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Farmers' Willingness to Pay for Improved Irrigation Water — A Case Study of Malaprabha Irrigation Project in Karnataka, India

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In principle, the approach toward irrigation management in India has gradually shifted from a government-dominated, supply-side paradigm toward a user-preferred, demand-side paradigm. Yet, decisions regarding water allocation and irrigation charges do not adequately incorporate farmers' preferences and their willingness-to-pay (WTP) for improved irrigation. Since public investment on irrigation projects is sizeable and the opportunity cost of irrigation water is increasing, there exists a need to estimate the economic value of irrigation water in order to utilize it in an efficient manner. This paper presents results of a contingent valuation (CV) study conducted in a semi-arid region, namely, the Malaprabha Irrigation Project in Karnataka, India, which elicited farmers' preferences and their WTP value for improved irrigation. The results suggest that farmers predict a significant increase in agricultural benefits due to additional irrigation and they are willing to pay significantly higher than what they are currently paying to secure these benefits. It implies that improved irrigation increases not only the farmers' benefits but could potentially increase the government's revenue, resulting in a win–win outcome.

Keywords: Irrigation management; contingent valuation method; willingness-to-pay; water policy; India.

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1. Introduction

Water is a major factor constraining agricultural development, especially in a developing country like India and there has been much discussion on how to use economic instruments to allocate irrigation water in an efficient, equitable and sustainable manner (Hellegers and Perry 2004; Molle and Berkoff 2007). In the policy domain, there has been a categorical shift from supply-side approach (dominated largely by government decisions) toward a demand-side approach (with more of user participation), in order to generate more crop per drop (National Water Policy 2002).[1] However, imperfect markets or absence of markets for irrigation water in developing countries undermine its true opportunity cost. As a result, policy makers find it difficult to formulate suitable water pricing policies and design other institutional reforms to meet the increased water requirements of the farmers, and to recover the full cost. Thus, estimating the economic value that farmers place on incremental changes in irrigation water becomes vital in the process of deciding the economic viability of new irrigation projects.

India's National Water Policy (2002[1]; 2012[2]) emphasized the need to fix water rates periodically such that at least the operations and maintenance (O&M) costs can be recovered from the users. At the same time, there is an increase in the O&M cost due to inefficiency in the system which is unrecovered from the users, so a utility-based price of water can be expected to produce a better outcome. The Karnataka State is one among many states which has invested heavily in the irrigation sector since India's independence. During the last two decades, the capital outlay on major and medium irrigation projects in Karnataka has increased from INR 31.63 billion in 1992–1993 to about INR 209.37 billion in 2005–2006. However, the revenue collected constitutes a small percentage of the total O&M costs. The state's O&M costs have increased from INR 2.23 billion in 1992–1993 to INR 6.50 billion in 2001, whereas the gross receipts from water charges collected was 7.38% of the O&M costs in 1992–1993, which decreased to 2.84% in 2000–2001.[3] This has resulted in a "vicious cycle" (Gulati *et al.* 2005: p. 20) where poor revenue generation from irrigation projects has led to poor reinvestment

[1]Available at: http://wrmin.nic.in/writereaddata/linkimages/nwp20025617515534.pdf [20 January 2014].

[2]Available at: http://mowr.gov.in/writereaddata/linkimages/NWP2012Eng6495132651.pdf [20 January 2014].

[3]The Government of India document reporting this information shows a steep and suspicious drop in working expenses (O&M) from 6.5 billion rupees in 2000–2001 to about 0.68 billion rupees in 2001–2002 after which it hovers between 0.68 and 0.80 billion rupees till 2007 (pp:167). (http://www.cwc.gov.in/main/downloads/JS_Pricing%20of%20Water%20in%20Public%20System-%20Final-RN_29.10.pdf [24 February 2014]).

and subsequently to poor service delivery, which leaves the farmers with low farm income. Farmers' low income influences them to place low value on the current, unreliable irrigation, leading to further poor revenue generation. In the Xth five-year plan (2003–2007), the revenue that should have been collected under the Malaprabha project was 43.5 million, but the actual amount collected was only 8.23 million (*Karnataka Neeravari Nigama Limited* or KNNL officials at Belgaum, personal communication). As long as farmers benefit from the non-collected revenue, it would result in increased welfare. However, poor service delivery does not improve the farmers' welfare and uncollected O&M cost may impose a welfare loss in the society.

What explains the above phenomenon? Policy makers in India usually assume that farmers are averse to the notion of paying for irrigation water. The assumption that farmers did not pay in the past[4] and therefore they will not pay in the future as well dominates the agriculture and irrigation policies. Essentially, water supplied through a public irrigation system is a common-pool resource generating non-marketed use value to all the farmers in the command area. Although the use of irrigation water is *rival* in nature, once provided, no farmers can be *excluded* from consuming it and as a result, potential free-riding farmers can enjoy as much benefit as a farmer who pays for the service. In many cases, it is the powerful, large farmers who enjoy most of the benefits from government policies. Substantial transaction cost involved in excluding free-riders hinders identifying and excluding them. In India, as in other developing countries where large tracts of farmlands are divided into small and fragmented sections, the resources involved in monitoring and metering canal water use at farm level would be prohibitively high — making the volumetric pricing approach an opportunistically costly affair (Johansson 2000). As a result, fixing water charges much lower than the marginal cost, and poor revenue collection have become a low-level Nash equilibrium in the irrigation sector.

