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Willingness to Pay for Assured Irrigation and Equity in Distribution of Tank Water in Central Dry Zone of Karnataka

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Abstract

The present study was carried out to estimate the factors determining and willingness to pay (WTP) by farmers for assured irrigation and equity in distribution of tank water in Central Dry Zone of Karnataka. Two tanks one managed by Minor Irrigation Department (MID) and the other by farmers were considered. Ninety farmers from each tank management regimes were selected based on simple random technique. The mean willingness to pay was ₹ 894 and ₹ 809 per acre per year in case of farmers and MID managed tank regimes. Factors affecting farmers' WTP were education, area under tank irrigation, location of the farm and gross farm income. Shift in the threshold willingness to pay for the farmers under farmers managed tank regime was ₹ 118 per acre per year. Farmers under both the management regimes were ready to pay for assured irrigation and equity in distribution of water.

Keywords : Willingness to pay, Equity, MID and farmers managed tanks, Institutions, Free riding

Irrigation water is one of the major constraints faced by the farmers in India. Karnataka is the second highest drought prone area in the country (Srikantha and Indumati, 2011). In recent times, the climate change is causing uneven distribution of rainfall. Hence, it is obligatory to utilize the scarce water resources efficiently. Free distribution of water has led to inefficient allocation of the scarce resource. Determining the value of water serves as an option for improving water allocation and management of the irrigation systems (Karthikeyan *et al*., 2009). Irrigation tanks significantly contribute towards agriculture development in South India (Palanisamy and Balasubramaniyan, 1998).The irrigation tanks in Karnataka are mostly managed by the Water Users Association (WUA). Each WUA has its own rules and regulations in managing, operating and distribution of water. Lack of collective action and the problem of free riding have led to defunct of few WUA questioning the equity in distribution of tank water. One such case is Ayyana Kere in Central Dry Zone of Karnataka which is currently managed by Minor Irrigation Department (MID managed tank). Hence, it is necessary to form or to rejuvenate the existing WUA which ensures the equity in distribution of tank water for irrigation. Bukkarayana Kere is a tank situated near to Ayyana Kere where there is an active WUA managed by farmers through collective action (Farmers managed tank) which ensures the equity in distribution of tank water. Water is first released to the tail end farmers then to head reach farmers and each farmer is provided with irrigation for four hours. Farmers are being charged ₹ 500 per acre per year to meet out the operation and maintenance expenditure. Whereas, in the MID managed tank area, irrigation water is released normally from head reach to tail reach farmers. Farmers in the tail end do not get the water indicating non-equity in distribution of irrigation water leading to conflicts among farmers (Suresh, 2010) and no water charges are collected from the farmers', it is completely borne by the MID. Hence, Willingness to Pay (WTP) to replicate the same institution which results in assured irrigation and equity in distribution of water between head and tail reach farmers as found in farmers managed tank area is essential. Whereas, willingness to pay to meet out the increasing operation and maintenance cost and to sustain the existing institution is necessary. The present study throws a spot light on estimating the farmers' willingness to pay for assured irrigation and equity in

distribution of water under two water management regimes in Central Dry Zone of Karnataka. In this context, it was hypothesized that,

a. Farmers in the tail reach are prepared to pay more for assured irrigation and equity in distribution of water than the head reach farmers.

b. There is no significant difference in WTP between two water management regimes.

Methodology

Study area and sampling

The study was carried out in the Central Dry Zone of Karnataka during agriculture year 2017-18. Two tanks in Central Dry Zone of Karnataka were selected purposively, one under farmers management (Bukkarayana Kere) and the other tank managed by the MID (Ayyana Kere). Farmers were selected based on random sampling technique. Data was collected from 90 farmers using pre-tested well-structured schedule through personal interview method. Finally after omitting the outliers, data of 80 farmers from each management regime was considered for the analysis.

