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Economic impact of Water users cooperatives: Institutional and economic dynamics in Cauvery Basin, India

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Preamble

Water economy plays a crucial role in Indian economy. Being a vast and monsoon-dependent country, water resource availability has wide variation over time and space. The water resource potential is 1,953 billion m^3 of which 1122 billion m^3 can be utilized under current technological and economic conditions. However, the actual water resource developed from both surface and groundwater sources at present is about 644 billion m^3 forming 57 percent of utilizable potential. The total water requirement of the country is projected to be 694 to710 billion m^3 by 2010 and 784 to 850 billion m^3 by 2025. This increasing supply-demand gap, in relation to economic and demographic growth leads to a continuous decline in per capita water availability. In India, the per capita water availability declined from 5277 m^3 in 1955 to 1970 m^3 in 2000 (Ministry of Water Resources, 2001).

The Water User Cooperative Society (WUCS) is an organization of water users administered using the principles of Cooperation. The role of WUCS is to implement the water institutions, and in the process achieve a fair water allocation across different locations. Thus WUCS are Water Institutions as they implement the Institutions relating to water use.

WUCS are being formed in the Cauvery basin of Karnataka, India through CADA. The WUCS is envisioned for better water distribution in the head and tail reaches and in collecting water rates, based on extent of area and crop. In the Cauvery Basin of Karnataka, 581 WUCS have been registered under Cooperative Society Act. This study is a modest attempt to assess the economic impact of WUCS on agriculture productivity and to study the institutional and economic dynamics of WUCS in the Cauvery Basin of Karnataka with the following objectives:

I. To study the factors governing the institutional and economic dynamics of Water Users Cooperative Societies (WUCS).

II. To determine the factors that distinguishes members from non-members of WUCS.

III. To estimate the willingness to pay additional water rates for assured irrigation supply.

In order to study farmer cooperation, participation, and their cropping, thirty Water User Cooperative Societies (WUCS) of Tirumakudalu Narasipura Taluk in the Krishnarajasagar (KRS) and Kabini command of Cauvery basin were selected for the study.

Among the 30 WUCS chosen, Rajaparameshwari WUCS (Kempaiyanhundi) and Benakanahalli WUCS were active performers, while Yariyur WUCS was Passive performer. Thus two WUCS with Active WUCS and one with Passive WUCS were chosen for analysis. Among the two active WUCS, it was found that in one WUCS there was no Conjunctive use of water while in another, there was Conjunctive use. The Benakanahalli has larger number of borewells for to assure summer irrigation to their crop, and hence the society has been named as "Active with conjunctive WUCS" (Active-CU WUCS). The Rajaparameshwari WUCS and the Benakanahalli are accordingly studied as Active-WUCS and Active with Conjunctive Use (Active-CU WUCS) respectively. As a contrast, the recently formed WUCS namely the Yariyur WUCS was studied as control or passive performing WUCS, to compare the Active WUCS and named as "Passive-WUCS". Discussion with the "Cooperation Division" of CADA, Mysore helped to identify the two well-performing WUCS and one passive WUCS as control. To be objective, "Control" should be the area with surface irrigation without WUCS. However, such areas were not available as "Control", because by the amendment to the Irrigation Act, all the major and medium Irrigation by *de jure* were covered by WUCS. Thus the control for the study is the WUCS which is recently formed, even though the farmers under this WUCS could have bunched together to form WUCS at least five years ago. Thus such a "Control" WUCS is named as "Passive" WUCS for the purpose of the study.

Method

Cluster analysis is used to classify objects or cases into relatively homogeneous groups called clusters. Objects in each cluster tend to be similar to each other and dissimilar to objects in the other clusters. Set of variables or characteristics representing the objects to be clustered and used to calculate the similarity between objects. The cluster centroid is the mean values of the variables for all the cases or objects in a particular cluster. Cluster membership indicates the cluster to which each object or case belongs.

The analysis of Variance was performed to see whether there is difference in the net returns of the farmers between Active and Control WUCS. The F-value of ANOVA explains whether there is significant difference among the WUCS.

$$\text{F-value (ANOVA)} = \frac{Between\ groups\ mean\ sum\ of\ squares}{Within\ group\ mean\ sum\ of\ squares}$$

Student t-test was used to know which WUCS are significantly different from the others. (i.e. Testing two means with respect to net returns per acre per annum.)

