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Canal Irrigation Management through Water Users Associations and its Impact on Efficiency, Equity and Reliability in Water Use in Tamil Nadu

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Abstract

The study has examined the impact of Water Users Associations (WUAs) on efficiency, equity and reliability in canal irrigation. The economic and data envelopment analyses have been carried out to measure the profitability and technical efficiency among the participating and non-participating farms. Reliability scores are developed to assess the reliability of canal water and Garrett ranking technique has been used to find constraints to participation in WUAs. The overall participation in WUAs has been found satisfactory and the participation increases as farm-size increases. However, the inputs and technical know-how supply has been found weak. The number of canal irrigation application and yield realization are higher on participating than non-participating farms. The participating farms are technically more efficient in crop production than the non-participating farms. The reliability scores for irrigation management parameters are more for participating than non-participating farmers. The lack of unity, cooperation and interest among water users has been found to be the most limiting factor, followed by the inequity in water allocation for the active participation in the WUAs. To realize the full benefits of scarce canal water resource, efforts should be directed towards enhancing participation of all sections of the farming community in WUAs. The WUAs should be multifunctional to facilitate the timely supply of good quality agricultural inputs along with irrigation water management.

Key words: Water users associations, irrigation management, paddy, Tamil Nadu

JEL Classification: O13, Q12, Q25

Introduction

Participatory Irrigation Management (PIM) that involves farmers in the planning, operation and maintenance of the irrigation system, is considered an effective way of enhancing efficiency and equity of irrigation water. Setting up of organizations is accorded a significant attention in the PIM programmes (Chopra *et al.*, 1990). But, the institutional aspects of farmers' participation in irrigation have received little attention in the current PIM policies. Several states in India are looking towards involvement of farmers in the operation and maintenance at higher levels through a variety of PIM and Irrigation Management Transfer programmes (Gulati *et al.*, 2005). The National Water Policy also emphasizes on the participation of farmers in management of irrigation system, principally in water distribution and collection of water rates (GoI,

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2002). The Vaidyanathan Committee on Pricing of Irrigation Water has also suggested farmers' participation in the management of irrigation systems (GoI, 1992). Under the Restructured Command Area Development and Water Management Programme more emphasis is being given to the participatory approach in India. Under these programmes, the payment of central assistance to states is linked with the formation of Water Users Associations (WUAs). Apart from this, the farmers have to contribute a minimum of 10 per cent of the costs of works in the form of cash/ labour in construction of field channels, reclamation of waterlogged areas and desilting. For the projects included under the restructured programme, management subsidy has been enhanced to ₹ 1000/ha to be shared as ₹ 450, ₹ 450 and ₹ 100 by the centre, state and farmers, respectively.

On the efficiency of WUAs, some researchers have expressed concerns (*see* for example, Chambers, 1988; Sengupta, 1991), while others have opined that these organizations have been successful in distributing the benefits more equitably and in enhancing efficiencies in agricultural production (*see*, Arun, 2011; Asghar and Chizari, 2008; Vermillion and Samad, 1999). Tamil Nadu has harnessed its surface water resources to the fullest extent. There are several WUAs operating in the state; however, their impact on reliability, efficiency and equity in water use is less known. The performance of WUAs on agricultural inputs, services and technologies delivery functions has also not been assessed. Therefore, the present study was undertaken to (i) examine the participation of farmers in WUAs in the canal irrigated areas in Tamil Nadu, (ii) assess the impact of WUAs on efficiency, equity and reliability in canal irrigation, and (iii) identify the factors affecting farmers' participation in WUAs.

