Famers' Willingness to Pay for Irrigation Water and Participation in Irrigation Management – A Study in Saline Zone of South 24 Parganas in West Bengal

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Abstract: Irrigation plays the vital role in improving the yield or productivity in the agricultural sector. Among the irrigation sources, tank irrigation is considered as most important, particularly in the dry and saline zones. The present paper attempts to find the determinants of willingness to pay (WTP) for tank irrigation water based on the primary survey of 300 households in five blocks of South 24 Parganas. The paper also discusses the farmer's participation in the tank irrigation management. The results show that socio-economic aspects like education, age etc. play crucial role in farmer's WTP for irrigation water and proper maintenance of tanks can manage the sustainability of irrigation systems. .From the Principal component analysis of farmer's participation in water body irrigation management it had been found that well maintained channels, proper maintenance, adequate water supply, sufficient effort are much needed for irrigation management and these are the decision making factors.

***Keywords* - Irrigation water, Tanks, Farmers, Willingness to pay, Sustainability.**

I. INTRODUCTION

With the increasing population, the freshwater sources are being exploited all over the world. Groundwater becomes the only source of potable water in the region where fresh surface water is not available (Bhadra et al., 2018). At least, half of the world's population depend on ground water to meet their potable water need (UNESCO, 2015). Being natural resource water cannot be treated as pure public good; sometimes it acts as private good as it is available at private cost (Gatto and Lanzafame, 2005). This ultimately creates an upward pressure, leads to a crisis, conflicts and disagreement among the users. Moreover it generates excessive, unexpected and unhealthy pressure on ecology and environment which ultimately leads to environmental degradation (UN Water Report, 2007).With an increase in the consumption of water resources by 70% and withdrawals of water resources by 15%, agricultural production will be increased by 60% to feed 9 billion people by 2050. Due to this high rate of growth of population, demand for fresh water increases by lips and bound. If demand for the utilization of water resources is increasing at this repaid rate then about 1.8 billion people of this globe will reside in water scarce regions by 2025 (UN Water Report, 2007).India will be declared as water scarce region if per capita availability of fresh water falls to 1000 cubic meter per year (Das, 2009).

Irrigation is the most important factor behind the success of agriculture in Indian economy, because of the geomorphological differences in the different region of the country. More over temporal and spatial variation of the rainfall in the country calls for a scientific and environmentally sustainable irrigation management in the country with a long term perspective. With the introduction of mechanized system of irrigation techniques, India relied much on ground water lifting for irrigation purpose, since independence. But with the threat of global warming, environmental degradation and ground water depletion tank water irrigation through rain water harvesting can plays a significant role in agricultural production in arid and semi-arid region in India. Tanks store the monsoonal run-off which also acts as a recharge of ground water, are utilized for the multidimensional purposes. Tanks as a common property resources are generally used for the purposes of irrigated agricultural, for the domestic uses, for drinking water and for aquaculture. It also helps to restore sustainable ecological balance. In the rural economy of India, tanks are the life line through which people earned their livelihood. Stakeholders like small farmers, marginal farmers, landless agricultural labourers and women are heavily dependent on the tank for their livelihood. Tanks store this huge runoff and also act as a genuine moderator of flood. So, this century old rainwater harvesting irrigation system is still one of the important sources of irrigation in rural India in dry seasons and acts as an insurance against drought.

Basic problems of this irrigation tank are the poor and insufficient maintenance and management of this common only used water bodies from time immemorial. Due to this negligence, siltation, reduction in storage capacity, encroachment, high degree of seepage in the delivery system are commonly seen in the tank irrigation system which is an obstacle in way of utilizing tank irrigation in a sustainable manner. Therefore, there is an urgent need of strong, effective and rational management system for socially, economically, environmentally sustainable use of this tank irrigation system for the better present and future use.

For the sustainable management of tank irrigation systems, the paper attempts to find the determinants of willingness to pay (WTP) for tank irrigation water and discuss the farmer's participation in the tank irrigation management.

II. STUDY AREA

South 24-parganas district is located in saline zone in West Bengal in India. It is situated in the extreme southern part of West Bengal (22° 33' 45" N - 21° 29' 00" N latitudes and 89°4'50" E - 88° 3'45" E longitudes). The total geographical area of the district is 9960 sq.km. The district is bounded by Kolkata and North 24 Parganas on the North, Sundarban and Bay of Bengal on the South, Bangladesh on the East and Hooghly River on the West.