Double bounded dichotomous Contingent Valuation Method (CVM)

In order to estimate the farmers' willingness to pay for assured irrigation and equitable water distribution, double bounded dichotomous contingent valuation method was employed. CVM is a survey method which rests in the creation of imaginary (hypothetical) market situation to elicit the preferences of the individuals and households towards the environmental goods and services. Irrigation water in many cases are undervalued or not at all valued. Water as a free gift of nature has both active [irrigation] as well as passive uses [option value] (Durba and Venkatachalam, 2015). In this particular study, active use value of tank irrigation water is elicited by using CVM (Durba and Venkatachalam, 2015). Contingent valuation method suffers with many biases viz., strategic bias, starting point bias, hypothecation bias and vehicle bias. To avoid such biases, following steps were considered. To avoid the starting point bias, the water rate charged per acre under farmers managed tank system *i.e.,* ₹ 500 per acre per year was taken as the initial bid amount. Annual payment of the water charges during the month of December (prior to the release of irrigation water) directly to the water users association was considered as the payment vehicle. In order to avoid hypothecation bias, similar institution prevailing in farmers managed tank area was considered as all farmers in MID managed tank area were aware of this institution.

Based on the response from the farmers, the farmers were grouped into four different categories *viz.,* YY (Yes for first bid and Yes for second bid), YN (Yes for first bid and No for second bid), NY (No for first bid and Yes for second bid) and NN (No for first bid and No for second bid). Along with this, their actual willingness to pay (in ₹ per acre per year) for the assured irrigation and equity in distribution of water was also collected. These four different categories were used as endogenous variables and the exogenous variables like age, education attainment, gross farm

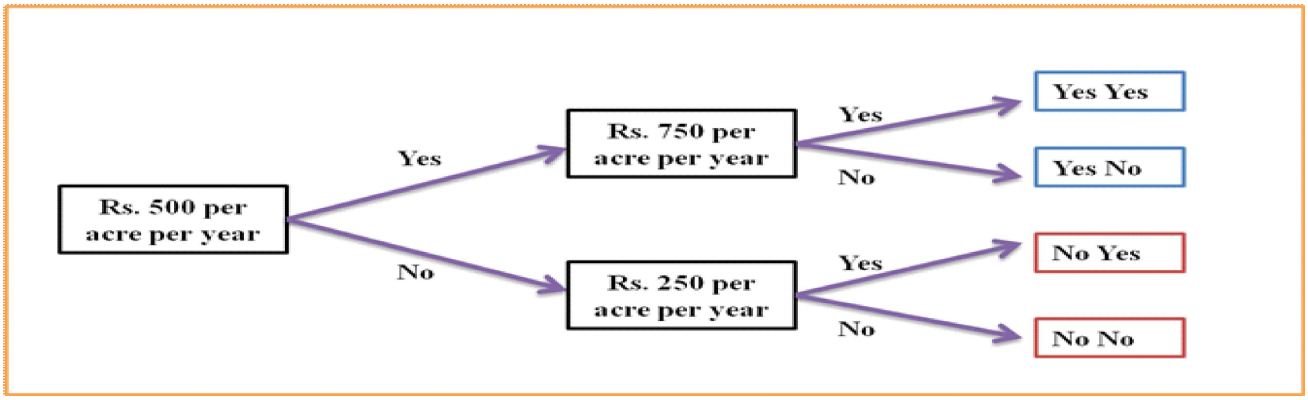

Fig 1: Format of double bounded dichotomous CVM used to estimate willingness to pay

income, area under tank irrigation and dummy for the location of the farm (1 = head reach and 0 = tail reach) were considered to figure out the factors affecting the farmers' willingness to pay. Multinomial logistic regression was used to elucidate the factors affecting the willingness to pay by the farmers in MID managed tank area whereas, binary logistic regression was used in case of farmers managed tank area.

Logistic regression/ multinomial logistic regression

To elucidate the factors affecting the willingness to pay (WTP) for assured irrigation and equity in distribution of tank water logistic regression was employed.

The regression was run with YY=1 and YN=0 as dependent variable for logistic regression (Farmers managed tank) and YY=1, YN=2, NY=3 and NN=4 in case of multinomial logistic regression (MID managed tank). The base category was YY in case of multinomial logistic regression.

