective, it is necessary to introduce suitable measures to institutionalize farmers' participation under the minor irrigation schemes, which does not presently exist under the minor irrigation sector in Kerala State of India.

Acknowledgments The authors are thankful to the Executive Director, Centre for Water Resources Development and Management (CWRDM), for his encouragement and support during the course of this study. The financial support from the Kerala State Council for Science, Technology and Environment (KSCSTE) for the three-year project 'Performance Evaluation of Selected Minor Irrigation Projects in Kerala', based on which, this paper is prepared is also thankfully acknowledged.

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