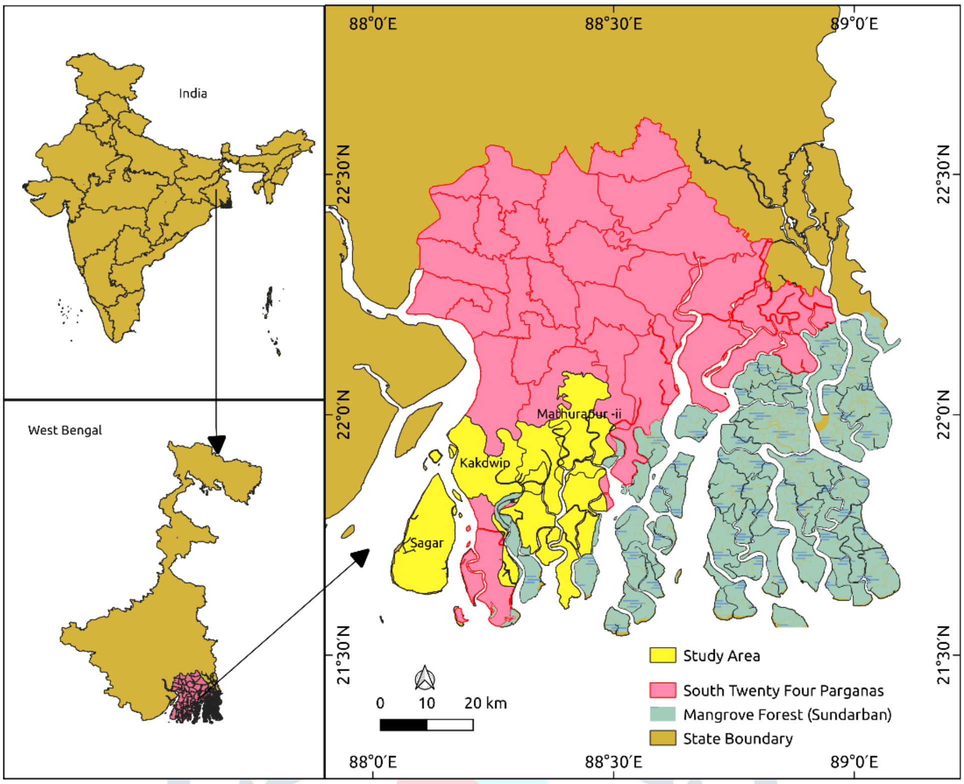

Figure 1.The study area map of South 24 Parganas

According to 2011 census, the total population of South 24 Parganas is 8.16 million and growing at an estimated rate of 1.82% per year, which is higher than that of the state of West Bengal (1.38%) and India (1.76%) between 2001 and 2011. People are mainly dependent on agriculture, working as cultivators and agricultural labourers. The major crop grown in the district is rice. The yield rate of rice is 2322 kg per hectare in South 24 Parganas (DSHB, 2011). Along with agriculture, rural people practice multiple secondary livelihood activities such as aquaculture, honey collection, crab collection. Five blocks of South 24 Parganas district namely Patharpratima, Matharapur-II, Kakdwip, Sagar and Namkhana which are closer to Bay of Bengal have been selected for the study. There is high degree of salinity problem in the ground water and surface water (river water) in the selected blocks. Agricultural activities of these blocks mainly depend on the rain fed surface water irrigation system i.e. tanks (ponds, khal, and beals).

III. METHODOLOGY

Total 300 farmer households have been randomly surveyed in the selected sites of South 24 Parganas to know their willingness to pay (WTP) for irrigation water and participation in irrigation management. To achieve the above mentioned objectives, ordinary least squares regression and principal component analysis methods have been applied for the present study in STATA and SPSS platforms.

Ordinary Least Squares Regression (OLS): In this study, farmers' WTP for irrigation water is demonstrated as a model of various individual, household level and farm level factors.

The OLS regression model is represented as follows:

WTP = b0 + b1AGE + b2EDN + b3FSIZE + b4WORKM + b5COMDA + b6FINC+b7DISTF + b8 WTREQ + error

Where, WTP = Farmers' WTP for irrigation water (amount per acre per year)

AGE = Age of the respondent/ household head (years)

EDN = Education level of the head of the household

FSIZE = Family size (numbers)

WORKM = Working members (number)

COMDA = Command area (hectares) and

FINC = Family income (rupees)

DISTF = Distance from the field

WTREQ = Water requirement (=1 if yes, =0 otherwise)

To explain the relationship between the independent variables and dependent variable, the regression co-efficient with p-value for each independent variable has been examined.