Data and Methodology

The study has used primary data collected through multistage sampling technique. Thanjavur district at the first stage, two blocks at the second stage and two villages with farmers participating in WUAs and two villages with farmers not participating in WUAs were selected purposively at the third stage of the sampling. Finally, primary data were collected from randomly selected 60 participating and 60 non-participating farmers from the selected villages for the agricultural year 2009-10. To assess the impact of WUAs, the information on the number of irrigations applied, costs incurred and returns realized in the cultivation of crops was collected from the participating and non-participating farmers. The farmers' perceptions were also recorded on the participation in the activities of WUAs, reliability about canal water access and constraints to the participation in WUAs. The selected farm households were classified as marginal (up to 1ha), small (1-2 ha) and medium (above 2 ha). Participation Index (PI) was developed by using standard weights assigned to 20 activities related to irrigation. For assigning standard weights, fifteen subject matter specialists were asked to provide weights to each activity. The scores were obtained based on the number of activities they participated and the farmers were categorized into two groups, viz. active participation and inactive participation. The farmers having more than 0.5 PI were considered as active participants, otherwise inactive participants. The factors which affect the participation of farmers in WUAs were tested by fitting a logistic regression as active participation as a binary dependent variable. The size of operational holding (ha), age of family-head (years), education of family-head (illiterate=0, primary=1, secondary=2 and higher=3), number of adult family workers, ownership of tubewell as binary category (if yes=1, otherwise 0) and distance between the farm and canal (km) were hypothesized to influence the active participation of farmers in WUAs.

The reliability of canal irrigation was assessed by reliability scores of participating and non-participating farmers. Reliability scores were calculated by taking the average of farmers' opinion (1 for poor, 2 for satisfactory and 3 for good) on important aspects of irrigation management. Accessibility of canal water to all fragments of the farm, adequate availability of water during *kharif* and *rabi* seasons and at critical stages of crop growth, namely transplanting (stage-I), tillering (stage-II) and flowering (stage-III) and control on canal water in *kharif* and *rabi* seasons were considered to assess the reliability of canal irrigation. Tabular analysis was carried out to measure the equity in the irrigation application and yield realization on participating and non-participating farms. Paddy cultivation in *rabi* season, an important crop in the study area, was considered for analysis. Independent t-test was used to test the significance between the mean values of participating and non-participating farms. In order to

assess the profitability of rice (*rabi*) crop irrigated through canal irrigation system, the returns over different costs were calculated using cost and return concepts. All the variable costs incurred and fixed costs computed were used to calculate Cost A_2, Cost B_2 and Cost C_3 in paddy cultivation and value of grain and straw were added to get gross income from paddy cultivation. Garrett's ranking was used to identify and rank the constraints to the participation in WUAs.

Data Envelopment Analysis (DEA) was used for the estimation of technical inefficiency of participating and non-participating farms in paddy cultivation in *rabi* season. Per farm use of human labour (in days), machine charges (in rupees), fertilizers (in kg), plant protection chemicals (in rupees) and irrigation (hours) were considered as inputs and gross income (in rupees) (value of grain and straw) was considered as output for estimation of farm level technical inefficiency. The actual wage, fertilizer price and irrigation charges paid by the farmers were used. The DEAP V2.1 computer programme was employed with the assumption of constant return to scale. To study the distribution of farms according to technical inefficiency, the inefficiency scores were divided into four ranges as 0-10 per cent, 10-20 per cent, 20-30 per cent and 30-40 per cent.

Structure of Water Users Associations in Tamil Nadu

In 2009, there were 876 WUAs registered under Tamil Nadu Societies Registration Act, 1975 by Agricultural Engineering Department in Non-Water Resources Consolidation Project command area, i.e., Cauvery Command, and 765 WUAs were formed through elections conducted by Water Resources Organization, Public Works Department under Tamil Nadu Farmer Management of Irrigation System Act, 2000 in the Water Resources Consolidation Project up to March 2010.

There is a three-tier structure of WUAs, namely, Farmers' Federation at Apex level, Farmers' Councils at the distributary level and Farmers' Association at sluice level. The main role of Farmers' Federation is to take policy decisions like date of release and closing of water, duration of supply, cropping pattern, etc. in consultation with the government departments, to arrange visits and training of the farmers in improved water management techniques, functioning of associations, etc. The area of operation of Farmers' Councils is from distributaries head to the sluices. It is the main responsibility of the Council to negotiate for the quantum of water from the irrigation department and to distribute the same up to sluice level in proportion to the respective command areas. The main functions of Farmers' Associations at the sluice level are to get proportionate discharge of water from the sluice head, to distribute water among member farmers equitably based on rotational supply schedule prepared by the irrigation department, to maintain the system below the sluice in coordination with farmers and to help in amicable settlement of conflicts amongst farmers within the sluice command.