The basic form of the logistic function is,

$$P_i = P_i\left(Y = \frac{1}{X_1, X_2, X_3, X_4, \ldots . X_k}\right) = \frac{e^Z}{1+e^Z} = \frac{\exp(Z)}{1+\exp(Z)} \ldots\ldots(1)$$

Where, Z= $\beta_0 + \beta_i X_i$ and X_i are set of predictor variables.

$$\frac{P_i}{1-P_i} = e^{Z_i} \ldots\ldots\ldots(2)$$

$$L_i = \ln\left(\frac{P_i}{1-P_i}\right) = Z_i = \beta_0 + \beta_i X_i \ldots\ldots\ldots(3)$$

The quantity $\frac{P_i}{1-P_i}$ is called the odds and hence, $\ln\left(\frac{P_i}{1-P_i}\right)$ is Logit. The coefficients β_i are logit regression coefficients. Odds ratio were computed using these coefficients. In the case of a dichotomous independent variable, the odds ratio can be interpreted as the increased odds of a positive outcome on the dependent variable for the affirmative category (X=1) over the negative one (X=0). Logistic regression commands in the Stata 14.2 version software was used to analyze the data.

Tobit Analysis

A sample in which information on the dependent variables are available only for some observations is known as a censored sample and in such cases tobit is used (Gujarati, 2004). In view of the fact that the actual willingness to pay was zero for few farmers, tobit model was estimated to find the factors affecting the actual WTP. Censored tobit regression commands in the Stata 14.2 version software were used to find the maximum likelihood estimation of the independent variables.

$Y_i = \beta_0 + \beta_i X_i + u_i$ if RHS>0 and, $Y_i = 0$ otherwise……. (4)

The following model was used,

$$\text{WTP (₹)} = \beta_0 + \beta_1 (X_1) + \beta_2 (X_2) + \beta_3 (X_3) + \beta_4 (X_4) + \beta_5 D_1 + \beta_6 D_2 \ldots\ldots . (5)$$

Where,

X_1= Age (Years)

X_2= Education attainment (Years of schooling)

X_3= Area under tank irrigation (acres)

X_4= Gross farm income (₹)

D_1= Dummy for location (If Head reach D_1=1, otherwise 0)

D_2= Dummy for the type of institution (If Farmers managed D_2=1, otherwise 0)

Results and Discussion

Socio-economic characteristics of the respondent farmers

The farmer respondents were classified based on their socio-economic characteristics and are presented in Table 1. Results indicated that, majority of farmers in both the irrigation tank management regimes belonged to the age group of 40-60 years *i.e.,* 66 and 76 per cent in farmers and MID managed tank system, respectively. The percentage of farmers in the old age (>60 years) group was the second highest (20% in farmers and 13 Per cent in MID managed tank). The pattern of distribution of age was non-significant. The average age of the farmer respondents under both the situation was 49 years and the difference was found non-significant indicating the homogeneity of the sample.

It was noticed that majority of farmer respondents belonged to medium sized family (4-6 no.), followed by large family (> 6 no.). In farmers managed tank area, 13 per cent, 72 per cent and 15 per cent of farmers belonged to small, medium and large sized family, respectively. While, it was 9 per cent, 74 per cent and 18 per cent of the famers in small, medium and large sized family, respectively in case of MID managed tank area. With regard to average family size, it was same in both the situation (5 No.) and was statistically non-significant (Table 1).

More than 70 per cent of the farmers were small farmers. The average size of land holdings was higher in farmers managed tank area (1.78ha) than MID managed tank area (1.63ha). However, the difference was found non-significant.

There was no significant divergence between the groups with respect to the socio-economic characteristics indicating that the samples were homogeneous and hence they can be meaningfully compared.

Factors affecting farmers' willingness to pay

The farmers were presented with the double bounded dichotomous CVM format. It was noticed that, majority of farmers in farmers managed tank regime expressed their willingness to pay for assured irrigation and equity in distribution of irrigation water from tank. Fifty one per cent of the farmers expressed their willingness to pay for both initial and second bid and 49 per cent of the farmers belonged to Yes No category (Table 2). Majority of farmers expressed their willingness as they have realized the benefits of equity in distribution of water. It was appealing to note that, none of the farmers irrespective of head reach or tail reach expressed their non-willingness to pay. This clearly indicates the influence of collective action/institution on the egalitarian decision of the farmers and absence of free riding problem.

