Valuation of access to irrigation water in rural Ethiopia: application of choice experiment and contingent valuation methods

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Abstract:

Water scarcity for various uses constitutes a major global concern affecting millions of people but the problem is more serious especially in Africa. In a situation where farmers do not pay for irrigation water use, this study aims to investigate demand-side issues by eliciting farmers' willingness to pay (WTP) for access to irrigation water. We employ choice experiment and contingent valuation methods to valuing access to irrigation water taking Ethiopia as a case in point. Unlike previous studies, the study covers users and non-users of irrigation water using the same baseline (status quo) conditions and compares the preferences of these two groups. Four attributes identified in the choice experiment are number of crop seasons, frequency of watering in a season, crop type and payment. Results show that marginal WTP was Birr 17.7, 261.8 and 87.6 for number of crop seasons, watering frequency in a season and crop type respectively. Our estimate of WTP of farmers for operation and maintenance of irrigation schemes per hectare of irrigated land range from Birr 738 (from the CE) to Birr 784 (from the CVM). We find non-users are willing to pay more in general as well as for the number of crop seasons specifically.

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ABSTRACT

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Key words: irrigation water, choice experiment, contingent valuation, Koga irrigation project, Ethiopia.

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1. Introduction

Agriculture, particularly irrigation, is the largest consumer of water accounting for 50 to 70% of the world's water resources (Rosegrant et al., 2002; Molle, 2002). The poverty reduction role of agricultural water use is one that has received currency in the international debates on water scarcity (ADBG, 2010, Mendali and Gunter, 2013; Sasson, 2012). In particular, there tend to be strong links between irrigation and agricultural development in Sub-Saharan Africa in general and Ethiopia in particular and hence expanding irrigation is viewed as a way out to enhancing productivity and reducing poverty (ATA, 2010; Awulachew, 2010; Namara et al., 2012; You, 2008).

In Ethiopia agriculture still contributes close to 40 percent of GDP (Matousa, Todob, & Mojoc, 2013) and the bulk of the agricultural output comes from around 11.7 million individual peasant/smallholder farmers (Diao and Pratt, 2007; MoARD, 2010; Gebreegziabher et al., 2012). The various policies and strategies of Ethiopia have also emphasized the role of irrigation in the development and growth of the agricultural sector (MoWR, 1999; NPC, 2016). Ethiopia's Climate Resilient Green Economy (CRGE) strategy also envisages creating new agricultural land through reclaiming degraded areas and improving productivity through small-, medium-, and large-scale irrigation to also limit encroachment into forest land and reduce the pressure on forests (FDRE, 2011).

The government of Ethiopia has been investing in irrigation projects aimed at changing the rain-fed subsistence agriculture to irrigated commercial agriculture (MoWE, 2010). A key problem is that irrigation water is not properly priced. Proper pricing of irrigation water is essential for various reasons. Firstly, irrigation water or water in general is a scarce resource. Second, the delivery of irrigation water requires a lot of investment and cost recovery is important for sustainability of irrigation schemes and their expansion (Easter and Liu, 2005). Thus water charges could be thought of as a means of cost recovery of public money spent on irrigation. The pricing of irrigation water is viewed to be essential to rationally utilize irrigation water and to water use discipline (Ortega et al., 1998).

However, there are very few rigorous empirical studies that use valuation methods to analyze farmers' preferences for irrigation water especially in Africa. The main objective of this study is to assess demand-side issues by eliciting farmers' willingness to pay (WTP) for attributes of irrigation water and for operation and maintenance of irrigation schemes, and suggest mechanisms for water pricing taking Ethiopia as a case in point. Key questions involved in this regard are: what is WTP of farmers for operation and maintenance of irrigation schemes? To what extent do farmers value characteristics such as water availability/reliability in a season and across seasons and whether there is scope for differentiated irrigation water charges? In a situation where users do not pay for irrigation water, would there be differences in willingness to pay between users and non-users when both are put in the same baseline (status quo) condition?

The study employs choice experiment and contingent valuation methods to valuing irrigation water. Our respondents live around the Koga irrigation project area and some are beneficiaries of irrigation water while others are not. Considering the farmers in our study area do not currently pay for irrigation water and are poor, what is proposed in this study is willingness to pay of farmers to cover operation and maintenance cost of the irrigation schemes[1]. Unlike previous studies of value of irrigation water, we also make comparison of preferences of users and non-users of irrigation water when both are put under the same baseline (status quo) condition. Based on review of the literature, a pilot study and discussion with experts, the following three attributes were identified in the choice experiment (in addition to a payment attribute included in such choice experiments): number of crop seasons, frequency of watering in a season, and crop type. Results show that marginal WTP of farmers in out sample was Birr 17.7, 261.8 and 87.6 for number of crop seasons, watering frequency in a season and crop type respectively. Willingness to pay of farmers for operation and maintenance of irrigation schemes per hectare of irrigated land range from Birr 738 (from the CE) to Birr 784 (from the CVM). We also find that non-users of irrigation water are willing to pay more per hectare than users.

The rest of the paper is organized as follows. The next section discusses water pricing, reviews some empirical studies on valuation of irrigation water; and ends with a description of what the current study does. Section 3 presents the theoretical and empirical framework

[1] An implication of this focus on covering only the operation and maintenance costs of irrigation schemes is that we cannot directly compare the willingness to pay measures generated this way with measures of marginal value/contribution of irrigation water that may be calculated based on observational data on agricultural inputs and outputs.

employed in this paper. Section 4 provides data, survey design and context. Section 5 presents results and section 6 discussion and draws some policy implications.