The other functions of WUAs are (i) protecting the irrigation structures from damage, (ii) protection of crop from damage due to cattle and theft, (iii) maintaining the decorum among the members and increasing the income of individual farmers, (iv) monitoring channels to ensure adequate distribution of water to tail-end farmers, (v) protecting the farmers' rights and provisions and also helping members in acquiring new rights and facilities, and (vi) helping the farmers in availing the facilities provided by the government.

The important functions of WUAs related to agricultural input and service delivery are (i) helping the members to obtain fertilizers, farm implements, seeds and pesticides from the Department of Agriculture, (ii) introducing advanced technologies to farmers in order to increase crop production, (iii) arranging marketing facilities and establishing direct procurement centers within the limits of WUA, and (iv) helping the members to hire tractor, bulldozer and power tiller at low charges.

Results and Discussion

The study area is dominated by marginal and small farms with average size of operational holding as 1.2 ha (Table 1). A good proportion of male family members were engaged fully in agriculture, while most of the females were engaged partially. The participating and non-participating farmers had poor education and only 10 per cent and 13 per cent family-heads had higher education, respectively.

Table 1. Socio-economic status of selected farmers

Particulars	Participating farmers				Non-participating farmers			
	Marginal	Small	Medium	All	Marginal	Small	Medium	All
Sample farms (No.)	29	23	8	60	22	31	7	60
Sample farms (%)	48.33	38.33	13.33	100	36.67	51.67	11.67	100
Average size of holding (ha)	0.71	1.28	2.66	1.18	0.62	1.38	2.20	1.20
Average size of family (No.)	4.14	4.41	5.63	4.44	4.41	4.78	4.57	4.62
Male family workers (No.)	1.21	1.14	1.63	1.24	1.09	1.37	1.43	1.28
Female family workers (No.)	1.03	1.05	1.00	1.03	0.96	1.34	1.00	1.17
Age of family-head (years)	38.69	39.41	43.00	39.54	43.00	40.06	44.00	41.57
Education of family-head								
Illiterate (%)	7	0	0	3	5	0	0	2
Primary (%)	52	41	25	44	32	47	14	38
Secondary (%)	31	55	50	42	50	44	57	48
Higher (%)	10	5	25	10	14	9	29	13

Farmers' Participation in Water Users Associations

A 'Participation Index' was prepared by considering all the activities of the participating farmers in WUAs. A perusal of Table 2 showed that the overall value of participation index was 0.58 and the participation increased as farm-size increased. This inferred that medium farmers had active participation in WUAs. Marginal farmers' participation was more in the activities like attending meetings, contribution of labour/money for repairs and maintenance of field channels, payment of the water charges, etc. The participation of small farmers was more in purchasing of construction materials, contribution of labour/money towards construction of field channels and involvement in irrigation scheduling. Medium farmers were involved in supervision of construction works, as member of watch/ward team, payment of water charges, involvement in irrigation scheduling/ distribution, contribution of labour/money for repair of common field channel and involvement in arranging finance for WUAs. The participation weight of medium farmers in visits to other WUAs was 0.045 which was discerned impressive. The average participation of all the categories of farmers was similar in activities like attending meetings for repair and maintenance, payment of water charges and consultation with WUA officers. Surprisingly, all farmers irrespective of size-categories, lacked in access to technologies, inputs, and services like arranging marketing facilities and hiring machinery through WUAs. Therefore, it may be concluded that WUAs were managing canal water only.