Principal Component Analysis (PCA): In this study, PCA or factor analysis method has been employed to reduce the set of 13 decision variables to the key decision making variables (Table 3).The decision variables have been measured in 1 to 5 scale. The new set of variables, or factors, can be interpreted as farmer's decisions for managing irrigation system. The Kaiser-Meyer-Olkin (KMO) test has been done to detect multi-collinearity issue in the data and also to measure the sampling adequacy. The Bartlett's (1954) Test of Sphericity tells whether correlation matrix is significantly different from an identity matrix.
In this analysis, only those components or factors with an eigenvalue (the variances extracted by the factors) more than 1.0 have been retained using the 'eigenvalue-greater-than-one' rule proposed by Kaiser (1960). The varimax (orthogonal) rotation has been opted to improve the interpretability of factors.

IV. RESULTS AND DISCUSSION

Table 2 provides some information about 300 respondents surveyed in the selected sites of South 24 Parganas. The average age of respondents is 49 years. Respondents are mainly household heads and farmers. Average Family size is 4.17, and working member per household is 2.46. Annual income is INR 80,000 per household. Most of the respondents reported that they can pay INR 225 per acre per year for irrigation water.

Table 1. Descriptive Statistics of the Surveyed Households

Descriptive Statistics	N	Range	Minimum	Maximum	Mean	Std. Deviation
Age (years)	300	62	25	87	49.15	12.819
Schooling (years)	300	17	0	17	5.76	3.439
Family size (numbers)	300	7	1	8	4.17	1.399
Working members (numbers)	300	5	0	5	2.46	.919
Command area (bigha)	300	15.0	0.0	15.0	1.540	1.7835
Family annual income (lakh)	300	3.3	.3	3.5	.827	.3247
Willing to pay (Rs./acre/year)	300	600	0	600	225.00	176.006
Distance (meter)	300	2200	0	2200	300.08	310.666

To understand the factors/variables influencing farmers' WTP for irrigation water, ordinary least squares regression model has been used. The regression results are presented in Table2. The results show that model is fit for analysis and explains 41 percent of the variation in the data.

Table 2. Estimated Regression Coefficients for the Willing to Pay Model

Willing to Pay	*Coefficient*	*Std. Err.*	*t*	*Sig.*	*[95% Conf. Interval]*	
Age	1.336485	0.7076782	1.89	0.060*	-0.0563515	2.729322
Education	4.457555	2.560646	1.74	0.083*	-0.5822511	9.497361
Family size	-3.325169	6.724703	-0.49	0.621	-16.56058	9.910243
Working members	-3.376191	10.32425	-0.33	0.744	-23.69615	16.94377
Command area	16.21417	5.002567	3.24	0.001****	6.368226	26.06011
Family income	69.9932	28.35543	2.47	0.014**	14.18467	125.8017
Distance	0.0988866	0.0274135	3.61	0.000****	0.0449319	0.1528413
Water requirement	239.585	23.3171	10.28	0.000****	193.6928	285.4772
Constant	-159.9202	52.33577	-3.06	0.002***	-262.9263	-56.91411
Observations = 300; F(8, 290) = 25.18; Prob. > F = 0.0000; R-squared = 0.4099						
**** p < 0.001, *** p < 0.01, **p < 0.05, * p < 0.1						
Data Source: Estimated from Primary Survey, 2018						

The results indicate that the command area, distance, water requirement, family income are significant variables and have higher positive coefficient values. It can be said that respondents with higher income, large command area, water requirement will pay more for irrigation water.

It is understood that socio-economic aspects play crucial role in farmer's WTP for tank water. Education has two different types of effects on WTP for tank water. One is education sometimes offers exit options which is likely to reduce WTP. Another one is farmers with education can influence in the household and participate in the tank management related activities. This means farmers' WTP will be positively influenced by education. The age of the respondents is another important and critical for taking decisions on family and farm operations. Age normally reflects the experience of the respondents. The different sources of income positively influence the farmers participation in household and tank management activities and hence the WTP. It is also understood that if farmers have more income from different sources, then farmers likely to pay more for the tank water. The command area is expected to influence the WTP for tank water. Normally, the small and marginal farmers (working less than 6 months) who are totally dependent on tank water for irrigation may have higher WTP.

Farmers' participation in irrigation management in saline zone is also important in tank irrigation study. The description of the variables used in the present study is provided in Table 3.