2. Irrigation Water Pricing: Literature Review

2.1. Water pricing

The quality and quantity dimensions of water scarcity constitute major challenges (Molden, 2007; UN, 2007; Noemdoe et al., 2006; Duchin et al., 2012; WWAP, 2012) and pricing of water is among the variety of policy interventions that could be envisaged to address both of these dimensions of scarcity and to enhance water use efficiency (Ortega et al., 1998; Ray, 2002; Molle and Berkoff, 2007; Molle, 2009). Specifically, water pricing is expected to play two important roles; that is, one is financial and another one economic (Dinar and Mody, 2004; Dinar and Saleth, 2005).[2] The different systems of water pricing available could broadly be classified into two as volumetric and non-volumetric (Dudu and Chumi, 2008). While the volumetric approach relates the price with volume of water used prices are set independent of the volume of water in the non-volumetric approach. Each of these approaches has its own merits and demerits (Johansson *et. al.*, 2002).

In reality, the application of volumetric pricing approach could be one of marginal cost pricing or block rate pricing. In case of marginal cost pricing the price of water is equated to the cost of producing an extra unit of water (Tsur and Dinar, 1997). In contrast, block rate pricing is an increasing price schedule. The distinguishing feature of block rate pricing is that it induces water use reduction without burdening farmers with the full cost that simple marginal cost pricing entails (Bar-Shira and Finkelshtain, 2000; Bar-Shira *et. al.,* 2006). However, the difficulty of monitoring the actual quantity of water consumed is one of the limitations in practical applications of volumetric pricing (Dudu and Chumi, 2008).

[2] As regards to its financial role, water pricing serves as a way of recovering the investment as well as operation and maintenance cost of irrigation provision. Concerning its economic role, water pricing is viewed helps signaling the scarcity value and the opportunity cost of water in order to guide allocation decisions both within and across subsectors of water. [see Dinar and Mody (2004) and Dinar and Saleth (2005)]

In practice, non-volumetric pricing is the most widely used approach (Bos and Walters, 1990; Johansson *et al*., 2002). The 'per area pricing' is the most common water pricing approach within the class of non-volumetric pricing. In this case, users are charged according to the size of land they irrigated. As compared to the volumetric approach this is easier to implement and administer and less data intensive (Tsur and Dinar, 1997). For the present study, we consider 'per area pricing'. However, we also take into account crop type (to consider crop water requirement), water availability in a season and number of crop seasons which reflect the quantity of water that could be used. Thus, this could be considered as semi-volumetric pricing.

2.2. Past studies on valuation of irrigation water

Irrigation valuation studies cover developed and developing countries, though very limited in number. Latinopoulos (2005) use CVM and hedonic pricing method (HPM) and finds that the value of irrigation water is low irrespective of the method employed. Akter (2007) studies the economic value of irrigation water in a government managed small scale irrigation project (GMSSIP) in Bangladesh. Her estimate of WTP for use of irrigation water from GMSSIP is Taka 1670 (US$ 23.85) per kani (1.32 acres) of land per cropping season implying farmers are WTP 12 percent of their average agricultural income per cropping season. Karathikeyan et al. (2009) using CVM find WTP of farmers for irrigation water is INR (Indian rupee) 218/ha/year.

Barton and Bergland (2010) and Uwera and Stage (2015) are studies we could find outside Ethiopia that use a choice experiment in developing countries on irrigation water. Both studies consider individual status quo options. Barton and Bergland (2010) evaluate hypothetical irrigation water pricing regime in Karnataka State, India. The proposed attributes include increasing the availability of water in the dry season, increasing irrigation frequency, water sharing with downstream water users, set against the introduction of a semi-volumetric irrigation price. Given the large heterogeneity in farmers' status quo (SQ) water availability, irrigation practices and current water tax payments, the SQ could not be given a unique baseline interpretation. By coding the individual SQ situation of farmers, they observed considerable increase in the explanatory power of the choice experiment models. Barton and Bergland (2010) also find that the majority of farmers chose the status quo (SQ) option.

In Ethiopia, some unpublished works there are not empirical studies related to valuation (pricing) of irrigation water for agricultural use . Other studies in developing countries related to water that apply contingent valuation and choice experiment include Whittington et al. (1990), Goibov et al (2012) and Tarfasa and Brouwer (2013). However, these studies do not consider uses of water for irrigation.

In sum, the literature on valuation of irrigation water using stated preference valuation methods is limited. The application of choice experiment method in irrigation water valuation is even more limited in developing countries in general and Ethiopia in particular. Hence, it would be an important contribution to value irrigation water in a developing country context applying choice experiment method. This provides an approach to indirectly revealing the extent to which farmers would be willingness to pay for the different attributes and levels of irrigation water. In addition, this would also be helpful for assessing the feasibility of a pricing scheme that may depend on attributes (Barton and Bergland, 2010). In this study we use both choice experiment and contingent valuation methods to valuing irrigation water taking Ethiopia as a case in point. Taking advantage of data collected from users and non-users of irrigation in the study area and unlike previous studies, we also make comparisons between preferences of these two groups (users and non-users). The comparison is made possible with the use of the same baseline (status quo) conditions for both groups.[3,4]

3. Conceptual and Empirical Framework

3.1 Conceptual framework

Choice experiments (CE) are becoming a popular means of environmental valuation (Hanley et al., 2001) with their theoretical grounding in Lancaster's model of consumer choice (Lancaster,

[3] For a detailed discussion of issues related to baseline (status quo) options in choice experiments see Whittington and Adamowicz (2011).

[4] We do the comparison for the following two related reasons: (1) users are not paying for irrigation services and the idea is to introduce payment to cover operation and maintenance costs of irrigation schemes; so even users are expected to pay for everything they currently use and not just for the improvements from their existing situation. While this implies that the status quo conditions would be hypothetical for users and real for non-users, this appears to be more appropriate given the objective of introducing payment and the need to make reasonable comparison between the two groups; (2) while considering individual status quo conditions could be more realistic for users of irrigation services (instead of using hypothetical status quo conditions) we believe there may be a tendency for users to choose the status quo condition as they may be satisfied and therefore may want to continue with the existing condition where they do not pay for the service. [see Barton and Bergland (2010)].