The participation index values were classified into three categories (< 0.50, 0.50 – 0.75, > 0.75) to see the distribution of farmers. Most of the marginal farmers (59 %) fell under less than 0.5 index value, 52 per cent of the small farmers fell in 0.50-0.75 index value and 62.5 per cent of medium farmers were in the index category of greater than 0.75 (Table 3). Similarly, the average number of participating activities increased from marginal farmers (9.9) to medium category of farmers (14.4). Further, it was found that solely canal irrigated farm owners participated more actively in the WUAs in comparison to canal-cum-tubewell irrigated farm owners. Further, the members had accepted the cost-sharing norms followed in the WUAs management. This showed the power of social capital and social mobilization using string of group action for efficient irrigation water management.

Determinants of Farmers' Participation in WUAs

The results of logistic regression showed that the model provided 91 per cent and 79 per cent correct predictions for the active and inactive participation of farmers in WUAs, respectively (Table 4). Larger the value of observed significance of log-likelihood ratio, the better was the model fit to the data. The coefficients of factors education of family-head, and operational holdings were positive and statistically significant. This confirms that knowledge and size of holdings lead to

Table 2. Participation index of selected WUA-participating farmers

Variables	Participation index				
	Standardized weights	Marginal farmers	Small farmers	Medium farmers	All farmers
Participation in training organized by WUA	0.043	0.026	0.019	0.043	0.026
Visit to other WUA	0.045	0.026	0.030	0.045	0.029
Motivating other farmers to participate	0.054	0.048	0.036	0.054	0.045
Attending meetings on planning	0.057	0.041	0.044	0.045	0.042
Involvement in purchasing of construction materials	0.051	0.024	0.031	0.030	0.027
Contribution of labour towards construction of field channels	0.055	0.014	0.022	0.022	0.017
Contribution of cash towards construction of field channels	0.057	0.003	0.013	0.011	0.007
Contribution of materials towards construction of field channels	0.053	0.013	0.012	0.021	0.013
Supervision of construction works	0.063	0.040	0.049	0.063	0.045
Member of watch and ward team	0.059	0.018	0.013	0.059	0.020
Attending meetings for repairs and maintenance	0.055	0.054	0.052	0.055	0.053
Contribution of labour/ money for repair of farmers' field channel	0.053	0.047	0.050	0.053	0.048
Contribution of labour/ money for repair of common field channel	0.059	0.010	0.013	0.047	0.014
Consultation with WUA officers for repair and maintenance	0.049	0.047	0.041	0.049	0.045
Inspection of field channels	0.046	0.038	0.043	0.046	0.040
Involvement in irrigation scheduling/distribution	0.052	0.026	0.034	0.052	0.031
Involvement in arranging finance for WUA	0.052	0.020	0.023	0.041	0.023
Payment of water charges	0.058	0.056	0.058	0.058	0.057
Inputs (seed/ plant, fertilizer, etc.) delivery through WUA	0.041	0.001	0.000	0.008	0.001
Participation Index	1.000	0.552	0.582	0.803	0.583

Source: Computed by Author, 2009-10

Table 3. Distribution of participation index

Particulars	Marginal farmers	Small farmers	Medium farmers	All farmers
Distribution of participation index (%)				
Less than 0.50	58.6	30.4	0.0	40.0
0.50-0.75	24.1	52.2	37.5	36.7
Greater than 0.75	17.2	17.4	62.5	23.3
Source-wise participation index				
Solely canal irrigated farms	0.614	0.625	0.604	0.616
Canal+ tubewell irrigated farms	0.476	0.563	0.851	0.568
Average participation in activities (No.)	9.9	11.3	14.4	11.1

Source: Computed by authors, 2009-10

active participation of farmers in management of WUAs. The coefficient of distance from canal to farm was statistically significant but negative, which indicates with increase in distance decreases the probability of participation in WUAs. The age of family-head, ownership of tubewell and adult family workers depicted positive signs but were non-significant.