The discriminant analysis model is a linear combination of the farmers' characteristics;

$$\mathbf{Z = b_0 + b_1X_1 + b_2\ X_2 + b_3\ X_3 + b_4\ X_4 + b_5\ X_5}$$

Z= Dependent variable (Member =1, Non-member=0)

b's = Standardized Discriminate coefficients or scores.

X_s = Predictors or independent variables

The above function 'Z' is used to discriminate the farmers who are members of the WUCS and non-members of the WUCS

X_1 = Land holding of the farmers (acres)

X2 = Ratio of Borewell irrigated area to total irrigated area.

X_3 = Distance of the farm from the canal outlet (meters)

X_4 = Paddy area grown during the summer season (acres)

X_5 = Net returns of the farmer per year per acre (Rs)

Willingness to Pay (WTP)

To assess the willingness to pay for assured summer irrigation, Logit and Tobit regression

The logit used was $Pi = E\langle Y = 1 \mid Xi \rangle = \frac{1}{1 + e^{-Z}} = \frac{e^{Z}}{1 + e^{Z}}$

$$Where \;\; Z = b_0 + + b_1 X_1 + b_2 X_2 + b_3 X_3 + b_4 X_4 + b_5 X_5$$

$$Odds\ Ratio = \left(\frac{P}{1-P} \right) = e^{\hat{b}_0 + \hat{b}_i \overline{X}_i + u_i}$$

$$Log - Odds = Li = Ln\left(\frac{P}{1-P} \right) = \hat{b}_0 + \hat{b}_i \overline{X} + u_i$$

P= Probability of farmers willing to pay additional water rates for assured summer irrigation.

1-P = Probability of farmers not-willing to pay additional water rates for assured summer irrigation.

Y = Farmers Willingness to Pay (Willing to Pay additional water rate for assured summer irrigation=1, Not-Willing to Pay=0)

X_1= Performance of WUCS (Active-WUCS and Active-CU-WUCS=1, Passive WUCS=0).

X_2 = Location / reach of the Farm (1= Head reach, 0= Tail reach)

X_3 = Land holding of the farmers (in acres)

X_4=Use of Borewell Irrigation (Yes=1, No=0)

X_5= Distance of the farm from canal outlet (in meters)

Tobit Regression Function:

Y = Farmers Willingness to Pay additional water rate for assured summer irrigation (Rs.)

X_1= Performance of WUCS (Active-WUCS and Active-CU-WUCS=1, Passive WUCS=0).

X_2 = Location / reach of the Farm (1= Head reach, 0= Tail reach)

X_3 = Land holding of the farmers (in acres)

X_4=Use of Borewell Irrigation (Yes=1, No=0)

X_5= Distance of the farm from canal outlet (in 100 meters)

Results

The water management of each WUCS is based on volumetric procurement of water from project level federation. The water charges are paid to Irrigation Department by WUCS at Rs. 12 per 1000 cubic meter. The WUCS are empowered to collect water charges from its members on the basis of area and crops grown. The water budget is estimated to each WUCS based on its revenue (water rates collected from members) and expenditure (water rates paid to Irrigation Department) of water use.

In order to analyze the impact of the performance of WUCS, three societies were selected for micro level study): Rajaparameshwari WUCS, Benakanahalli WUCS and Yariyur WUCS, and they were termed as “Active-WUCS”, “Active with conjunctive water use-WUCS” (Active-CU-WUCS) and recently formed society as “Passive-WUCS” respectively.

Using Cluster analysis, Water User Cooperative Societies were grouped into three clusters with similar characteristics with respect to explanatory variables (Table 1). Considering the strength of different variables responsible for clustering WUCS, the first cluster has six societies, clustered around as one group. Similarly, six WUCS were clustered as moderate performing, and eighteen WUCS were clustered as poor performing WUCS.

All the three group of societies have the similar characteristics with respect to the number of villages in their jurisdiction, command area, number of members and the number of farmers. The first cluster with six WUCS is characterized as well performing WUCS, since it had the lowest transaction cost of forming WUCS (3 months), high cooperation with highest fund available (Rs.