More than 20 per cent of the farmers (19 No.) in the MID managed tank area expressed their non willingness to pay for the irrigation water and all belonged to head reach. They opined that water is a free gift of nature and hence a common property resource (Karthikeyan *et al.,* 2009). Few head reach farmers also expressed their willingness to pay for assured irrigation and equity in distribution of tank water demonstrating their concern towards the tail end farmers. About 40 per cent of the farmers in MID managed tank area belonged to YY category followed by 22 per cent in NN category (Table 2). Farmers in the tail end received irrigation only once as against three to four irrigations for the head reach farmers.

TABLE I

Socio-economic characteristics of farmers under different tank management regimes

Particulars (No.)	Farmers managed tank area (n=80)	MID managed tank area (n=80)	Significance of mean
I. Age Group			
a. Below 40 years	11 (14)	9(11)	
b. 40-60 years	53(66)	61(76)	
c. Above 60 years	16(20)	10(13)	
Average age (Years)	49	49	$t=0.44^{NS}$
II. Education Level			
a. Primary	14(18)	59(74)	
b. High School	26(33)	8(10)	
c. College	35(44)	10(13)	
d. Illiterate	5(6)	3(4)	
Average Years of Schooling	10	9	$t= -1.52^{NS}$
III. Family Size			
a. Small (<4)	10(13)	7(9)	
b. Medium (4-6)	58(72)	59(74)	
c. Large (>6)	12(15)	14(18)	
Average family size	5	5	$t= -1.62^{NS}$
IV. Land Holding			
a. Small farmers (< 2 ha)	56(70)	59(74)	
b. Medium and Large farmers (> 2.01 ha)	24(30)	21(26)	
Average land holding (ha)	1.78	1.63	$t= -0.57^{NS}$

Note: NS= Non Significant; Figures in parenthesis indicates percentage to total

TABLE 2

Number of respondents under each category of bids and mean willingness to pay

Particulars	Farmers managed tank area	MID managed tank area
Yes Yes (YY)	41 (51)	34 (43)
Yes No (YN)	39 (49)	14 (17)
No Yes (NY)	0 (0)	13 (16)
No No (NN)	0 (0)	19 (24)
Mean WTP** (₹ per acre per year)	894	809

Note: Figures in parenthesis indicates percentage to total; ** Significant at 5 %

Hence, farmers in the tail end of the channel were ready to pay for the institution that ensures equity and sustain the irrigation water. They were of the opinion that, they are ready to pay both initial as well as second bid as the benefit they would receive from tank irrigation is more than the proposed bid and saving their crop was more important.

Mean willingness to pay was marginally and significantly higher in case of farmers managed tank area (₹ 894 per acre per year) than MID managed tank area (₹ 809 per acre per year).

Willingness to pay was estimated since the operation and maintenance cost has been increasing over the years and to ensure assured irrigation and equity in distribution of tank water, existing institutions needs to be sustained. Hence, farmers' willingness to pay was estimated for the tank managed by the farmers. Since the response of the farmers falls in only two categories, logistic regression (1 for YY and 0 for YN) was used to elucidate the factors affecting WTP. Farmers' education attainment, area under tank irrigation and gross income from farming were the factors that significantly affected the farmers WTP (Table 3).

Pseudo R^2 value was 0.60 indicating that 60 per cent of the variation in WTP is explained by the explanatory variables included in the model. The overall model was significant at one per cent (P>chi-square=0.000). The odds ratio for education was 1.83 indicating that, education was 1.83 times higher in Yes Yes group than Yes No group. The results are in contrary to the results of the study conducted by Rezhen *et al.* (2015) where they concluded that educated people had other alternative jobs hence, WTP was less. But in the current investigation, majority of farmers were educated and their main occupation was farming. The odds ratio for area under tank irrigation was WTP for assured irrigation and equity in distribution of water was 3.88 times in Yes Yes group compared to Yes No group and is perhaps due to positive scale effect. Results of the study are aptly supported by the findings of Tang *et al*. (2013). The results are differing from the findings obtained by Karthikeyan *et al.* (2009)

TABLE 3

Factors affecting willingness to pay for assured irrigation and equity in distribution of tank water in farmers managed tank area