1966). The econometric basis for the current choice modeling theory stems from McFadden (1974, 1978), who later extended the random utility theory (RUT) that was developed by Thurstone (1927) to multiple comparisons and choices (McFadden & Train, 2000). Lancaster proposed that consumers gain their utility not from goods, but rather from the attributes these goods render.[5] We assume that the utility (or returns) farmers attain from involving in one or another irrigation water option within a particular choice set, say *C*, consists of all attributes related to these options. Thus, farmers utility function in relation to the choice setting being considered can be specified as follows (Brouwer et al. 2010a,b; Goibov et al. 2012):

$$U_{ij} = V(Z_{ij}, S_i)+\varepsilon_i \qquad (1)$$

where U_{ij} refers to utility that farmer-*i* derives from choosing or involving in irrigation water option *j*; *Z*- denotes the attributes of the irrigation water option *j*; S_i stands for socio-economic characteristics of farmer *i* and $\varepsilon_{i.}$ is the error term. Equation (1) suggests the level of utility the *i*th -farmer attains is linked to attributes of irrigation water option *j*, $Z_{ij,}$ socio-economic characteristics of farmer *i*, S_i, and error term ε_i. Note also that, as RUT posits, farmer *i*'s utility level associated with the choice of irrigation water option *j* as in (1) is composed of observable/deterministic component *V(.)* represented by *Z*-vector of attributes describing the goods which affects the farmers' preferences complemented by *S*-vector of farmer's socio-economic characteristics, and stochastic component -ε_i. All other unobservable factors having impact on farmer *i*'s decision in choosing irrigation water options *j* are captured by stochastic component ε. Conventional wisdom suggests that farmer *i* will choose an option which gives the greatest utility.

Therefore, more formally, the probability that farmer – *i* chooses alternative –*j*, amongst all other alternatives, given choice set *C*, can be specified as (Goibov et al., 2012):

$$P_i(j) = Pr\ (U_{ij} > U_{ik}),\ \forall\ j \in Ci, j \neq k \qquad (2)$$

Substituting the arguments in (1) into (2) it follows that:

$$P_i(j) = Pr(\ V(Z_{ij}, S_i)+\varepsilon_{ij} > V(Z_{ik}, S_i)+\varepsilon_{ik}),\ \forall\ j \in Ci, j \neq k \qquad (3)$$

[5] For a more elaborate discussion on the method, i.e., choice experiment, see, e.g., Adamowicz et al. 2008; Carlsson et al. 2004; and Alpizar et al. 2001.

Note that the dependent variable in the above formulation takes three or more values and a random parameter logit model could be envisaged. Moreover, assuming that the stochastic component or error terms satisfy the condition of independent and identical distribution with a Gumbel distribution, it follows that the relative probabilities of selecting between two options will remain unchanged by the introduction or removal of other options. In addition, choice experiments are consistent with utility maximization and demand theory when a status quo option is included. Or, put differently, comparator has to be included in the choice sets to ensure precise estimation of monetary welfare measures, which is done in this study (Bateman et al., 2002).

We have also applied the contingent valuation (CV) (with the double bounded elicitation format) to estimate willingness to pay for operation and maintenance of irrigation schemes. The conceptual framework for our contingent valuation analysis also draws from the RUT. The application of double bounded methods is not common in valuing irrigation water. Despite its shortcoming that the respondents' answer to the second bid may be influenced by the first bid proposed, known as anchoring bias (Flachaire and Hollard, 2006), it is more efficient (Hanemann *et al*., 1991).[6]

3.2. Empirical models

In what follows, we specify the empirical counterpart of the above conceptual model. As noted, the analyses for the estimation of the economic value of irrigation water in the study area were carried-out through the application of the two major valuation techniques discussed in some more detail below: CV and CE methods.

3.2.1 Choice experiment (CE) method

Multinomial logit model is one of the candidates in estimation contexts where the dependent variables assumes three or more values. The IIA property of multinomial logit model implies that the condition of independently and identically distributed stochastic component must come

[6] Hanley et al. (2001) discuss the advantages of choice experiment method over contingent valuation.

across in line with a Gumbel distribution (Luce, 1959). That is, it requires independence of disturbances. This also shows that the relative probabilities of selecting between two options will remain unchanged by the introduction or removal of other options. Therefore, generally speaking, choice experiments are consistent with utility maximization and demand theory when a status quo option, i.e., a comparator is included in the choice sets, which in turn also ensures precise estimation of monetary welfare measures (Bateman *et al*., 2002).

Assuming a conditional indirect utility function taking a linear form, $\forall\ j \in Ci$, equation (1) can be rewritten as (McFadden, 1974; Goibov *et al*., 2012):

$$Vij = \mu(\beta + \beta_1 Z_1 + \beta_2 Z_2 + \ldots + \beta nZn + \beta_a S1 + \beta_b S2 + \ldots + \beta_m Sj) \quad (4)$$

where β stands for ASC (Alternative specific constant) representing the utility of zero payment option and defined in this study as a '*status quo*'. The vector of attributes of irrigation water options are represented by coefficients β_1 to β_n, and β_a to β_m. S1 to Sj stand for the farmer's socio-economic characteristics.

Once parameter estimations are accomplished, then, a measure of economic value for irrigation options can be calculated using the following equation:

$$W1 = \frac{\ln \sum_m \exp(V_{mi}) - \ln \sum_m \exp(V_{m0})}{\alpha} \quad (5)$$

where W1 is the welfare estimate, α is the marginal utility of income or returns from irrigation, which represent the coefficient of monetary attribute in the choice experiment, and *Vmi* and *Vmo* are indirect utility functions before and after the change under consideration.