311081). The cluster two (six WUCS), which can be characterized as moderate WUCS, had experienced a transaction cost of 3 months with a total fund of Rs. 21283. The third cluster is classified as poor performing WUCS as it had the largest transaction cost of around 5 months with low fund availability with being Rs. 21950.

Table 1: Grouping the WUC Societies with common societal characteristics using cluster analysis and summarization of its characters

Sl. No.	Characteristics	Well performing WUCS as Cluster-I (Number of societies = 6)	Moderate performing WUCS as Cluster-II (Number of societies = 6)	Poorly performing WUCS as Cluster -III (Number of societies = 18)
1	Number of villages in the societies command (No.)	5.0	4.0	3.0
2	Farmers cooperation in forming the society (Well cooperative (2), Moderate cooperation (1), No-cooperation (0))	1.16	1.05	0.66
3	Transaction cost of forming WUCS (contribution of time in months)	Three months	Three months	Five months
4	Percentage of farmers attending General body meeting (%)	74.4	63.5	51
5	Number of year, after signing MOU (Memorandum of understanding)	4 years 8 months	One year and six months	Five years
6	Command area (acres)	1,208	1,263	1,196
7	Total fund available with society (Rs.)	3,11,081	21,283	21,950
8	Members in WUCS command	212	212	219
9	Farmers in Society area (No.)	453	596	597
10	Total fund per Farmer (Rs.)	785.0	38.6	40.5

In the first cluster the farmer cooperation was good (1.16), while that in the third cluster was low (0.66). Other than the transaction cost of forming WUCS, the fund available and the

extent of cooperation there were no distinctive feature, which characterize the three clusters. In each cluster, it was found that WUCS did not cluster around with respect to their location. Thus the good, moderate and poor WUCS were interspersed in any location. With the result there was no discernible performing. It is expected that the socio-economic features of good performing societies influenced the moderate and poor performing WUCS. There were instances were farmer members from poor and moderate performing WUCS visited the actively performing WUCS, for a face-to-face interaction for learning from others experience with regard to managing WUCS. Such interactions are positively looking and need to be encouraged by CADA.

Net returns

In order to test whether the difference in net return among the three WUCS are statistically significant, ANOVA was performed. The Table 2 provides results from ANOVA to test for the mean net return of farmers among WUCS. The F-value gives the ratio of the mean squares between (Active-WUCS, Active-CU-WUCS and Passive-WUCS) and within group. The F-value of 5.40 is significant at 1 percent indicating that there is significant difference among the group means (Net return per acre per annum) than within the groups.

Table 2: Results of ANOVA (Analysis of variance) to test the mean of net returns per acre per year among WUCS present in Cauvery command, 2005

	Sum of square	df (degrees of freedom)	Mean squares	F-value	Significance
Between group (Active-WUCS, Active-CU-WUCS and Passive-WUCS)	1.73 E+08	2	86680946	5.402	0.006
Within group	1.40 E+09	87	16046791		
Total	1.57 E+09	89			

Further to analyze the significance of difference of net return between two WUCS, t-test was performed and presented in Table 3.

Table 3: Testing significance of two means (Net returns per acre per year) of the WUCS farmers in Cauvery command, 2005

Sl. No.	Between two means (Net returns per acre per year)	Group mean (Net returns per acre per year in Rs.)	F-value	Significance of F-value	T-value	Degree of freedom (df)	Significance of T-value
1	Active WUCS	3989					
	Active with Conjunctive water use-WUCS (Active-CU-WUCS)	5368	0.074	0.786	1.317	58	0.193
2	Active WUCS	3989					
	Passive-WUCS	1980	0.839	0.363	2.022	58	0.048
3	Active with Conjunctive water use-WUCS (Active-CU-WUCS)	5368					
	Passive- WUCS	1980	0.414	0.523	3.379	58	0.001

When the grand mean of net return of Active-WUCS (Rs. 3,989) and Active-CU-WUCS (Rs. 5,368) were compared, F-value of 0.074 indicates that the two groups have uniform variance. Thus uniformity in variance between the two groups is a pre-requisite for testing equality of two means. The t-value of 1.31 at 19 percent significance indicated that the hypothesis of equal means (Active-WUCS and Active-CU-WUCS) was accepted. Hence there is no significant difference between the Active-WUCS and Active-CU-WUCS with respect to net return per acre per annum for all crops put together. When the grand mean of net return of Active-WUCS (Rs. 3,989) and Passive-WUCS (Rs. 1,980) were tested, the F-value of 0.839 indicated that the two groups have the same variance. The t-value of 2.022 at five percent

significance indicated that the net return of the two groups (Active-WUCS and Passive-WUCS) differed significantly.