Explanatory variables	Co-efficient	Odds ratio	Probability	p value
Age	0.037	1.038	0.51	0.425
Education attainment	0.607 *	1.836	0.65	0.001
Area Under Tank Irrigation	1.357 *	3.886	0.80	0.000
Gross Farm Income	6.52 e^{-07}**	1.000	0.50	0.030
Location of the farm (Head reach = 1, Tail reach = 0)	-0.114	0.892	0.47	0.889
Constant	-12.345 *	4.35 e^{-06}	0.00	0.001

Note: Chi-square=66.42; Pseudo R^2=0.60; * Significant at 1%; ** Significant at 5%

where area and WTP had a negative relationship. The co-efficient was positive for farm income and was significant at one percent indicating that as farmers expected benefit increases, farmers WTP also increases. The results of the study are in line with the studies of Durba and Venkatachalam (2015) and Tang *et al.* (2013). However, increase in farm income does not contribute much for the increase in WTP since the odds ratio is exactly equal to one (Table 3).

Probability gives an indication of the magnitude of the various variables on willingness to pay. The probability for education was 0.65 indicating that as education attainment increases by one year, the probability of WTP is 0.65 and the probability value was 0.80 and 0.50 for area under tank irrigation and farm income, respectively. Location of the farm had no significant effect on the WTP, this is because the farmers received irrigation water equally.

As all the farmers in tank managed by MID did not receive the irrigation water equitably, estimation of their willingness to pay to ensure the equity in distribution of water by means of establishing water users association like in case of Bukkarayana Kere tank (farmers managed) was taken up. Multinomial logistic regression was used to find the factors affecting the WTP. Pseudo R^2 was 0.44 which means that, 44 per cent of the variation in the dependent variable is explained by the independent variables included in the model. YY category was taken as the base reference category. Results revealed that, education attainment, area under tank irrigation, gross farm income and location of the farm had significant impact on WTP in case of YN category. In case of NY category only farm income had positive significant effect on WTP whereas, gross farm income and location of farm had significant effect in case of NN category.

It was found that, as the education attainment increases by one year, the log of odds ratio, probability of YN category to probability to YY category, falls by 0.231 indicating that there are less chances to remain in YN category when the education increases by one year. It also means that, if education increases by one year the probability of moving to YY category is 0.56 (1-0.44=0.56). This indicates the role of education in equitable distribution of irrigation water and in reducing free riding in water use. Similarly, if the area under tank irrigation increases by one acre, the log of odds ratio, probability of YN category to probability to YY category falls by 1.275. The probability of moving to YY category is high (*i.e.,* 1-0.22=0.78), this is quite common as the area under tank irrigation increases, the benefit farmers realizes from using tank water is more. Hence, farmers are ready to pay more or shift from YN category to YY category (Table 4).

The log of odds ratio, probability of YN category to probability of YY category, probability of NY category to probability of YY category and probability of NN category to probability of YY category in case of farm income had positive co-efficient *i.e.,* they tend to stay in the same category of YN, NY and YY category even there is increase in the farm income. Farmers with higher income might command more capital for the economic use of water allotted (Tang *et al.,* 2013). However, if we look at the probability value it was 0.50 in all the categories. The co-efficient was very less indicating a positive impact on WTP but low in magnitude.

The log of odds ratio, probability of YN category to probability of YY category for location dummy rises if the farmers are located at the head reach. The probability of remaining in YN category is high (0.95), if the farmers are in head reach indicating their non-willingness to pay. The results of the current study are in accordance with the study conducted by Durba and Venkatachalam (2015). They reported that WTP value was significant and farmers who faced high scarcity were willing to pay more than those farmers who had no water scarcity. The farmers in head reach received sufficient water and hence they remain in YN and NN category. WTP of farmers for timely and adequate supply of irrigation water differed with farm location *i.e.,* tail end farmers WTP was more compared to that of head reach farmers. The results are in line with the study conducted by Ravi *et al.* (2002).