The reduced form of equation (5) can be specified as (Hanemann 1984):

$$W = -1\left(\frac{\beta attribute}{\alpha monetaryattribute}\right) \quad (6)$$

Where βattribute represents the coefficient of an attribute and αmonetaryattribute is the coefficient of the monetary attribute used. Note that the ratio in (6) represents marginal implicit price or, put differently, marginal rate of substitution between irrigation water attribute and money.

In terms of specific estimation models, discrete choice models such as multinomial logit and random parameter logit models are among the candidates. The study applied random parameter logit model to analyze the factors underlying the choices of irrigation water attributes/alternatives. The random parameter logit model relaxes the very restrictive IIA (independence of irrelevant alternatives) assumption of the multinomial logit model related to its underlying iid property (Brouwer et al. 2010b; Train 2003; Louviere et al. 2000; and Hensher et al. 2005).

3.2.2 Contingent valuation (CV) method

The other purpose of this study is to assess the farmers' willingness to pay for operation and maintenance of irrigation schemes and to suggest mechanisms for water pricing and cost recovery. Hence, we estimated the mean WTP using a parametric model. Note that we have used the dichotomous choice with follow-up questionnaire also known as double bounded elicitation format. As indicated, this is more efficient in estimating willingness to pay (WTP) than the single bounded elicitation format. Hence, in what follows, following Cameron and Quiggin (1994) we specify the empirical model employed.

Suppose that each farmer has some unobserved true point valuation for the environmental resource in question, i.e., in our case the improvement in irrigation water, at the time the first dichotomous choice CV question is posed. Let y_{1i} be the individual farmer *i*'s unobserved value with the discrete choice response indicator variable I_{1i} denoting the observable counterpart of y_{1i}. Also let the arbitrarily assigned first offer threshold to this individual be denoted as t1i. Similarly, in relation to the follow-up question or data, let y_{2i} be the the individual farmer *i*'s implicit underlying point valuation of the improvement in irrigation at the time the follow-up question is posed with indicator variable, I_{2i}, representing the observed counterpart of y_{2i}. Also let the arbitrarily assigned second offer threshold to this individual be denoted as t_{2i}. Hence, individual farmer *i* will answer yes, i.e., s/he will state is WTP the first offered amount (i.e., I_{1i} =1) iff $y_{1i} > t_{1i}$ and farmer *i* will state otherwise, i.e., will be unwilling to pay this much (which means $I_{1i} = 0$) iff $y_{1i} < t_{1i}$ (Cameron and Quiggin 1994). Simiarly, individual farmer *i* will answer yes, i.e., s/he will state is WTP the second offered amount (i.e., I_{2i} =1) iff $y_{2i} > t_{2i}$ (implying that t_{2i} is explicitly endogenous), and farmer *i* will state otherwise, i.e., will be unwilling to pay this much (which means $I_{2i} = 0$) iff $y_{2i} < t_{2i}$.

Generally, most applied empirical work in CV, assume a utility function that is additively separable in the systematic and stochastic components of preferences (Cameron 1988; Cameron and James 1987; Hanemann 1984). Hence, following the literature, let the unobserved valuation of individual farmer *i*, y_{1i}, consist of a systematic component, $x_{1i}'b_1$, which is a function of a vector of the individual farmer's observable attributes x_{1i}, plus an unobservable random component, e_{1i}. Similarly, assume the unobserved point valuation of individual farmer *i* in relation to the second offered amount, y_{2i}, will again consist of a systematic component, $x_{2i}'b_2$, and a random unobservable component, e_{2i}. Hence, droping subscript *i*, this implies that:

$$y_1 = x_1'b_1 + e_1 \qquad (7)$$

$$y_2 = x_2'b_2 + e_2$$

where the error terms e_1 and e_2, respectively stand for all unmeasured determinants of the value of the improvement in irrigation water to individual farmer i in relation to the first offered and second offered thresholds and assume are respectively distributed N(0,s). Also note that, in general, the vestors of explanatory variables $x_1$and x_2 need not be identical to each other.

Note that estimation of the above two models in eq(7) boils down to running two separate regressions of the individual models y_1 and y_2 when the error correlation r=0, i.e., when the two error terms e_1 and e_2, are uncorrelated. However, obviously, the second offered threshold is not independent of valuation information that farmer *i* revealed in answering the first offered WTP question. More specifically, the offered threshold entering into the second quation reflects the probabilities associated with the discrete outcome I_1. Therefore, failure to recognize that the error term e_2 is correlated with e_1 (and by implication also with t_2) will result in potentially biased estimates of all the coefficients comprising the vector b_2 (Cameron and Quiggin, 1994). Therefore, we must develop an empirical framework that allows us to capture this interdependence. That is, we develop the empirical model in the context of a joint distribution of (y_1,y_2). Hence, we assume that the two implicit valuations are bivariate normal distribution,i.e., $BVN(x_1'b_1,x_2'b_2,s,s,r)$.

There are four possible pairs of outcomes to these questions: (I_1,I_2) = (1,1), (1,0), (0,0) and (0,1). Hence, when $r \neq 0$, we have the joint probability for the outcome (I_1,I_2) = (1,1) as:

$$\begin{aligned} p_{11} &= \Pr[I_1 = 1, I_2 = 1] \\ &= \Pr[y_1 \rhd 0, y_2 \rhd 0] \\ &= \Pr[-e_1 \lhd x'_1 b_1, -e_2 \lhd x'_2 b_2] , \\ &= \Pr[e_1 \lhd x'_1 b_1, e_2 \lhd x'_2 b_2] \\ &= \Phi(x'_1 b_1, x'_2 b_2, \rho) \end{aligned} \quad (8)$$

where Φ is the standardized bivariate cummulative density function; x_is, for i = 1,2, are vectors of regressors; and b_i are vectors of parameters to be estimated.