The t-test between Active-CU-WUCS and Passive-WUCS indicated that there is no statistical difference in the group variance as the F-value is 0.523. However, the t-value of 3.37 indicated that there is significant difference between the net returns per acre by farmers in Active-CU-WUCS and Passive-WUCS, and is significant at one percent. Thus, among the three groups, there was significant difference in the net return per acre per year between "Active-CU-WUCS and Passive-WUCS", and "Active-WUCS and Passive-WUCS."

Table 4: Linear discriminant function to differentiate member and non member of the WUCS

Dependent variable (Member=1, Non member=0), Number of sample=90

Independent variable	Standardized Coefficients	Non members mean value	Members mean value	F-value
Size of holding (acres)	0.802**	1.30	3.03	35.1
Proportion of Borewell Irrigated area to the total irrigated area	0.552**	0.09	0.29	7.32
Distance of the farm from the canal outlet (meters)	-0.360*	627.45	424.35	3.10
Paddy area during summer season (acres)	0.248**	0.360	1.132	8.21
Total net returns per year (Rs.)	-0.128	3341.5	4304	1.16
Chi-square value	41.87**			
Eigen value	0.632			
Canonical correlation	0.622			

Note: **Significance at 1%, *Significance at 5%.

Farmers in the WUCS command preferred to become member based on different criteria and characteristics. Factors influencing farmers to enroll as member of WUCS are presented in

the Table 4. The discriminant function analysis indicated that, the size of holding and the ratio of area irrigated by borewell to total area were the major factors influencing the discriminating power of the function. The efficiency of the linear discriminant model to classify the farmer as member/non-member indicates that out of the total fifty-one non-members, 86 percent were classified as non-members using the discriminate function (Table 5).

Table 5: Classification result of the discriminant function based on its discriminant scores

WUCS membership		**Predicted Membership group**		**Total**
		Non-Member	**Member**	
Original membership (Count)	Non member	44	7	51
	Member	10	29	39
Original membership (Percentage)	Non member	86.3	13.7	100
	Member	25.6	74.4	100
Result: 81.1 percent of the original cases are correctly classified.				

About 13.7 percent of the non-members were misclassified while 26 percent of members were misclassified. With respect to the members of WUCS (39), about 74 percent of the farmers were correctly classified as members (29), and the rest 26 percent are misclassified. The model is thus able to classify the farmers as member/ non-member of WUCS based on the predictor variables inter alias size of holding, ratio of borewell irrigated area to total irrigated area, distance of the farm from the outlet, paddy area during summer and net return per acre; where 81 percent of the farmers are correctly classified to their original membership group. Significant (desirable) characteristics / predictor variables identified by discriminant function for a farmer to be a member of WUCS are (i) size of holding of 3.03 acres (ii) paddy area during summer season of 1.13 per farm and (iii) proportion of borewell irrigated area to total area equal to 29 percent

per farmer. Therefore farmers in possession of explanatory variables below these provided by discriminant function are classified as non-members (Tables 4 and 5).

Factors influencing farmer's willingness to pay additional water rate for assured summer irrigation

The factors influencing the farmer's "Willingness to pay" for water for the assured irrigation supply for summer crop are presented in the Table 6.