TABLE 4

Factors affecting willingness to pay for assured irrigation and equity in distribution of tank water in MID managed tank area

Explanatory variables	Yes No (YN)		No Yes (NY)		No No (NN)	
	Co-efficient	p value	Co-efficient	p value	Co-efficient	p value
Age	-0.390 (0.40)	0.4340	0 .020 (0.51)	0.779	0 .008 (0.50)	0.899
Education attainment	-0.231 ** (0.44)	0.019	-0.076 (0.48)	0.565	-0.101 (0.48)	0.380
Area Under Tank Irrigation	-1.275 ** (0.22)	0.022	-0.781 (0.31)	0.210	-0.373 (0.41)	0.463
Gross Farm Income	3.43 e^{-06}** (0.50)	0.020	5.30 e^{-06}* (0.50)	0.003	3.59 e^{-06}** (0.50)	0.025
Location of the farm (Head reach = 1, Tail reach = 0)	2.934 * (0.95)	0.008	19.334 (1.00)	0.984	6.032 * (0.99)	0.000
Constant	2.833 (0.94)	0.425	-21.254 (0.00)	0.983	-5.658 (0.003)	0.164

Note : Chi-square=91.62; Pseudo R^2=0.44; Base Category: Yes Yes (YY); Figures in parentheses indicate probability value;
* Significant at 1 %; ** Significant at 5%

The log of odds ratio, probability of NN category to probability of YY category for location dummy was 6.032. The probability of remaining in NN category was very high (0.99). This clearly indicates the problem of free riding (using water without paying) by the head reach farmers.

Functional analysis was used to find the extent of farmers' willingness to pay for assured irrigation and equity in distribution of tank water for irrigation

Farmers actual willingness to pay for assured irrigation and equity in distribution of tank water for irrigation was estimated using the tobit model [Table 5] (Rohith and Chandrakanth, 2011; Divya *et al.*, 2015). Actual amount the farmers were willing to pay was taken as latent variable for the tobit model. Actual willingness to pay was zero for NN category which makes it suitable to use the tobit model. Zero willingness to pay indicates that the farmers may think that the tank water is a free gift of nature or he/she cannot afford to pay for the tank water (Divya *et al.,* 2015).

Thus, it is evident from the analysis that, mean WTP for the farmers in head reach coming under farmers and MID managed tank regimes was ₹ 607 and ₹ 461 per acre per year, respectively. Whereas, it was ₹ 1208 and ₹ 993 for the farmers in tail reach in farmers and

TABLE 5

Extent of farmers' willingness to pay for assured irrigation and equity in distribution of tank water

Explanatory variables	Co-efficient	p value
Age	-1.30	0.773
Education attainment	4.26 **	0.014
Area Under Tank Irrigation	-11.88	0.564
Gross Farm Income	0.00006	0.156
Location of the farm [D_1] (Head reach = 1, Tail reach = 0)	-601.45 *	0.000
Type of Institution [D_2] (Farmers managed =1, MID managed = 0)	118.74 **	0.013
Constant	1031.62 *	0.000

Note: * Significant at 1%; ** Significant at 5%

MID managed tank regimes, respectively. The average willingness to pay by the farmers located in farmers managed tank regime was, ₹ 908 (607+1208/2) per acre per year, whereas it was ₹ 727 (461+993/2) per acre per year by farmers in MID managed tank area.

In the farmers managed tank area, there was equity in distribution of water which resulted in the higher

willingness to pay (₹ 894 per acre per year) by the farmers for the assured irrigation and equity in distribution of water. Farmers in this area have recognized the importance of collective action and are acting according to the social welfare. Whereas, the tail end farmers in MID managed tank area reported that there was no equity in the distribution of tank water. The mean willingness to pay for assured irrigation and equity in distribution of water was Rs.809 per acre per year. There was a significant difference in mean WTP. Hence, the hypothesis that there is no significant difference in WTP between two water management regimes was rejected. Education attainment, area under tank irrigation and gross farm income were the significant factors affecting WTP in farmers managed tank area. Education attainment, area under tank irrigation, gross farm income and location of the farm were significant factors affecting the farmers WTP in tank area managed by MID. It is evident from the analysis that, farmers in the tail end were ready to pay more than the head reach farmers indicating the need of equity in distribution of water. Therefore, hypothesis that farmers' in the tail reach are prepared to pay more for assured irrigation and equity in distribution of water than the head reach farmers was accepted. It can be noticed that the farmers are ready to pay for assured irrigation and equity in distribution of water. Hence, there is a need to establish and to sustain the institutions which ensure the equity in distribution of water between head and tail end farmers. Same institution prevailing in the Bukkarayana kere can also be replicated to ensure the equity in distribution of water.

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