Note that after dropping the subscript i, $I_1 = 1$ implies $y_1 > t_1$. Hence, using the expressions $y_1 = x_1'b_1+e_1$ and $y_2 = x_2'b_2+e_2$, the condition in eq (7) can equivalently be expressed as:

$$\begin{aligned} (e_1/s_1) &> (t_1-x_1'b_1)/s_1 \\ (e_2/s_2) &> (t_2-x_2'b_2)/s_2 \end{aligned} \quad (9)$$

where e_1/s_1 and e_2/s_2 are standard normal random variables. Denote the standardized normal error e_1/s_1 as z_1 and denote e_2/s_2 as z_2.

Assuming the probabilities associated with regions in the domain follow a standard bivariate normal distribution where the pair (z_1,z_2) is distributed BVN(0,0,1,1,r) and letting $g(z_1,z_2)$ be the bivariate standard normal density function, then, this takes the explicit form (Cameron and Quiggin 1994):

$$g(z_1,z_2) = [1/(2p(1-r^2)\_)] \exp \{ -(2-2r^2)-1 [z - 2rz_1z_2 + z] \}, \quad (10)$$

where $z_1 = (t_1 - x_1'b_1)/s_1$ and $z_2 = (t_2 - x_2'b_2)/s_2$. Then estimation is done through maximization of the log likelihood funciton (for more details please see Cameron and Quiggin (1994); Haab and McConnell (2002); and Lopez-Feldman (2012) .

4. Data, Survey Design and Context

4.1 Data and survey design

We use a dataset collected from Koga irrigation project. A total of 600 farmers (households) are selected. First sample size per kebele is determined based on population. The sample covered both beneficiary and non-bebeficiary households. Sample households are selected from both beneficiary and non-beneficiary households based on proportionate sampling technique. A stratified random sampling technique is applied in selecting sample households. Systematic random sampling is used in selecting individual sample households. Table A1 in the Appendix provides details about sample sites and sample size by kebele. The survey included questions on the respondents' socieoconomic charcateristics, access to infrastructure, crop production activities, income sources, etc.

In order to be able to identfiy the value attached to the different attributes we have conducted a choice experiment (CE). As discussed earlier, the relevant attributes were chosen based on the available literature and consultation with experts. We have also conducted a pilot survey to make sure that both the attrbitues as well as the levels are appropriate for the survey in the area. As noted above, we use the same status quo (baseline) conditions both for users and non-users of irrigation services. The description of each attribute including the statu quo (baseline) conditions is presented below.

1. **Number of seasons**: This refers to the number of crop seasons which is made possible due to availability of irrigation water. Irrigation water availability during the dry season in the command area allows cropping during the dry seasons. That is, irrigation water/dam could help farmers produce crops during all seasons of the year. The status quo option is only rain-fed crop production in one season per year. The levels of this attribute for the non-status quo alternatives are 2, 3 and 4 crop seasons in a year.

2. **Irrigation frequency in a season**: This refers to how many times you will have access to irrigation water during a crop season. The farmer's turn could be once a month, twice a month (or once in two weeks) or four times a month (weekly). The status quo option is no irrigation water.

3. **Crop type:** As is done in some cases there could be restrictions on the type of crop to be grown as water requirements of crops differ. Assume that you are given alternative choices for crop types to be grown on the irrigated land. There are three possibilities: wheat only, wheat and maize, and wheat, maize and potatoes. The status quo option is production of any crop.

4. **Annual payment per *kada*[7] in Birr**: Money is needed to cover the operation and maintenance of irrigation schemes. Irrigation water users associations are organized in the area to collect the contributions from each farmer/household per *kada* (0.25ha) of irrigated land. The status quo option is no payment with no irrigation. The levels for the non-status quo alternatives are Birr 100, 300, 500, and 700 per kada (0.25 ha) of irrigated land.

We created a choice experiment design that incorporates main effects and the design achieved D-efficiency (Louviere et al. 2000). The choice tasks were arranged in two blocks 'block 1' and 'block 2' each consising of six choice sets with different configurations and a respondent was asked either 'block 1' or 'block 2'. Each choice set contains two alternatives and one status quo (baseline) option from which a respondent chooses.
Before the actual questions about the choice experiment were asked respondents were presented with an example of a choice question to test whether they understood the choice task.

Table 1 shows a sample choice set used in the survey.

Table 1 about here

The farmer's willingness to pay for operation and maintenance of irrigation water facilities is also assessed using double-bounded CVM. A general script used for both CE and CV as well as a specific one for the CV scenario employed is provided in Appendix B.

The results of the contingent valuation survey revealed that, a majority of the farmers (69%) are willing to pay for the irrigation water if the amount asked to pay is ETB 100 per *kada*. Around 37% of the farmers were willing to pay 300 per *kada*. Only 25% and 19% of the farmers were willing to pay ETB 500 and 700 per *kada*, respectively. Consistent with the theory/expectations,

[7] 1 *kada* ≈ 0.25 hectare

the number of households who responded ’yes’ decreases as the amount of money propsed to be paid per *kada* increases.

Table 2 below presents descriptive statistics showing characteristics of sample households. Most of the sample farmers/households are male headed (90%) and the average age of the head is 43 years. About 70% of the sample hoseholds have irrigated land in koga with an average of 1.87 *kada* (0.47 ha). Some farmers also experienced irrigation practice before the establishement of koga irrigation project. The descriptive statistics show that irrigation farming experience before starting in Koga (in years) ranges between 0 and 25 years. But, on average, sample households' experience is less than a year.