Estimating the economic value of irrigation water on the basis of users' utility-based marginal WTP value would help in breaking the vicious circle prevailing in the irrigation sector. Traditionally, revealed preference (RP) methods, such as production function approach, hedonic pricing method and replacement cost method, were used to estimate the economic value of irrigation water. For example, the production function approach regresses the agricultural output against various inputs including irrigation water; c*eteris paribus*, the market value of the marginal increase in output for a unit increase in irrigation water becomes the economic

[4]A few decades back, irrigation charges were not levied on many of the crops cultivated in Karnataka.

value of water used (see Maler 1991; Acharya 2000; Sahibzada 2002). However, the production function approach becomes problematic if the change in one of the inputs — such as technology — substantially changes the quantity of other inputs and consequently the corresponding outputs and prices. Similarly, production function may not reveal the scarcity value of water in the presence of large price or quantity shocks due to external factors. Moreover, in the presence of externalities and information asymmetry, the RP methods may not be able to capture the true preferences of the users. However, over the years there has been a steady increase in the use of contingent valuation (CV) method in many developing countries, including India which has proved to be a useful method of non-market valuation (Biller *et al.* 2006). The CV studies pertaining to irrigation water in developed and developing countries have categorically demonstrated that farmers can gain significant amount of producer surplus from improved irrigation projects, which is reflected in terms of their maximum WTP value (Tiwari 1998; Latinopoulos 2005; Weldesilassie *et al.* 2009; Mesa-Jurado *et al.* 2012; Bakopoulou *et al.* 2010; Tang *et al.* 2013). The present study attempts to investigate whether farmers in a different context, namely, in a semi-arid region in India, are willing to pay for an incremental change in availability of canal water for irrigation and if so, how much. A water scarce region in Karnataka, India, is used as the case study.

The rest of the paper has been organized as follows: Sec. 2 provides a description of the study area; Sec. 3 details the selection of study villages and sample households; Sec. 4 describes implementation of the CV study in the field and Sec. 5 deals with the CV results. The final section discusses the policy implications of the results.

2. Description of the Study Area

Our study area is located in the canal command of Malaprabha Irrigation Project which is situated in the semi-arid region of northern Karnataka. Construction of the Malaprabha Dam for protective irrigation[5] was completed in 1972; however, construction of some of its tail-end distributaries is still underway. The project consists of a gross command area of 3,448,000 ha, and a gross irrigated area of 275,000 ha.[6] The full capacity of the reservoir is 2079.50 million cubic meters. There are two major canals from the dam; the Malaprabha Left Bank Canal

[5]Protective irrigation system is meant for extensive irrigation, where dry irrigated crops are expected to be cultivated.

[6]http://india-wris.nrsc.gov.in/wrpinfo/index.php?title=Malaprabha_Project_JI02768 [12th January 2014].

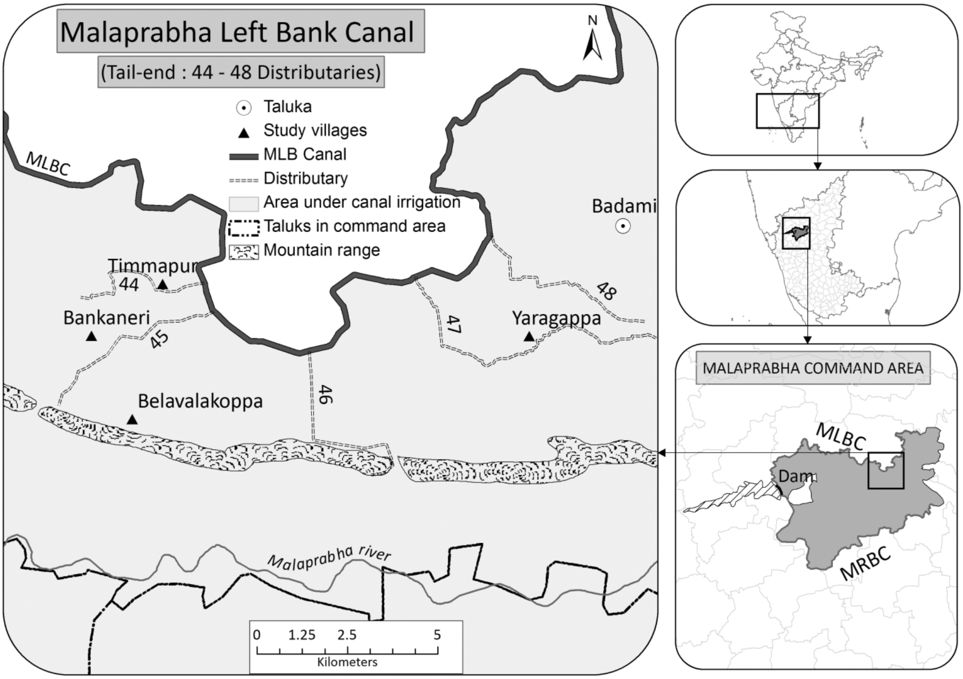

Figure 1. Map of the Study Area

(MLBC) which is 150 km long and the Malaprabha Right Bank Canal (MRBC) which has a length of 130.32 km. Both the canals are further networked through numerous distributaries. The MLBC is designed to irrigate 46,109 ha. The MLBC was appended to the main project in the mid-1960s after the villagers in that region expressed a strong preference for water (Karnataka Government 1991). Specifically, our study villages are located in the tail-end of the MLBC, which lies in Bagalkot district of Badami taluk (Figure 1). Water is released for about 5–6 months every year, beginning at the end of July/first week of August till the first week of February. This period covers the entire wet season and a part of the dry season, especially in the tail-end region.

Administration of the canal water is undertaken by the KNNL, which is a government agency. Water is released based on its availability in the dam, nature of the crop cultivated and the crop-water requirements in the command area. The KNNL decides on the nature of the crops to be grown in the command area during a particular cropping season and the decision is finalized through a consultative process among the KNNL officials, the elected representatives of *gram panchayats* and the water users associations (WUAs); the KNNL informs its decision to the farmers though local government bodies. In reality, however, there has been violation of the approved cropping pattern throughout the command area due to weak enforcement of the guidelines (see Reddy 1998: p. 188).

Principle crops cultivated during the *rabi*/dry season (October–December) are wheat, sunflower, pulses, groundnut and *jowar* (sorghum); in *kharif*/wet season (June–September), mainly maize and *jowar* are cultivated. Some farmers who own working borewells also cultivate sugarcane (January–October), which is irrigated exclusively with groundwater at present. Currently, the water rates for various crops are as follows: INR 400/acre for sugarcane, INR 100/acre for paddy, INR 60/acre for cotton, wheat, groundnut and sunflower, INR 35/acre for *jowar*, maize and *ragi* (finger millet) and INR 15/acre for fertilizer crops. However, the water rates are not strictly enforced since there is no institutional and infrastructural mechanism to punish the free-riders.