Table 4. Logistic regression coefficients of factors affecting active participation of farmers in WUAs

Particulars	Coefficients	Standard error	Wald statistics	Significance	Odds ratio
Constant	-17.645*	6.528	7.306	0.007	
Operational holding (ha)	3.381**	1.446	5.468	0.019	29.410
Education of family-head	3.487*	1.116	9.763	0.002	32.693
Distance from canal to farm (km)	-0.400**	0.199	4.043	0.044	0.670
Age of family-head (years)	0.145	0.102	2.006	0.157	1.156
Ownership of tubewell (yes=1 & No=0)	1.360	1.097	1.538	0.215	3.896
Adult family workers (No.)	0.328	0.693	0.225	0.636	1.389
-2 log likelihood	25.27				
Chi-square	44.56*				
Correct prediction (0) (%)	79.2				
Correct prediction (1) (%)	91.4				

Note: * and ** indicate significant at 1 per cent and 5 per cent levels, respectively.

Table 5. Season-wise and source-wise net irrigated area on WUA-participating and non-participating farms

(Per cent)

Particulars	Participating farms				Non-participating farms			
	Marginal	Small	Medium	All	Marginal	Small	Medium	All
***Rabi* season**								
Canal irrigated area	93.1	88.1	87.6	89.3	88.1	28.4	15.8	36.8
Tubewell irrigated area	6.9	11.9	12.4	10.7	11.9	71.6	84.2	63.2
Total irrigated area	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
***Kharif* season**								
Canal irrigated area	-	-	-	-	-	-	-	-
Tubewell irrigated area	11.9	12.9	31.4	18.3	11.9	71.6	84.2	63.2
Canal+ tubewell irrigated area	49.5	55.4	61.0	55.4	11.9	26.6	15.8	21.6
Total irrigated area	61.4	68.3	92.4	73.6	23.8	98.2	100	84.8
***Zaid* season**								
Canal irrigated area	-	-	-	-	-	-	-	-
Tubewell irrigated area	57.4	69.1	92.4	72.8	23.9	98.2	100	84.8
Total irrigated area	57.4	69.1	92.4	72.8	23.9	98.2	100	84.8

Irrigated Area on WUA-Participating and Non-participating Farms

The total area was fully irrigated in the *rabi* season on both WUA-participating and non-participating farms (Table 5). In the *kharif* and *zaid* seasons, nearly three-fourths and 85 per cent of operational holdings were irrigated on WUA-participating and non-participating farms, respectively. Of the total irrigated land, 89 per cent and 55 per cent were under solely canal irrigation and canal-cum-tubewell irrigation on WUA-participating farms in the *rabi* and *kharif* seasons, respectively. Contrary to this, only 37 per cent and 22 per cent of the total irrigated land was exclusively under canal irrigation and canal-cum-tube well irrigation on non-participating farms in the *rabi* and *kharif* seasons, respectively. Focused group discussions with farmers confirmed that some land was under solely canal irrigation before three years in the *kharif* season on both types of farms, but was not under practise this year (2009-10) due to late release of canal water. Further, canal water was not available during the *zaid* season. This shows an improvement in the canal irrigated area on WUA- participating farms.

Table 6. Reliability scores of canal irrigation for WUA-participating and non-participating farmers

Variable	Participating farmers				Non-participating farmers			
	Marginal	Small	Medium	All	Marginal	Small	Medium	All
Accessibility to all fragments	2.61	2.44	3.00	2.59	1.79	1.60	1.67	1.69
Adequate availability of water (*Kharif*)	1.97	1.89	2.00	1.95	1.36	1.23	1.00	1.28
Adequate availability of water (*Rabi*)	3.00	2.89	3.00	2.97	2.64	2.53	2.33	2.57
Control on canal water (*Kharif*)	2.00	2.00	1.80	1.98	1.18	1.07	1.00	1.11
Control on canal water (*Rabi*)	3.00	3.00	3.00	3.00	2.61	2.47	2.67	2.54
Adequate availability of water at critical stage-I	2.81	2.67	2.60	2.75	1.89	2.00	2.67	1.98
Adequate availability of water at critical stage-II	3.00	2.94	3.00	2.98	2.32	2.07	2.33	2.20
Adequate availability of water at critical stage-III	2.81	2.50	3.00	2.73	1.89	1.80	2.00	1.85