Table 2 about here

As shown in table 2, the number of crop seasons per year increased to 2.1 after joining the project, which used to be 1.1 before joining the project. Those who did not join the project have 1.1 crop seasons on average. This indicates that irrigation helps increase the number of crop seasons which in turn enhances the production capacity of smallholder farmers in a year.

4.2. Study area descriptiion

Our study was carried by taking Koga irrigation project as a case in point. The Koga Irrigation and Watershed Management Project is situated adjacent to the town of Merawi in the Mecha Woreda, West Gojam Zone in the Amhara regional state. The Koga irrigation scheme is designed to improve watershed management in the catchment area of about 22,000 ha of land and supply irrigation water to more than 7,000 ha of command area which is divided into twelve irrigation units corresponding to the secondary canals. The project is also expected to improve other resources such as forestry, livestock, and soil and water conservation in the catchment area which has already been affected by frequent droughts.

Table 3 about here

As shown in table 3 the main types of crop grown by sample households are maize (36 %), finger millet (26%), and wheat (22 %). Some households produce multiple crops.

In the study area, water user associations are the main irrigation institutions. While most farmers are members of the water use associations, some are not. A main reason given for not being willing to be a member of the instituions is that they do not believe they will get any benefit from the water user associations.

5. Results

This study applies choice experiment and contingent valuation methods to elicit farmers' willingness to pay (WTP) for operation and maintenance of irrigation schemes. Here we present and discuss the results from both choice experiment and CV exercises.

5.1. Choice Experiment

A distinguishing feature of CE from CV is that it provides an approach to indirectly revealing the extent to which farmers' would be willingness to pay for the different attributes and levels of irrigation water. Hence, key questions are do farmers value availability/reliability, etc and, if yes, is there a scope for differentiated pricing schemes or differentiated irrigation water charges and do preferences of users and non-users of irrigation services differ? Accordingly, attributes and levels for the choice experiment were identified based on literature review and pilot survey. Four attributes considered in our analysis are number of crop seasons, watering frequency (in a season), crop type and payment. We use multinomial logit and random parameter logit models in the estimation. Estimation results for the full sample are presented in table 4. All atrributes were statistically signifant at less than 1% level except the number of crop seasons which was significant only at about 15%.

Table 4 about Here

Marginal willingness to pay (MWTP) was estimated for each of the three attributes (except the payment attribute which, as usual, was used for calculation of MWTP for the other three attributes). Results show that marginal WTP was Birr 17.7, 261.8 and 87.6 for number of crop seasons, watering frequency in a season and crop type, respectively. This shows the very high value farmers in our study area attached to watering frequency within a season as well as crop type, among the attributes considered. The relatively low marginal WTP for number of crop seasons and the insignificance of the coefficient of this attribute (Table 4) suggest the lower value attached to increasing the number of crop seasons. We also find that total willingness to pay using CE is Birr 738 per ha of irrigated land. Moreover, the results for users and non-users of irrigation services are more or less the same for the different attributes with the exception of the number of crop seasons where marginal willingness to pay by non-users is large and significant while it is not significant for users (Appendix C). This suggests that unlike users, non-users attach a high value to the possibility of being able to harvest in different seasons. This result also means that the total willingness to pay of non-users is higher than that of users.

We may also note that while we used the same baseline (status quo) options for both users and non-users of irrigation water, we find that the percentage of respondents that chose the baseline (status quo) option in the full sample was about 25.19% and this percentage was basically the same for users (25.34%) and non-users (25%). This is unlike the results for Barton and Bergland (2010) who used individual status quo options and found that most respondents chose the status quo option suggesting that these respondents were more comfortable with what existed instead of the proposed improvement. On the other hand, the results from our study suggest that those who benefit from irrigation water without paying for the water are not more likely than the non-users to choose the baseline option of no irrigation and no payment.

One of the major interests in conducting CE survey is that this helps to understand whether agents have different valuations for the attributes considered and the scope for devising differentiated pricing schemes for the environmental good in question based on such results. In this regard, our results suggest that there is some scope for differentiated pricing schemes (i.e., irrigation water charges), for example, based on watering frequency in a season and crop type.

5.2. Contingent Valuation

Another purpose of this study is to assess the farmers' willingness to pay for operation and maintenance of irrigation water provision using CVM. Hence, we estimated the mean WTP using a parametric model. As noted above, we used the double bounded value elicitation format. Table 5 presents the results of double bounded estimation using the doubleb command in Stata following Lopez-Feldman (2012). The results show that the WTP for operation and maintenance of irrigation water schemes is approximately equal to ETB 196 per *kada*. That means it is ETB 784 per hectare. Consistent with the results from the CE study, CVM results also show that non-user's willingness to pay is higher than that of users (Appendix D). This is perhaps because of higher value attached by non-users to number of crop seasons compared with users as suggested by marginal willingness to pay estimates from the CE.

Table 5 about Here

6. Discussion

Water *scarcity* for various uses constitutes a major global concern affecting millions of people. This study used choice experiment to estimate farmers' willingness to pay for attributes of irrigation water. This approach helps to assess the feasibility of a pricing scheme as well as for devising differentiated pricing schemes (i.e., differentiated irrigation water charges) using results from farmers' willingness to pay for the different attributes and levels of irrigation water. The study also applies the contingent valuation method to valuing irrigation water using the double-bounded value elicitation format taking Ethiopia as a case in point. Four attributes identified for the study are number of crop seasons, watering frequency in a season, crop type and payment. In the full sample, except for the number of crop seasons, the coefficient estimates were found to be statistically significant at less than 1% level. Results show that marginal WTP was Birr 17.7, 261.8 and 87.6 for number of crop seasons, watering frequency and crop type, respectively. When we also note the fact that the coefficient of the number of crop seasons is insignificant in the regression analysis (Table 4), this suggests the very high value attached to watering frequency in a season compared to increase in the number of seasons due to irrigation. We also note the value attached by farmers to crop type. CE results also show that marginal willingness to pay for number of crop seasons is large and significant for non-users of irrigation services while it is insignificant for users; the results for other attributes are similar for both groups.