The cropping pattern in the command area has changed between the "pre-Dam" and the "post-Dam" decades and several head-reach farmers have shifted from cultivating a single crop that has four-month duration to water-intensive crops with eleven-month duration (see Reddy 1998). The cropping pattern suggested that the irrigated areas are dominated by *kharif* crops (69.3%), while only 39% of the irrigated area is occupied by *rabi* crops. Sugarcane cultivation was found to be very limited in the area (i.e., 7.75%). Focus group discussions with farm households revealed that canal water supply was inadequate in terms of timing and quantity. Persistent water leakages[7] due to broken canal lining, debris accumulation in sub-distributaries and broken gates of distributaries further aggravated the condition due to which relatively resourceful farmers have switched over to groundwater irrigation through borewells.

3. Selection of Study Villages and Sample Households

The CV study was conducted in the tail-end of MLBC which is irrigated by the 44th–58th distributaries. Although the whole region experiences inadequate canal water supply, there is variation in the levels of scarcity faced by the farmers located along the canal. Villages which receive water from the 44th, 45th and 46th distributaries face a lesser degree of scarcity than villages connected with

[7]Leakages provide groundwater recharge and repairing the canal can conceivably make groundwater extraction more expensive. However, in the study area there are significant percentages of farmers who do not have borewells and depend on canal water to meet their irrigation needs. These farmers are arguably more vulnerable to changes in water availability as compared to those farmers who own borewells. For such farmers, additional canal water provides greater irrigation security and it can be argued that there is a strong case for repairing the canals to benefit such farmers.

distributaries further down. Consequently, our study villages belong to both the high water scarcity zone (Zone A) and low water scarcity zone (Zone B).

After extensive field visits to the study area, four villages — Yaragoppa, Belawalakoppa, Bankaneri and Timmapur — were "purposively" selected for the survey. We ensured that the villages differed significantly in terms of irrigation water availability in order to estimate the relationship between improvments in water availability and WTP values. Yaragoppa (Zone A) faced a relatively higher level of water scarcity, whereas Timmapur, Bankaneri and Belawalakoppa (Zone B) experienced a relatively lower level of water scarcity. According to the 2001 Census of India, household population across Zone A (Yaragoppa — 388) and Zone B (Belawalakoppa — 240; Bankaneri — 106 and Timmapur — 152) were fairly evenly distributed. A three-stage sampling procedure was followed to select the sample households. In the first stage, all the households which were entitled[8] to receive canal water at village level were stratified into four categories, based on their land-holding size. In the second stage, sample households have been drawn in proportion to the total number of households within each stratum. In the third stage, a simple random sampling method was used to select the households from the list of respondents in each stratum (Table 1).

The overall socio-economic profile of the sample households appears to be similar. A little over 91% of the total respondents stated that agriculture was their main occupation and on an average a farmer had over 18 years of experience in agriculture. In terms of education, 85% of the respondents had received education up to secondary level which was comparable to the overall male literacy levels in

Table 1. Proportion of Sample Households According to Size of Land Holding

	Size of Landholding				
Size of Population	*Marginal Households* (< 1 Ha.)	*Small Households* (1–4 Ha.)	*Medium Households* (4–10 Ha.)	*Large Households* (> 10 Ha.)	Total
District population of *Bagalkot*	6477 (23.6)	16578 (60.5)	3607 (13.2)	731 (2.7)	27393 (100.0)
Sample population from the study area	44 (19.5)	147 (64.7)	31 (13.6)	5 (2.2)	227 (100.0)

Source: Directorate of Economics and Statistics (2007) and primary survey.
Note: Figures in parentheses are percentages.

[8]Since the dam is designed on "gravity flow" principle, farmlands which lie higher than the channels do not receive the canal water. From the KNNL office in Badami, we collected a list of households in each village which receive canal water.

Karnataka which was 75.36% (Census 2011). Only 8% of the respondents were women, and less than 3% of the households were female-headed, which echoes the state-level statistics where less than 14% of the rural households are female-headed (Census 2011). On an average, a respondent was a 40 year old male from a backward caste (*kurubas*) living in a joint family with 2–3 other adults including his spouse and three children of less than 18 years of age. The estimated median annual household income for the whole sample was INR 32,250. The median annual household income does not differ much across Zone A (INR 30,241) and Zone B (INR 33,720). These figures are comparable to the State's per capita income at constant prices for the year 2008–2009 which was INR 31,041 (Govt. of Karnataka 2010). Owing to a few wealthy farm households, the estimated mean annual incomes have more variation across Zone A (INR 51,081) and Zone B (INR 76,798).

4. CV Scenario and Households' Willingness to Participate in the Program

The CV is a survey method employed to elicit the preferences of the individuals and households towards environmental goods and services that are mostly non-marketed in nature (Freeman 1993). Water as an environmental good generates both active use values (e.g., irrigation benefits) and passive use values (e.g., option to use water in future) and unlike other RP methods, the CV method is useful in estimating the passive use values as well. It is also useful when the active use values are provided in a "differentiated" form which, in the present study, is the "improvement" in the irrigation water to be delivered. Also, when farmers perceive some extra-market benefits (such as, drinking water for cattle, fish for commercial sale) from irrigation, the CV can be assumed to capture them as well. The CV method is, however, vulnerable to *biases* and *errors* if it is not administered properly in the field (see Mitchell and Carson 1989; Carson 2012). To ensure that our CV results are not affected by potential biases and errors, we followed various guidelines prescribed in the CV literature (Arrow *et al.* 1993) — right from designing the survey instrument up to generating the final results. The interview schedule and survey instruments (such as value elicitation technique) were refined through focus group discussions with farmers from the study villages. We also conducted multiple rounds of discussions with KNNL officials and farmers to build a realistic CV scenario (see Table 2). The survey instruments were then subjected to pre-testing to check for the clarity and realism of the hypothetical scenario, completeness of information regarding socio-economic indicators and agriculture/ irrigation practices. Subsequently, inputs from the pre-tests were incorporated into