Table 7. Number of irrigations applied and yield realized for paddy (*rabi*) crop on WUA-participating and non-participating farms

Particulars	Participating farms				Non-participating farms			
	Marginal	Small	Medium	All	Marginal	Small	Medium	All
Canal irrigations (No.)	33.3	30.7	32.5	32.0*	33.4	19.5	18.0	25.5
Tubewell irrigations (No.)	6.4	7.2	7.0	6.9#	2.0	18.0	18.0	10.9
Grain yield (q/ha)	55.2	52.9	52.1	53.4*	47.1	51.0	47.4	49.0
Straw yield (q/ha)	47.1	45.9	45.4	46.1*	40.0	43.2	37.1	41.2

Note: * and # denote significantly higher and lower at 1 per cent level on participating farms in comparison to non-participating farms, respectively.

Reliability of Canal Irrigation

Reliability of irrigation influences the allocation of land and other resources to different crops and farm enterprises. Reliability scores were computed on different parameters of canal irrigation. All reliability parameters scored better for participating than non-participating farmers, as shown in Table 6. This confirms that availability of canal water and control has improved for WUA-participating farmers.

Irrigation Application and Yield Realization in Paddy Cultivation

The average numbers of canal irrigation applied in *rabi* paddy were more on WUA-participating (32) than non-participating (25.5) farms (Table 7). Contrary to this, the average numbers of applications of tube-well irrigation were 11 on non-participating farms and only 7 on non-participating farms. This infers that the applications of canal irrigations were more and tubewell irrigations were less on WUA-participating farms than non-participating farms, except the marginal farms. On marginal farms, the number of canal irrigations applied was almost same on both types of farms. Regarding paddy yield, it was observed that WUA-participating farms realized a higher yield (53.4 q/ha) than non-participating farms (49.0 q/ha). The similar trend was also observed on all categories of farms. The average values of number of canal irrigations applied and yield realized was found to be statistically significantly higher on participating farms than that of non-participating farms. Converse to it, the average numbers of tubewell irrigations applied were significantly higher on non-participating farms than participating farms.

The average number of irrigations applied and yield realized in *rabi* paddy cultivation on exclusively canal-irrigated farms is given in Table 8. A comparison revealed that the participating farmers applied more irrigations in *rabi* paddy as compared to non-participating farmers and also realized more grain yield compared to their non-participating counterparts. It inferred that farmers were benefitted due to

Table 8. Number of irrigations applied and yield realized for paddy (*rabi*) on exclusively canal irrigated WUA-participating and non-participating farms

Particulars	Participating farms				Non-participating farms			
	Marginal	Small	Medium	Total	Marginal	Small	Medium	Total
Canal irrigations (No.)	41.7	38.9	40.6	40.4*	35.9	35.0	-	35.8
Grain yield(q/ha)	56.62	51.41	48.54	52.26*	47.00	45.94	-	46.92
Straw yield (qtl/ha)	47.28	45.05	44.25	45.55*	39.67	39.52	-	39.65

Note: * denotes significantly higher at 1 per cent level on participating farms in comparison to non-participating farms.

Table 9. Returns from paddy (*rabi*) cultivation on participating and non-participating farms

(₹/ha)

Particulars	Participating farms				Non-participating farms			
	Marginal	Small	Medium	All	Marginal	Small	Medium	All
Gross income	65541	62835	62245	63533	55607	61410	60175	59960
Farm business income	29839	26033	26708	27390	19573	23641	24711	22925
Family labour income	18910	16641	10182	15740	7912	9258	6045	8467
Net income	8437	6753	-991	5349	-3541	-2121	-5685	-2982

Note: Farm business income = Gross income – Cost A_1; Family labour income= Gross income – Cost B_2 and Net income= Gross income –Cost C_3.

participation in WUAs in terms of better access to canal irrigation and higher yields.