We also find that willingness to pay per hectare to cover operation and maintenance costs is Birr 738 using CE and Birr 784 using CVM. The results suggest possibilities to generate finance from farmers to cover operation and maintenance costs of irrigation schemes. Nonetheless, a further analysis is necessary to compare this figure with the costs incurred to cover the expenses for irrigation related activities.

Generally, the literature on valuation of irrigation water is thin. Specifically, the application of choice experiment method is limited in developing countries in general and Ethiopia in particular. Hence, our study makes contributions to this thin literature through valuing irrigation water in a developing country context applying choice experiment method especially in understanding the demand side issues of irrigation water. Unlike previous studies, the data used and the absence of payment for irrigation water by users allowed a comparison of preferences of users and non-users of irrigation services when both are put in a baseline (status quo) condition that corresponds to the real status quo situation of the non-users with no irrigation (which is a hypothetical baseline for users).

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Table 1. A sample choice set presented to the respondents

Attribute	Plan 1	Plan 2	Status quo
Irrigation water availability	All four crop seasons	Two crop seasons	One crop season (no irrigation)
Water frequency for a given season	 Four times a month	 Twice a month	None
Crop type	 Wheat only	, , and  Wheat, maize and potato	Any crop
Annual payment in Birr	 225 Birr	 75 Birr	0 Birr
Please tick/mark (√) only one			

Table 2. Descriptive statistics of selected variables on sample households

Variable	Obs	Mean	S. D.	Min	Max
Gender of the household head, 1=male,0= female	600	0.9	0.3	0	1
Age of the household head	600	42.9	12.33	20	85
Highest education level attained (in years)	600	4.11	6.52	0	18
Distance to all weather road (in minutes)	600	43.94	48.57	0	300
Access to credit (able to obtain 200 Birr credit in a week's time) 1=yes, 0=no	599	0.81	0.39	0	1
Land size in Kada (1 Kada=0.25 ha)	600	4.24	2.29	0	15
Land tenure security (household expects a decrease in size of agricultural land) 1= yes, 0= otherwise	596	0.29	0.45	0	1
Household has irrigated land, 1= yes, 0= no	599	0.69	0.46	0	1
Irrigated land size in Koga (in Kada)	600	1.87	2.24	0	25
Irrigated land size outside Koga (in Kada)	600	0.08	0.36	0	4
Irrigation farming experience in Koga (in years)	600	1.48	1.15	0	4
Irrigation farming experience before starting in Koga (in years)	447	0.79	2.71	0	25
Number of crop seasons per year before joining Koga	407	1.08	0.27	1	2
Number of crop seasons per year after joining Koga	406	2.07	0.31	1	3
Number of crop seasons if household did not join Koga per year	195	1.13	0.35	1	3
Livestock owned (in Tropical Livestock Units, TLU)	600	3.09	1.8	0	18
Irrigation water users cooperatives/association membership, 1= yes, 0= no	597	0.62	0.49	0	1

Table 3. Yield (in kg) of primary crop types grown by sample households using irrigation water during January –December 2012

Crops grown	Obs	Mean	S. D.	Min	Max
Maize	238	1128	931	3	10000
Wheat	142	410	305	2	1800
Finger millet	170	468	297	2	2000
Potato	65	1349	1671	10	12000
Barley	45	275	247	1	1260

Table 4. Estimation results (choice experiment) using random parameter logit (full sample)

	Coeff.	Std. Error.	T-value	P-value
Number of crop seasons	0.053	0.036	1.456	0.145
Watering frequency	0.783***	0.023	34.081	0.000
Crop type	-0.262***	0.048	-5.476	0.000
Payment	-0.003***	0.000	-21.492	0.000
Constant	-1.167***	0.158	-7.386	0.000
Number of observations	3600			
Log likelihood function	-2850.025			
Info. Criterion: AIC =	1.58613			

Table 5. Estimation results of double bounded contingent valuation (full sample)*

	Coef.	Std. Err.	z	P>z
Beta _cons	195.85	19.32	10.14	0.00
Sigma _cons	384.67	21.36	18.01	0.00

*Doubleb command in Stata used based on Lopez-Feldman (2012)

Appendix A

Table A1 Sample sites and sample size by Kebele

Kebele	Total # of gots	Number of gots in the command area	Population			Population		% of total	Total sample	Sample size by Kebele
			Male	Female	Total	Beneficiary (with irrigated land under Koga project)	Non-beneficiary (with no irrigated land under Koga project)			
	A	B	C	D	E	F	G	H	I	J(=H*I)
Kudmi	8	6	4245	4019	8264	4850	3414	0.130878	600	78
Ambo Mesk	11	6	4423	3365	6842	4875	1967	0.108357	600	65
Inguti	8	8	2904	2176	5080	5080	0	0.080452	600	48
Amarit	16	16	9437	1514	10950	8670	2280	0.173416	600	104
Kolela	5	3			5778	4102	1676	0.091507	600	55
Awota/Andinet	8	4			8804	6140	2664	0.13943	600	84
Tagel Wedefit	16	8	3298	3217	6515	3924	2591	0.103178	600	62
Enamirt	8	1	2519	2403	4922	1940	2982	0.07795	600	47
Edget Behibret	12				5988	2790	3198	0.094832	600	57
Total					63143	42371	20772	1		600

Source: CSA (2007); Cost Recovery Study (2008), Marx (2011) and Own Compilation (i.e., by Supervisors)