Table 2. Description of the CV Scenario

Suppose that the government of Karnataka approves a five-year plan to supply additional water to the Malaprabha dam by the next year (July 2008). Suppose this additional water would mean that there would be 30 additional rounds of irrigation for your fields. KNNL will discuss with farmers similar to yourself to decide how best to distribute these 30 additional irrigations from the beginning of August to the beginning of February. The KNNL would provide this additional water on a reliable basis only if the people of your village including you and nearby villages pay for it. The water rates collected will be used toward various canal infrastructure maintenance activities. Additional water rates for this additional water will be collected each year by KNNL.
You are among many other farmers who are being interviewed and other households have provided answers to our questions based on their social and economic conditions and preferences. Please provide your answers honestly based on your preferences, household expenditure, income and use of borewell water.
Given this situation, do you think farmers like yourself should pay additional water rates over and above the existing water rates for the additional water? ___ [Yes = 1/No = 0]
Give reasons for your response ....
Now remember that you have a certain amount of annual income and the amount committed toward this programme will not be available to you for other expenditures. Considering all these, is your household willing to pay INR *X* per acre as additional water charges to KNNL on a yearly basis to procure <u>30 additional irrigations</u> per annum? ___ [Yes = 1/No = 0]
Give reasons for your response ....

the final interview schedule used in the main survey which was conducted for a four-month period (June–September) in 2007. The final interview schedule consisted of three broad sections: (i) the general socio-economic and demographic profile of the households; (ii) prevailing agricultural and water use practices of the farmers and (iii) the CV scenario. On an average each interview lasted for 20–30 min.

During multiple discussions with the KNNL authorities, it was found that if repair of the canal was undertaken, then the farmers in the tail-end would be able to receive enough water for 30 additional rounds of irrigation between August and February each year. In other words, implementation of this proposed program would ensure that the farmers receive four to five additional irrigations in a month. Therefore, the central objective of the CV study was to estimate the expected economic benefits to be enjoyed by the farmers due to 30 additional irrigations during a cropping season (Table 2). The farm households' maximum WTP value is assumed to reflect the "producer surplus" they would derive from additional water supply — apart from any other benefits (known only to the farmers) associated with irrigation water. At the time of the survey, a typical farmer in a tail-end village was receiving water for two days in a month. Nearly 92% of the total households interviewed reported that the prevailing irrigation water supply was insufficient in meeting their irrigation requirements and 64% of them felt that water was the most constraining factor affecting their crop production. Although nearly 57% of the farm households stated that even the proposed improvement was inadequate in meeting their entire irrigation requirement, they were willing to participate in the program as they felt it would still make them better-off. Many farmers expressed their preference for growing maize with additional water as it would make a significant and positive impact on its output and subsequently on their farm income.

The payment vehicle used in the CV survey was “additional water charges”, i.e., the charges for 30 irrigations over and above the current water rates paid to the KNNL. The payment vehicle was chosen for its believability. We used other payment vehicles (increased land tax) during pre-testing and found that “water charges” alone was universally accepted by the sample farmers. Although there was a general sentiment that the amount stated will not be collected by the KNNL, the pilot survey revealed that water charges continues to be the most believable payment vehicle given the political nature of canal water (Barton and Bergland 2010).[9] The interview schedule in general and the CV scenario in particular was pre-tested among 23 agricultural households. Based on the open-ended WTP values collected during the pre-test, a single-bounded dichotomous choice (DC) bid vector was designed. The bids used were: INR 90/INR 190/INR 340/INR 540, as additional water charge to be paid per acre per year. The bids were randomly assigned to the households. Multiple internal checks were built into the CV scenario to improve the internal consistency of the results. For example, farmers were told that the government would be able to provide reliable water supply only if the farmers in the command area were willing to pay for it. In order to eliminate farmers’ apprehensions about the way in which the revenue collected would be utilized by the officials, they were assured that the revenue collected would be used toward development of canal infrastructure and its maintenance to ensure sustainable water supply. They were asked to consider other household expenditures, household income and availability of substitutes (groundwater) before stating their final WTP value. Table 3 shows total number of households interviewed from both the zones for the final survey.

[9]The authors also use a form of water charges as a payment vehicle in a choice experiment study which was located in the neighboring *Bhardra* and *Tungabhadra* Basins. They incorporate “individual status-quo” situation of the farmers in a choice experiment model — as opposed to “uniform status-quo” situation across all the respondents. They found that a substantial number of farmers wanted to continue with the status-quo situation. Our study on the other hand uses CV method and we found that nearly all of the farmers are willing to participate in the proposed program. From their model they are able to calculate the marginal value of improvement for every month, whereas in our model we estimated the total marginal value of the water for the entire period.

Table 3. Number of Sample Households Interviewed Across the Zones

Villages		Number of Sample Households	Percentage
Zone A	Yaragoppa	112	49.3
Zone B	Timmapur	56	24.7
	Bankaneri	23	10.1
	Belawalakoppa	36	15.9
	Total	227	100.0

Source: Primary data.

The response rate to the survey was high (98%) and is attributed to the use of "in-person" interview method (Arrow *et al.* 1993). The personal interview mode facilitated the researchers to engage with the farmers and remove their suspicion and doubts regarding the survey. Based on the farmers' responses to the CV scenario (Table 2), we identified 22 households which were either unwilling to participate in the survey or gave biased responses[10]; these households were subsequently dropped from the final analysis (Table 4).

Table 4. Details of Response Types

Number of farmers interviewed	227
Number of farmers willing to participate in the programme	222
Responses of farmers unwilling to participate in the programme	5
1. "I am not interested in the programme"	
2. "I currently have enough water already"	
3. "I have had a bad experience with KNNL officials in the past"	
Biased responses	17
1. Protest bids ("Government should provide it for free")	
2. Free-riders ("I will get the water anyway")	
3. Strategic response ("I want to make sure water will reach my field")	
Valid responses	**205**
1. Positive utility ("Water is important to me" & "This is my value")	
2. Budget considerations ("This is what I can pay")	
Percentage of valid responses from the original data	91%

Source: Primary data.