Table 6: Factors influencing the additional willingness to pay for assured summer irrigation in Cauvery command, 2005

(Dependent Variable: Farmers willing to pay more than Rs. 100 as water rate=1, Farmers who are not willing to pay additional water rates=0)
(Number of sample=90)

Independent variable	B coefficient	Significance	Mean	Marginal additional probability
Performance of WUCS (Active-WUCS and Active-CU-WUCS=1, Passive WUCS=0)	-0.949	0.147	0.667	-0.107
Reach of the farmers land (Head reach=1, Tail reach=0)	-0.106	0.858	0.500	-0.012
Land holding of the farmers (acres)	0.249*	0.095	3.123	0.028
Use of Borewell Irrigation (Yes=1, No=0)	0.853	0.294	0.211	0.096
Distance of the farm from the canal outlet (in 100 meters)	0.314**	0.005	5.440	0.036
Constant	-0.080	0.915		
Odds ratio (P/1-P)	6.698			
Probability of additional WTP (P)	0.870			
Probability of not willing to pay additional WTP (1-P)	0.130			

Note: **Significance at 1%, *Significance at 10%.

Logit regression function, with willingness to pay water rate for assured summer irrigation as dependent variable (Dummy variable: Farmers willing to pay water rate for assured summer irrigation above Rs. 100 were given as "1" and others as "0") was considered. The independent variables considered were land holding of the farmer, distance of the farm from canal outlet and dummy variable to indicate the use of borewell (1=farmer irrigating with

borewell, 0=farmer not irrigating from borewell), Activeness of the WUCS (1=Active-WUCS and Active-Cu-WUCS, 0=Passive-WUCS) and location of the farm (1=head reach farm, 0=tail reach farm).

The odds ratio of this function is 6.69 which is the ratio of the probability of the farmer who is willing to pay additional water rates to the farmer who is not willing to pay. It indicates that odds are 6 to 1 for paying additional water rates for assured summer irrigation. The coefficient (slope) of independent variable indicates the change in the log-odds for their unit change. It tells how the log-odds in favor of WTP for a unit change in the independent variable. The odds ratio is the exponential (intercept + (coefficient of Xi * Mean of Xi)). The probability (P) of the farmers willing to pay additional water rates is 0.87.

The result shows that the land holding of the farmer (acres) and distance of the farm from canal (meters) were the significant factors influencing the willing ness to pay. The additional probability indicates the rate of change in the probability with respect to change in the independent variable. For 100 meters increase in the distance of the farm from the canal outlet (from its mean), the marginal additional probability to pay the additional water rate increases by 0.03 from the present probability of 0.87. Similarly, one acre increase in the land holding of the farmer from its mean, the marginal additional probability to pay the additional water rate increases by 0.028. The marginal additional probability is the product of the coefficient, probability (P) and (1-P).

The dummy variable used to indicate the activeness of WUCS (1=active, 0= control) has the negative coefficient which indicates that the farmers in the Passive-WUCS (control WUCS) were willing to pay more than the active-WUCS, but the variable is not significant. Similarly the farmers in tail reach of the command were willing to pay more than the head reach farmers, but it

is not significant. The farmers possessing borewell are also eager to pay additional water rate, but the variable is not significant.

Functional analysis to know the extent of farmers' willingness to pay additional water rates for assured summer irrigation

Factors influencing farmers' WTP additional water rates for assured water supply, was estimated using Tobit regression analysis (Table 7). The result shows that the land holding of the farmer (acres), use of borewell Irrigation and distance of the farm from canal (100 meters) were the significant factors influencing the farmers' willingness to pay. The mean additional WTP of the farmers are Rs.178.

The distance of the farm from the canal outlet, size of the land holding and use of borewell are positive and significant factor influencing additional WTP of the farmers. Sum of the regression coefficient, weighted by the mean of the respective independent variables, gives additional willingness to pay for water rate. Farmers with borewell and land (3 acres) located at a distance of 548 meters from canal outlet, in head reach of Active WUCS are willing to pay an additional water rates of Rs. 127. If the similar farm is located at further away by 100 meters (648 meters), the farmers are willing to pay an additional amount of Rs. eight. Similarly, if the farmers land holding increases by one acre, he is willing to pay an additional amount of Rs. 11 towards water charges. The farms located at a distance of 548 meters from canal outlet, without borewell irrigation in the tail reach of Passive-WUCS are WTP an additional amount of Rs. 148.

This study was taken up to examine the performance of the WUCS formed in T. Narasipura Taluk of Mysore during 2000. Twenty percent of the WUCS are well performing with 50 percent of membership, and every society here has received on an average a fund of Rs. 3,11,081 through membership fee, one time grant and godown grants. These societies have better cooperation, where 75 percent of member farmers attended the general body meeting.