Profitability in Paddy (*Rabi*) Cultivation

The gross income was computed to be higher on participating farms (₹ 6554/ ha) on account of higher yields than on non-participating farms (Table 9). The net income was found to be moderate on participating farms and negative on non-participating farms. This might be on account of higher cost of cultivation due to higher costs of tube-well irrigation and lower gross income due to lower yields on non-participating farms. As expected, the returns were found to be more on marginal farms, followed by small and medium categories of participating farms due to better management and intensive use of land.

The profitability of paddy *(rabi)* cultivation was also examined under exclusively canal and canal-cum-tubewell irrigation farms and is presented in Table 10. It was observed that exclusively canal irrigated participating farms incurred lesser cost on cultivation of paddy (r*abi*) crop in comparison to canal-cum-tubewell irrigated farms, which was due to the nominal charge for irrigation and less fixed investment on farms. The gross income realization was less on exclusively canal irrigated than canal-cum-tubewell irrigated participating farms. It was because of higher reliability of irrigation under canal-cum-tubewell irrigation. However, farm business income, family labour income and net income were found to be higher on exclusively canal irrigated than canal-cum-tubewell irrigated participating farms.

The comparison between participating and non-participating farms under exclusively canal irrigation regime showed that gross income, farm business income and family labour income were impressively higher on WUA-participating than non-participating farms. The net income was moderate on exclusively canal irrigated participating farms, and negative on non-participating farms. This clearly indicated that the participation in WUAs had a positive impact on the profitability of crop production, may be due to better reliability of canal irrigation after intervention of the WUAs.

Table 10. Returns from paddy (*rabi*) cultivation on exclusively canal and canal-cum-tubewell irrigated participating and non-participating farms

(₹/ha)

Particulars	Participating farms		Non-participating farms		
	Exclusively canal	Canal+ tubewell	Exclusively canal	Canal+ tubewell	Exclusively tubewell
Gross income	62377	64611	55540	59664	61541
Farm business income	27737	27067	20749	21230	24398
Family labour income	17573	14031	7953	8502	8620
Net income	7360	3472	-3398	-2837	-2911

Note: Farm business income = Gross income – Cost A_1, Family labour income= Gross income – Cost B_2 and Net income= gross income –Cost C_3.

Table 11. Average technical inefficiencies and distribution of farms according to technical inefficiencies in paddy (*rabi*) cultivation

(Per cent)

Particulars	Participating farms				Non-participating farms			
	Marginal	Small	Medium	All	Marginal	Small	Medium	All
Average technical inefficiency (%)	12.80 (7.56)	14.73 (7.79)	18.40 (10.88)	14.28 (8.21)	23.46 (9.81)	19.02 (8.89)	19.53 (11.40)	20.68 (9.59)
Inefficiency range								
0-10%	41.38	26.09	25.00	33.33	9.09	22.58	42.86	20.00
10-20%	41.38	43.48	12.50	38.33	27.27	29.03	-	25.00
20-30%	13.79	30.43	62.50	26.67	40.91	45.16	28.57	41.67
30-40%	3.45	-	-	1.67	22.73	3.23	28.57	13.33

Note: Figures within the parentheses are standard deviations.

Farm Specific Technical Inefficiency

The efficiency criterion is important to equity and reliability aspects of canal irrigation management through WUAs. The average technical inefficiencies on participating and non-participating farms were 14 per cent and 21 per cent, respectively (Table 11). The participating farms were 6 per cent more efficient than their non-participating counterparts. Similarly, participating farms of marginal category were 10 per cent more efficient technically than that of non-participating farms in rice cultivation in *rabi* season. The frequency distribution of farms according to technical inefficiencies revealed that the proportion of participating farms in the lowest technical inefficiency range (0-10%) was more (33%) than of non-participating farms (20%). Further, a good proportion of marginal and small participating farms lied in the low inefficiency range but most of the non-participating farms lied in the high inefficiency ranges (more than 10%). This confirmed that the intervention of WUAs had improved the technical efficiency of farms.