[10] To identify the "biased" responses, respondents were asked to state their motivations for accepting or rejecting a bid in an open-ended manner. These responses were then classified as: (a) "This is my value"; (b) "This is what I can pay"; (c) "Water is important to me"; (d) "Government should provide it for free"; (e) "I will get the water anyway" and (f) "I want to make sure water reaches my fields". Motivations falling in category (a), (b) or (c) were considered as valid responses; whereas responses classified as (d), (e) or (f) were considered as "biased responses".

Table 5. Relative Frequency of Accepting/Rejecting the Offered Bid

Bid Amount	Frequency of *yes* and *no* Responses		Percentage of *yes* Responses	Percentage of *no* Responses
INR 90 ($n = 55$)	Yes = 39	No = 16	70.9	29.1
INR 190 ($n = 45$)	Yes = 29	No = 16	64.4	35.6
INR 340 ($n = 52$)	Yes = 34	No = 18	65.4	34.6
INR 540 ($n = 53$)	Yes = 11	No = 42	20.8	79.2

Source: Primary data.
$N = 205$ valid responses.
Note: Figures in parentheses are the number of respondents offered one of the four bids.

Table 5 shows that the responses to various bids were in tandem with standard demand theory which states that as the price of a commodity goes up, the demand for it declines — *ceteris paribus*. As expected, 70.9% of the farmers presented with the lowest bid (INR 90) accepted it, whereas 79.2% of the farmers presented with the highest bid (INR 540) rejected it.

In the following section, we describe the theoretical model for estimating the mean WTP values from the DC responses and assess various socio-economic factors which determined farmers' WTP value.

5. Estimation of WTP Value

The single-bounded DC format employed in the present study closely replicates the choices that individuals face in a market situation. A respondent is asked about her WTP a monetary value to move from the 'status quo' situation (W_0) to an improved, alternative situation with 30 additional irrigations (W_1). If U_1 and U_0 are her utility from the two choices — namely, W_1 and W_0 such that $W_1 > W_0$, then as a utility maximizing agent, she will respond with a *yes* to the assigned bid only if $U_1 > U_0$, and will respond with a *no* otherwise. However, such a qualitative response will only indicate whether the respondent's WTP is above or below the bid value assigned rather than revealing her maximum WTP value. For example, if the respondent says *yes* to a randomly assigned bid (e.g., INR 90), it only tells us that her WTP is either equivalent to or more than the bid value. From the *yes* or *no* answers to the bids assigned, the researcher needs to estimate the actual mean WTP value. This is where the Random Utility Model (RUM) is employed.

The RUM assumes that the respondents know their utility function clearly, but not all components of this utility function are observable to the researcher (Hanemann and Kanninen 1998: p. 5; McFadden 1974; Greene 2010). We assume that the respondents will choose the most preferred option when deciding between the status quo and the alternative water supply scenarios. We also assume that their decision will be based on observable variables (e.g., bid value and number of additional irrigations) and unobservable variables (e.g., differences in taste and preferences). Denoting the stochastic component as ε, the indirect utility function of a farmer takes the following form: $U(Y, Z, W, \varepsilon)$, where $\boldsymbol{Y}$ is the total income; $\boldsymbol{Z}$ represents the vector of the socio-economic characteristics; $\boldsymbol{W}$ represents the levels of irrigations and ε represents the random error. When a move from W_0 to W_1 is considered preferable by the respondent, the linear formulation of the RUM is given as:

$$U_1(Y_i, Z_i, W_1, \varepsilon_{1i}) \geq U_0(Y_i, Z_i, W_0, \varepsilon_{0i}). \tag{1}$$

The respondent is informed that to move from W_0 to W_1 will cost her INR C, in which case the linear form of the utility function in (1) becomes:

$$\begin{aligned}[U(_1) = \alpha_1 + \beta(Y - C) + \gamma_1 Z + \delta_1 W_1 + \varepsilon_1] \\ \geq [U(_0) = \alpha_0 + \beta Y + \gamma_0 Z + \delta_0 W_0 + \varepsilon_0],\end{aligned} \tag{2}$$

where $U(_0)$ is the utility derived from the status-quo position (without additional irrigations), $U(_1)$ is the utility derived from the improved position (with 30 additional irrigations), $\boldsymbol{Z}_i$ is the vector of respondent's characteristics such as gender, age, education and caste, $\boldsymbol{C}$ is the random bid amount offered to the respondent, $\boldsymbol{W}_0$ and $\boldsymbol{W}_1$ are the two levels of irrigations and the random error term, ε includes the unobservables affecting the utility. For utility maximization, the probability of a respondent answering *yes* to INR C is given by the following specification (Boyle 1990; Greene 2010; Haab and McConnell 2002):

$$\Pr(\text{Yes}|C) = \Pr[(U_1 - U_0) > 0]. \tag{3}$$

Substituting for U_1 and U_0 from Eq. (2) in the above probability Eq. (3), we obtain:

$$\Pr(\text{Yes}|C) = \Pr[(\alpha - \beta C - \gamma Z - \delta W + (\varepsilon_1 - \varepsilon_0) > 0]. \tag{4}$$

In the above equation, α denotes $(\alpha_1 - \alpha_0)$; γ denotes $(\gamma_1 - \gamma_0)$ and δ denotes $(\delta_1 - \delta_0)$. After a few algebraic manipulations, we obtain:

$$\Pr(\text{Yes}|C) = \Pr[\varepsilon \geq -(\alpha - \beta C - \gamma Z - \delta W)]. \tag{5}$$

If the random error term ε follows a logistic *cdf*, we obtain:

$$\Pr(\text{Yes}|C) = \frac{1}{1 + e^{(\alpha - \beta C - \gamma Z - \delta W)}}. \tag{6}$$