Table 3. Descriptive Statistics of Selected 13 Variables of Farmer's Participation

Variables	N	Minimum	Maximum	Mean	Std. Deviation
Catchment	300	2.0	5.0	3.318	.7102
Water Supply	300	1.0	5.0	2.957	.6813
Control	300	1.0	5.0	2.613	.7591
Effort	300	1.0	4.0	2.389	.6788
Water Sharing	300	1.0	4.0	2.168	.7162
Channel	300	1.0	4.0	1.725	.7130
Maintenance	300	1.0	4.0	1.668	.6616
Sluice	300	1.0	3.0	1.564	.7003
Water Spread	300	1.0	4.0	1.543	.7369
Cooperation	300	1.0	3.0	1.282	.5034
Panchayat	300	1.0	4.0	1.279	.6172
Public Fund	300	1.0	3.0	1.039	.2285
Decision Making	300	1.0	3.0	1.061	.2538

Table 3 shows the descriptive statistics of selected 13 variables of farmer's participation in irrigation management. The range of each variable varies from 1 to 5 (strongly disagree to strongly agree). Most of the respondents agreed that catchment condition is good and water supply is adequate. Mean value of four variables – co-operation, panchayat, public fund and decision making is close to 1 which indicates that respondents are not agreed with the statements asked during the primary survey or in other words, respondents are dissatisfied. It has also been found that the variables are not highly correlated with each other.

Table 4. KMO and Bartlett's Test for PCA

KMO and Bartlett's Test		
Kaiser-Meyer-Olkin Measure of Sampling Adequacy.		.846
Bartlett's Test of Sphericity	Approx. Chi-Square	1560.124
	df	78
	Sig.	.000

The Kaiser-Meyer-Olkin (KMO) test suggests that there is no multi-collinearity issue in the data and the sampling adequacy is perfect for the study (Table 4). The determinant of the correlation matrix (0.003) and Bartlett's (1954) Test of Sphericity (0.000) indicate that PCA or factor analysis is appropriate for the data. Three components or factors with an eigenvalue more than 1.0 have been retained. The varimax (orthogonal) rotation has been opted to improve the interpretability of factors and presented in Table 5.

Table 5. Rotated Component Matrix in PCA

Rotated Component Matrix[a]			
	Component		
	1	2	3
Catchment	.641	-.023	.281
Water Supply	.730	-.056	.385
Control	.486	.116	.591
Effort	.710	.218	.179
Water Sharing	.614	.194	.226
Channel	.826	.059	-.039
Maintenance	.766	.384	-.051
Sluice	.687	.264	-.128
Water Spread	.373	.769	-.095
Cooperation	.218	.830	.243
Panchayat	-.030	.828	.269
Public Fund	.058	.157	.792
Decision Making	.041	.087	.641
Extraction Method: Principal Component Analysis. Rotation Method: Varimax with Kaiser Normalization.			
a. Rotation converged in 6 iterations.			

Three factors account for 62.87 percent of the total variation in the data. For the first factor (38.84%), channel, maintenance, water supply, effort have shown markedly higher positive loadings, while variables like panchayat, public fund, decision making have shown negative and low positive factor loadings. It can be said that well-maintained channels, proper maintenance, adequate water supply, sufficient effort are very much needed in irrigation management. This factor can be interpreted as the most important consideration of farmers in water body irrigation management. This factor can be labelled as proper maintenance of tanks. The second factor explains 12.94 percent of the total variation in the data. The second factor is far less important than the first factor. Variables like cooperation, water spread and panchayat have shown positive loadings for second factor. It means that good co-operation and good water spread area and the local panchayat have active role in water body maintenance. This factor can be labelled as good co-operation. The second factor explains 11.09 percent of the total variation in the data. Variables like public fund, control, and decision making have shown positive loadings. This factor can be treated as strength of decision making.

V. CONCLUSION

The study reveals that the average value of WTP for the tank irrigation water is found to be considerably less than the opportunity cost of the irrigation water which is indicating the unsustainable use of irrigation water from the tank system at present. Therefore it can be said that for both farmers' and government perspectives, sustainability of irrigation systems is very important in the present days. The analysis of farmer's participation in tank irrigation management in South 24 Parganas shows that well-maintained channels, proper maintenance, adequate water supply, sufficient effort are very much needed in irrigation management. They will need to be strengthened in order to overcome the conflicts concerning sharing the tank benefits, stimulate participation in tank irrigation management and achieve sustainable tank irrigation management in the saline zone in India. This study will help to the policy makers to develop an implementable, efficient and district level policy for irrigation activities.

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