Table 7: Farmers willingness to pay additional water rates for assured summer irrigation in Cauvery command, 2005

(Dependent Variable= Farmers willingness to pay for water above Rs. 100, Mean additional WTP= Rs. 77.58, Number of sample=90)

Independent Variable	Coefficient	t-value	Mean
Performance of WUCS (Active-WUCS and Active-CU-WUCS=1, Passive WUCS=0)	-23.58	-1.86	0.667
Reach of the farmers land (Head reach=1, Tail reach=0)	-10.01	-0.87	0.500
Land holding of the farms (acres)	11.45**	4.66	3.123
Use of Borewell Irrigation (Yes=1, No=0)	43.26**	2.61	0.211
Distance of the farm from the canal outlet (in 100 meters)	8.06**	7.82	5.440
Constant	59.07	11.18	

Note: **Significant at 1%.

In Active-WUCS, the cropping intensity is 195 percent, while it is 178 percent in Passive-WUCS, which indicates lack of access to irrigation water during summer season. The net returns of paddy at cost B2 in Active-CU-WUCS was Rs. 2,416, which is more than the Active-WUCS (Rs. 1,250) and Passive-WUCS (Rs. 1,266). Active-WUCS farmers have grown paddy in both the kharif and summer seasons, while the Active-CU-WUCS and Passive-WUCS have grown paddy only in kharif.

Between the head and tail reach farms, the difference in net returns per annum is maximum in Active-CU-WUCS (Rs. 3,584), followed by Passive-WUCS (Rs. 3,370) and Active-WUCS (Rs. 2,603), which indicates difference in water sharing among societies farmers. The Active-CU-WUCS received a highest net returns per acre per annum of Rs. 5368 followed by Active-WUCS (Rs. 3,989) and Passive-WUCS (Rs. 1,980), as Active-CU-WUCS grow sugarcane and tuberose which fetched high returns.

Small and Large farmers are becoming members of WUCS, compared to marginal farmers. The farmers whose land is located away from canal pipe outlet, is not willing to become member, but they are willing to pay more towards the assured summer irrigation. The farther farmers are not confident of the WUCS activity to ensure equal distribution of water. The odds ratio determined using logit model indicated for every one chance of not willing to pay additional water rate, there are seven chances of willing to pay.

Conclusions

The net returns from major irrigated crops such as paddy and sugarcane, even after considering the economic cost of water, are positive in the command area. This amply proves that the farmers have the capacity to pay for canal water up to Rs. 600 per acre of paddy, and up to Rs. 1200 per acre for sugarcane. The WUCS has to educate the farmers regarding the treatment of water as an economic good.

The WTP for additional water rate for assured irrigation in summer indicated that the probability of willingness to pay is 0.87, thus farmers are not averse to pay additional amount for water if supplied in summer.

Despite the odds facing any cooperative venture, about twenty percent of the WUCS had comfortable funding position with an average fund of around Rs. 3 lakhs per society. The remaining 80 percent of the societies are not comfortable with their total fund amounting around Rs. 20,000 per WUCS. Thus there is potential for the moderate and poorly performing WUCS to catch up with well performing WUCS.

The farmers with conjunctive use irrespective of their location, head (Rs. 6896) or tail reach (Rs. 3306) have received highest net returns per acre in the command area. The conjunctive use fetches maximum net returns when compared to other situations, and we

promote it to address the problem of drainage and water logging in head reach and to address the problem of inadequacy of water in the tail reach. There were no well failures in both the reaches.

Among the factors motivating a farmer to be a member of WUCS, the size of holding is the most important followed by the proportion of ground water irrigation to total irrigation (29%). Thus conjunctive use of ground water and surface water forms a crucial variable to motivate farmer as member of WUCS along with size of holding.

It is desirable for the project level committees to start functioning efficiently and the water management issues at the project level have to be deliberated in the larger interest of the members of WUCS. For efficient water management, the state's continuing support to WUCS at all levels of the irrigation systems is necessary. The users' institution should be the permanent institution, as a part of irrigation management and should not be treated as adhoc organization.

The support of the local Non Government Organizations in social mobilization can be availed as it is a challenging task to mobilise farmers to adopt to new system of water management through WUCS.