The right-hand side of Eq. (6) is the standard logit model, where α, β, γ and δ are the unknown parameters to be estimated. Estimates of these unknown parameters are obtained from constructing and maximizing the log-likelihood function, which in general form is given as (Hanemann and Kanninen 1998: p. 24):

$$\text{Log } L = \sum_{i=1}^{n} y_i \ln P_i + (1 - y_i) \ln(1 - P_i), \tag{7}$$

where $P_i = \Pr(\text{Yes}|C, Z, W, \theta)$ and θ is a vector denoting the unknown parameters α, β, γ and δ. After collecting the estimated parameters from the log-likelihood function, the mean WTP is calculated as

$$\text{Mean WTP} = \frac{1}{\beta} \ln[1 + e^{\alpha - \gamma z - \delta w}]. \tag{8}$$

The specific econometric model which was estimated from the functional form in Eq. (6) is

$$\begin{aligned} \Pr(yes) = {} & \beta_0 + \beta_1 \text{BID}_i + \beta_2 \text{ZONE}_i + \beta_3 \text{CANAL\_LAND}_i + \beta_4 \text{BW\_LAND}_i \\ & + \beta_5 \text{CROPINCOME}_i + \beta_6 \text{AGE}_i + \beta_7 \text{GENDER}_i + \beta_8 \text{MEMBER}_i \\ & + \beta_9 \text{ILLITERATE}_i + \beta_{10} \text{PRIMARY}_i + \beta_{11} \text{SECONDARY}_i \\ & + \beta_{12} \text{HIGHSCHOOL}_i + \beta_{13} \text{CASTE}_i. \end{aligned} \tag{9}$$

The above logit model was estimated using the STATA 11.1 package (see Table 7). The variable selection was based on a literature review of other studies which have used CVM to estimate the economic value of surface irrigation water.

Factors Influencing WTP Values:
As predicted by economic theory, we expected that farmers from Zone A (with high water scarcity) will have higher WTP than those in Zone B (with low water scarcity) (see Zakaria *et al.* 2013). Similarly, the WTP was expected to increase with increase in income (Weldesilassie *et al.* 2009; Tang *et al.* 2013) and decrease with increasing size of the bid, i.e., be negatively related to the size of the bid (Loomis 1988) — all under the assumption of *ceteris paribus*.

In Karnataka, since the last decade there has been an emphasis on creating institutions to facilitate participatory irrigation management (PIM); the State Water Policy (Government of Karnataka 2002) and the Karnataka State Irrigation Act (Government of Karnataka 2002) placed emphasis on decentralized decision making through establishing WUA. The new paradigm was aimed at transferring some of the important activities previously carried out by the government agents, such as, O&M, water distribution and revenue collection, to the farmers' associations (Biswas and Venkatachalam 2010). Although there has been emphasis on having inclusive decision-making processes at the national and state levels, the

Table 6. Summary of Variables used in the Final Model

Variable Name	Variable Definition	Mean Value	Min.	Max.
BIDS (discrete)	Bids offered to the respondents: INR 90; INR 190; INR 340; INR 540	291.70	90	540
ZONE[a] (dummy)	Location of the village: 1, if the household is located in the high water scarce zone and 0 otherwise.	0.521	0	1
CANAL_LAND (acres)	Total land irrigated mainly by canal water for the year 2005–2006	3.65	1.16	20
BW_LAND (acres)	Total land irrigated mainly by groundwater for the year 2005–2006	3.20	0	60
CROPINCOME (rupees)	Total annual income from sale of crops for the year 2005–2006	45,620	1500	478,250
AGE (years)	Age of the respondent	40.0	18	77
GENDER[a] (dummy)	Sex of the respondent: 1 if the respondent is male and 0 otherwise	0.912	0	1
MEMBER[a] (dummy)	Member of water user's association: 1, if the respondent is a member and 0 otherwise.	0.243	0	1
ILLITERATE[a] (dummy)	1, if the respondent is illiterate and 0 otherwise.	0.360	0	1
PRIMARY[a] (dummy)	1, if the respondent has at most a primary level education and 0 otherwise.	0.219	0	1
SECONDARY[a] (dummy)	1, if the respondent has at most a secondary level of education and 0 otherwise.	0.273	0	1
HIGHSCHOOL[a] (dummy)	1, if the respondent has at most a high school level education and 0 otherwise.	0.053	0	1
CASTE[a] (dummy)	Caste of the household: 1, if the household is from a backward caste and 0 otherwise	0.64	0	1

Note: [a]Mean estimates of dummy variables are to be interpreted as percentages. For example, mean gender of 0.91 implies that 91% of the respondents were male.

existing institutional arrangements still follow the command-and-control paradigm, which is a "supply-side approach" by nature. The centralized decision on the cropping pattern, penalty for crop violation and existing pattern of inter and intra-sectoral water allocation are evidences of the supply-side policies pursued by the governments. Moreover, the proposed institutional arrangements outlined in the

Table 7. Regression Results of the Logit Model

Variables	Coefficient	SE	z-Scores	$P > \|Z\|$
BID	−0.0051893**	0.0010369	−5.00	0.000
ZONE	1.794819**	0.4245674	4.23	0.000
CANAL_LAND	−0.0070958	0.0700543	−0.10	0.919
BW_LAND	−0.0843205*	0.0487426	−1.73	0.084
CROPINCOME	4.64e-06*	2.70e-06	1.72	0.085
AGE	0.0253675*	0.0132488	1.91	0.056
GENDER	−0.8928784	0.5997728	−1.49	0.137
MEMBER	0.1780384	0.4767809	0.37	0.709
ILLITERATE	−0.2098757	0.752953	−0.28	0.780
PRIMARY	−0.1638228	0.7580237	−0.22	0.829
SECONDARY	0.7379472	0.7161993	1.03	0.303
HIGHSCHOOL	0.5829297	0.9759222	0.60	0.550
CASTE	0.2267796	0.4267707	0.53	0.595
CONSTANT	−0.2220683	1.036933	−0.56	0.576
Log-likelihood	−106.51918			
Wald chi-square	51.17			
Prob > chi^2	0.000			
N	205			
Predicted probability	0.5677			
Pseudo R^2	0.2257			

**Denotes significance at 1% levels.
* Denotes significance at 10% levels.

State Water Policy 2002 have been tried elsewhere (e.g., River Basin Boards in *Palar* and *Thambirabharani* basins in Tamil Nadu) but they have become dysfunctional over time (Venkatachalam, 2006). Some studies have found the impact of farmers' participation in water allocation decisions to be insignificant (Weldesilassie *et al.* 2009); however, there is scope to investigate this relationship further in our study area.