Constraints to Active Participation in WUAs

A critical perusal of Table 12 shows that the lack of unity, cooperation and interest among water users topped the limiting factors, followed by inadequate availability of water / inequity in water allocation for active participation in the WUAs. The medium farmers perceived the lack of communication as the second most important factor. This might be due to their prominent engagement in farm operations and managerial activities. All the farmers perceived that

Table 12. Constraints to the effective participation in WUAs

Constraint	Marginal farmers		Small farmers		Medium farmers		All farmers	
	Garrett Score	Rank	Garrett Score	Rank	Garrett Score	Rank	Garrett Score	Rank
Lack of unity, cooperation and interest among users	70.12	1	73.47	1	71.01	1	71.8	1
Inadequate water/inequity in water allocation	44.51	2	51.14	2	51.27	3	48.63	2
Water availability is not as per crop requirement	44.01	3	47.58	4	50.07	4	48.19	3
Lack of communication among water users	41.44	4	48.17	3	55.58	2	47.05	4
Lack of money for repair of field channels	32.45	5	29.14	6	29.17	5	30	5
Users backed out or failed to finance WUAs	30.02	6	8.09	7	24.49	6	28.1	6
Rigid procedure in adopting to changing situations	10.18	7	30.47	5	8.87	7	9.86	7
Incapable/untrained operator/manager of WUA	8.45	8	7.45	8	7.11	8	7.78	8
Unfair procedure for electing officials	4.78	9	3.58	9	2.33	9	3.19	9
High water charges/ low economic gains	0.58	10	0.24	10	-	-	0.37	10

the designed WUAs were not able to provide the irrigation water at the desired time and quantum. Because of these factors, the stakeholders were found reluctant to participate in the WUAs at the expected level. Therefore, some provisions need to made to ensure active participation and addressal of their equity concerns.

Conclusions and Policy Implications

The success of WUAs depends on group action and efforts of members, effective management, capacity building of farmers and irrigation officials, political will, bureaucratic commitment, government and legal support, financial viability of WUAs, proper execution, and continuous innovative improvements. The overall participation index has been found satisfactory and the participation increased as the farm-size increased. Exclusively canal-user farmers participate more actively compared to the farmers having access to both canal and tubewell irrigation. The performance of WUAs on account of inputs supply and introduction of advanced technologies has been observed poor. Farmers' participation is directly influenced by educational level and size of operational holding and inversely by the distance from the canal to the field.

A significant increase has been observed in the numbers of irrigations applied and yields realized in paddy cultivation in *rabi* season on all sizes of participating farms in comparison to non-participating farms. The returns are also higher on the participating farms which depicts the positive impact of participation in WUAs. Further, distribution of these benefits has been observed more equitable among different farm sizes. The participating farms are more efficient technically than the non-participating farms. The reliability of canal irrigation has improved on participating farms. Therefore, the farmers' participation in WUAs is critical in improving farm water management and crop productivity in efficient and equitable manner under the canal command area. The major constraints to active participation in WUAs are lack of unity and cohesiveness among the farmers, inadequate water supply, inequity in water distribution/ untimely water supply and lack of communication.

While introducing institutional and organizational changes in the management of an irrigation infrastructure, a careful approach needs to be followed. The decentralization of irrigation management through WUAs is to be accompanied by agricultural inputs and services delivery system to increase agricultural productivity in a sustainable manner to realize the full benefit of scarce canal water resource. The efforts should be directed towards generating awareness among the farmers regarding the advantages of WUAs to induce effective and efficient participation of all stakeholders. Farmers should also be educated about the existing best practices of cultivation and optimal

use of irrigation. The creation of WUAs must be based on social capital and cohesiveness according to identified needs, common interests and collective efforts. These should be multifunctional to facilitate timely supply of good quality agricultural inputs and technology along with the management of water. More importantly, integrated and comprehensive reforms are needed to ensure effectiveness of WUAs as institutions for increasing efficiency and equity in access to irrigation, enhancing agricultural productivity and improving livelihoods.

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