Table A1 Continued

Kebele	Total sample	Sample size by Kebele	Proportion of beneficiary	Proportion of non-beneficiary	Beneficiary sample	Non-beneficiary sample
	I	J(=H*I)	K(=F/E)	L(=G/E)	M=(J*K)	N(=J*L)
Kudmi	600	78	0.586883	0.413117	46	32
Ambo Mesk	600	65	0.712511	0.287489	46	19
Inguti	600	48	1	0	48	0
Amarit	600	104	0.79178	0.20822	82	22
Kolela	600	55	0.709934	0.290066	39	16
Awota/Andinet	600	84	0.69741	0.30259	59	25
Taget Wedefit	600	62	0.602302	0.397698	37	25
Enamirt	600	47	0.394149	0.605851	19	28
Edget Behibret	600	57	0.465932	0.534068	27	30
Total		600			403	197

Appendix B: **Valuation Scenario**

To the interviewer:

Please read the scenario described below to the respondent and make sure that the respondents give attention to (and understand) your description before you proceed to the questions that follow.

B.1 General scenario (applicable to both the choice experiment and contingent valuation):

The construction of irrigation dam among others means providing adequate water for secured crop production and enabling enhanced (multiple) cropping during the dry season. The irrigation dam is used to provide reliable water at any time throughout the year for crop production and it will reduce the time and money that would be spent to bring irrigation water from a distant place. The construction of the irrigation dam will benefit the farm households by enabling them produce up to four times a year, increasing water availability in a season, and improving watershed in the area.

More specifically, the government of Ethiopia has constructed Koga Irrigation and Watershed Management Project (KIWMP) using loan from international organizations, mainly the African Development Bank. This irrigation and watershed management project could provide you as much irrigation water as you want throughout the year and will improve watershed (reduce erosion/flooding) problems. To provide or deliver this year round water, different irrigation canals (primary, secondary, tertiary) are constructed. Sustainably delivering this irrigation water to farmers requires money to cover costs of operation and maintenance for the next 50 years. This cost should be covered by the beneficiary farmers (households) in the command area. So, for this you will be charged a yearly irrigation water fee through the irrigation water users' association (IWUAs) based on *kada* (0.25hectare) of land irrigated.

Thus, to maximize the benefits from irrigation water, irrigation beneficiary households in the command area have to contribute money for the use of irrigation water and to maintain the sustainable use of the irrigation dam and canals. Note that if such money is paid for this purpose it means it cannot be used for other purposes.

B.2 Contingent Valuation (CV) Scenario

Now consider a situation where your household has a *kada* of irrigable land under the project. Your household will be able to produce four times a year. The household will be able to grow crops of your choice using irrigation water four times per month in a season. The operation and maintenance cost of the project has to be covered by users of the irrigation water. So, your household will be required to contribute every year for a period of 50 years to cover such costs. These contributions will be collected and administered by irrigation water users' associations. Note also that when you pay for this it means this money cannot be used for other purposes. Please also consider in your decision the fact that you have other expenses to cover.

1. under such conditions, will your household, be willing to contribute X (____) Birr / *kada* (0.25 ha) of irrigated land per year to keep the health of the dam and common irrigation channels to get year round irrigation water supply and to produce four times per year? ________ Yes= 1

    No = 2

2. If Yes to Q1, then would you be willing to pay 50% of X more (i.e._____Birr) ? _______yes=1 _____No=2

3. If No to Q1, then would you be willing to pay 50% of X less (i.e._______Birr)? ______yes=1 _____No=2

4. What is the maximum amount that you are willing to pay per *kada* (0.25 ha) of land for such a project per year? __________________ Birr

5. If you are not willing to contribute any amount to the irrigation activities, please specify your reason/s. ________

    1= I cannot afford to pay.

    2= Irrigation should be provided free of charge

    3= I know that the money will not be used properly.

    4= I do not fully understand the question.

    5= Others (specify) ____

Appendix C. Estimation results (choice experiment) for users and non-users of irrigation water

C.1 Estimation results (choice experiment) using multinomial logit for users of irrigation water

	Coeff.	Std. Error.	T-value	P-value
Number of crop seasons	0.00633	0.04401	0.14	0.8856
Watering frequency	0.80743***	0.02804	28.80	0.0000
Crop type	-.26768***	.05844	-4.58	0.0000
Payment	-.00309***	.00017	-18.28	0.0000
Constant	-1.12493***	.19168	-5.87	0.0000
Number of observations	2476			
Log likelihood function	-2669.2			
Info. Criterion: AIC =	3903.8			

C.2 Estimation results (choice experiment) using multinomial logit for non-users of irrigation water

	Coeff.	Std. Error.	T-value	P-value
Number of crop seasons	0.13730**	0.06498	2.11	0.0346
Watering frequency	0.73977***	0.04076	18.15	0.0000
Crop type	-0.24400***	0.08438	-2.89	0.0000
Payment	-0.00282***	0.00025	-11.36	0.0000
Constant	-1.21596***	0.28368	-4.29	0.0000
Number of observations	1086			
Log likelihood function	-1165.2			

Info. Criterion: AIC =	1770.8

Appendix D. Estimation results of double bounded contingent valuation (for users and non-users of irrigation water)

D.1 Estimation results of double bounded contingent valuation (for users of irrigation water)*

	Coef.	Std. Err.	z	P>z
Beta _cons	133.95	22.85	5.86	0.00
Sigma _cons	351.26	24.19	14.52	0.00

*Doubleb command in Stata used based on Lopez-Feldman (2012)

D.2 Estimation results of double bounded contingent valuation (for non-users of irrigation service)*

	Coef.	Std. Err.	z	P>z
Beta _cons	352.92	33.88	10.42	0.00
Sigma _cons	397.74	37.82	10.52	0.00

*Doubleb command in Stata used based on Lopez-Feldman (2012)