Groundwater is an important source of irrigation and a substitute for surface irrigation; considering that nearly 47% of the farmers we interviewed had at least one working borewell, it was expected that the size of the area under groundwater irrigation would be negatively related to the WTP value. Since borewells provide better control over water supply than the supply through canal systems and electricity for agricultural operations is highly subsidized, farmers were expected to have higher preference toward groundwater, thereby placing a lower WTP value on the canal water (see Tang *et al.* 2013; Srinivasan and Kulkarni 2014).

The standard socio-economic factors considered for the analysis include education, gender, caste and age of the respondent. Although many CV studies on drinking water supply found that the WTP was positively influenced by education

(Whittington *et al.* 1990; Venkatachalam 2006); in the case of irrigation, its influence was ambiguous (Chandrasekaran *et al.* 2009; Tang *et al.* 2013). Hence, there is scope to investigate if education levels influence a farmer's preference for additional water. In the case of gender, previous studies revealed mixed outcomes (Weldesilassie *et al.* 2009; Tang *et al.* 2013). Owing to the "masculine" nature of irrigation practices (Zwarteveen 2011, 1995) and the fact that women negotiate financial and agricultural decisions within complex and dynamic social situations, no specific direction between gender and WTP values was expected. Age was expected to bear a positive influence on the WTP because with age, farmers gain more experience in agriculture and are able to perceive the benefits of improvements in canal water supply.

Regression results revealed that the mean WTP value for the whole sample was at INR 219/per acre and the estimated median WTP value is approximately INR 144/per acre for 30 additional irrigations (USD 1 = INR 43 at 2008 exchange rates) for the total sample. The WTP value of the farmers from high water scarcity zone was significantly higher than that of farmers in low water scarcity zone. However, the O&M costs in 2008–2009 for repairing the Malaprabha canals was INR 19.6 million (USD 0.40 million) or INR 192/acre. This implies that based on the mean value, there is a significant scope that farmers can gain a significant amount of producer surplus even after paying for the cost of implementing the program.

In terms of farmers' preferences, more than 74% of the farmers wanted to utilize the additional irrigations to cultivate maize, implying that 74% of the respondents were willing to pay over six times the current water charges for maize (i.e., INR 35/acre). Poor water supply during crucial periods of the crop cycle usually leads to underdeveloped maize pods reducing their profitability substantially. The farmers, as rational economic agents are able to weigh this loss in profits from the status quo water supply situation against the gains from the proposed improvements and state their WTP value accordingly. With the improved irrigation, they may not be able to bring in additional land under maize cultivation, but they would be certainly able to increase the productivity of maize.

Results indicated that the variables included for the analysis behaved according to prior expectation (Table 7). The variable for the randomly assigned DC bids (BID) is highly significant and negatively related to WTP value, implying that as the bid amount (i.e., price of water) increases, the WTP value (reflecting the demand) declines significantly (Tables 7 and 8). This pattern is seen in other empirical studies as well (Tang *et al.* 2013; Weldesilassie *et al.* 2009), and conforms to standard demand theory which states "as the price of a commodity, increases, the demand for it declines" — confirming the theoretical validity. The

Table 8. Marginal Effects Model

Variables	dy/dx	SE	z-Scores	$P > \|Z\|$
BID	−0.0012732	0.00025	−4.99	0.000
ZONE[a]	0.4160873	0.08771	4.74	0.000
CANAL_LAND	−0.001741	0.01719	−0.10	0.919
BW_LAND	−0.0206884	0.01199	−1.73	0.084
CROPINCOME	1.14e-06	0.00000	1.72	0.086
AGE	0.006224	0.00326	1.91	0.056
GENDER	−0.2191264	0.14013	−1.56	0.118
MEMBER[a]	0.0433633	0.11516	0.38	0.707
ILLITERATE[a]	−0.0516431	0.18563	−0.28	0.781
PRIMARY[a]	−0.0404045	0.18771	−0.22	0.830
SECONDARY[a]	0.1740786	0.15992	1.09	0.276
HIGHSCHOOL[a]	0.1350389	0.20856	0.65	0.517
CASTE[a]	0.0558177	0.10526	0.53	0.596

Note: [a]For dummy variables, dy/dx is to be interpreted for a discrete change from 0 to 1.

influence of location (ZONE) of the villages on the WTP value was indeed significant and farmers who faced high scarcity (Zone A) were willing to pay significantly higher than those farmers in Zone B. The estimated marginal effects model shows that the probability of a *yes* response from farmers in Zone A is nearly 0.42 percentage points higher than the probability of a *yes* response from farmers in Zone B (Table 8). The influence of income generated from the sale of crops (CROPINCOME) on WTP value was positive and highly significant; it indicates that as a farmer's expected benefit increases, her WTP also increases. However, the estimated mean WTP of INR 219 is a small percentage of the total income, i.e., about 0.7% of the median annual income for the whole sample which was INR 33,480.

As mentioned earlier, a significant number of farmers reported having at least one working borewell indicating a conjunctive use of ground and surface water. Therefore, the land under borewell irrigation (BW_LAND) was significantly and negatively influencing the WTP value. The probability of a *yes* response declines by 0.021 percentage points for every unit increase in area under groundwater irrigation (Table 8). Srinivasan and Kulkarni (2014) pointed out that the farmers using groundwater have better control over the timing and the quantity of water to use. In Karnataka, electricity is free for farmers with borewells operated with less than 10 HP motors and almost all of the farmers with borewells use a 5 HP or a 7.5 HP motor in the study area. For farmers with borewells, the calculated opportunity cost of using electricity to pump groundwater was INR 635/acre/year which is borne by the state government since electricity is free. The amortized cost of borewells (including failed borewells) borne by the farmers was INR 6834/acre/year (see, Anantha 2009). Owing to increasing uncertainty of canal water, more and more farmers depend on the groundwater for irrigation. Therefore, as the land under groundwater irrigation for a farmer increases, substitution of groundwater for surface water increases and this can explain low level of WTP for surface irrigation as compared to the cost of using groundwater.

Theoretically, a well-functioning WUA would be able to manage and distribute the additional irrigation water better implying that the members will have access to better irrigation water supply than non-members and therefore their marginal utility of additional units of water will be lower as compared to the non-members. It was therefore expected that members of WUA would have a lower WTP than the non-members. Although in our study, the direction of the relationship of that variable (MEMBER) does not reflect this causation; its influence on the WTP is insignificant. It implies that members and non-members did not have significantly different WTP values for the program (see Weldesilassie *et al.* 2009). To some extent, this can be taken as an indication of the poor performance of the WUAs in the study area.

Although, the gender of the respondent (GENDER) was insignificant, the direction implies that women had lower WTP value for irrigation water than their male counterparts. Rural women in developing countries have a general lack of decision making autonomy over important natural and financial resources. In the case of water, rights over it are strongly linked with land rights and majority of the land is owned by men (Agarwal 1994). Therefore, women have often been neglected in irrigation management even when they contribute significantly to agriculture and irrigation in terms of labor (Zwarteveen 1997; van Koppen *et al.* 2001). Additionally, irrigation policies also fail to consider women's water use patterns which may be different from their male counterparts (Shah 2002; Zwarteveen 1995). In general, these factors may influence women to have relatively conservative WTP value for irrigation water and more empirical studies are required to explore this issue.

The levels of education of the respondents (dummy variables for education) turned out to be insignificant. One explanation could be that most farmers have either been practicing agriculture for a long time or have been exposed to various aspects of agriculture for most of their lives and therefore, even the illiterate farmers were well-versed with various dimensions of agriculture and irrigation. The age of the respondent (AGE) positively and significantly influences the WTP value implying that older farmers are willing to pay more than the younger farmers. One reason could be that older farmers, who have seen their lands being

Table 9. Predicted Probability of a *yes* Outcome for Each Zone Across Bids

Location	Bids			
	INR 90	INR 190	INR 340	INR 540
Zone A (*high water scarcity zone*)	0.9024	0.8441	0.7082	0.4105
Zone B (*low water scarcity zone*)	0.6213	0.4721	0.2773	0.1163

Source: Primary data.

cultivated with canal water some 10–15 years ago, may still consider canal water to be of good quality. At different levels of total annual income from crop sales (CROPINCOME), we find that the probability of paying additional water rates increases which conforms to the general demand theory. Even households with low levels of annual income were willing to pay for improved irrigation services. For instance, almost 50% of the low income households with annual income of INR 5000 or less were willing to pay for improved irrigation supply (table not reported here).

It was expected that the WTP for additional water will be lower in the relatively less water scarce region (Zone B) as compared to the high water scarce region (Zone A). From Table 9, we see that more farmers from Zone A were willing to accept the bids presented to them as compared to the farmers from Zone B. The probability that a farmer will pay the lowest bid is almost 90% in Zone A, but it is only 62% in Zone B. In the case of the highest bid of INR 540, the probability declines to 41% in Zone A and 12% in Zone B. Overall, we can see that for each bid level, farmers from Zone A showed a higher WTP as compared to the farmers in Zone B.

6. Discussion and Conclusion

Given the shift in the irrigation management paradigm in India, it becomes important for the policy makers to understand the economic value that the farmers would place on irrigation water as well as the factors that influence such values. We estimated economic values for improved irrigation water supply in the tail-end villages of the Malaprabha Irrigation Project. Using CV method, we estimated the mean WTP value of the proposed improvements in irrigation for the whole sample, which stood at INR 219/acre/year and the estimated median WTP stood at approximately INR 144/acre/year. There are important policy implications to our results. The O&M costs for repairing the Malaprabha canal to provide the additional irrigation was INR 192/acre/year which is less than the mean WTP. This implies that the additional charges would be able to cover the cost of repairing the canal infrastructure and could still generate a positive producer surplus. It is possible to use these estimated economic values to design pricing policy which accounts for the differences in the level of irrigation water availability and differential socio-economic background of the farmers.

Our results show that farmers were indeed willing to pay substantially more for the improved irrigation than their current cost. Secondly, a large number of farmers also expressed their preference to cultivate maize with additional irrigation; their mean WTP value was nearly six times greater than the current water rates for maize. Additionally, farmers facing high water scarcity were willing to pay significantly more than the farmers from low water scarce zone. Thirdly, borewell ownership as indicated by the land under borewell irrigation turned out to have a significant and negative influence on their WTP value. The implication is that farmers prefer groundwater to the prevailing supply of surface irrigation water due to the high level of control they have over groundwater use (see also Srinivasan and Kulkarni 2014). Finally, members of WUAs did not have a significantly different value for improved water supply as compared to the non-members. To some extent, this points toward the failure of WUAs in this region.

The results suggest that the policy makers, rather than following conventional command-and-control method of irrigation management, will have to take into account the preferences and associated WTP values of the farmers in a meaningful way while formulating irrigation policies. Our study categorically demonstrated that if irrigation water is provided on a reliable basis, the farmers would benefit from it significantly and will be able to pay a particular portion of their increased producer surplus for irrigation water. So, improvements should come first before collecting the revenue from the farmers. Farmers also seem to understand the fact that payment for improved water services alone will bring accountability on the part of the government since payment empowers them to question the government in case there is a government failure. So, true farmer participation in irrigation management does not emerge from WUAs in isolation but from the process of collecting revenues from farmers for improved, reliable water supply.

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