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Determinants of Farmers' Willingness to Pay for Irrigation Water of Lake Hawassa

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Abstract
The contingent valuation method is applied to analyze the economic value of quality improved irrigation water. Based on random sampling technique, 220 sample households were selected to determine farmers' preferences on how much they are willing to pay for quality improved irrigation water. The Heckman selection model was used to analyze the factors affecting households' participation in the lake quality improvement and the valuation of the quality improved irrigation water. The valuation result shows that most respondents have reflected their willingness to pay for the lake quality improvement stating their mean WTP of Birr 311.44 for irrigation water per hectare, which is equivalent to US$17.30 per hectare. The analysis on the determinants of WTP shows that education, annual income, multiple uses of the lake, farm size, gender, and age of households are the significant variables explaining the participation in the resource quality improvement and the valuation of the quality improved irrigation water. Therefore, identification of such variables and their relative importance in the valuation helps to obtain households who are willing to pay maximum level for the lake quality improvement.
Keywords: Contingent Valuation, Heckman Model, Irrigation water, Willingness to pay

1. Introduction

Irrigation agriculture increases productivity and production, thus contributing to an increased well-being of small holder farmers. In Hawassa watershed, where the seasonal rainfall fluctuations make rain-fed farming a risky venture, irrigation reduces some of the uncertainties and so promotes increased production. More than 1,700 hectares are developed under irrigation using Lake Hawassa. The farmers produce mainly vegetables like cabbage, kale, pepper, tomato, onion, carrot, lettuce, salad, garlic, and root crops like potato, sweet potato and red root. The farm size developed under irrigation ranges from 0.06 to 1.5 hectare with the average size of 0.4 hectare. Farmers have grown crops for more than 20 years using bucket, gravity motor pump and trickle/drip irrigation systems.

The water is not metered and the riparian land owners freely use the lake to produce crops ranging from small to large amount in water requirement. The farmers grow up to five different types of vegetables producing on average two times per year using the lake as the source of irrigation. On average the income ratio of products obtained through irrigation development to the products on rain-fed is 2.7, if other factors like inputs and soil management remain constant. The high productivity of irrigated agriculture allows fewer hectares to feed an ever increasing human population. The available household labor can also be engaged throughout the year, thereby improve labor productivity. This contributes to an economic, social and environmental wellbeing of the local farmers in addition to confirming their food security.

However, sediments, domestic sewages and industrial effluents discharged in to the lake are causing physical damages to the crops on riparian farms and the health risk to the consumers of the products irrigated by polluted water. When large amount of sediments settled at the bottom of the lake, the water level rises above the dyke and overflows to the farms and destroys the crops. Extensive use of polluted water for irrigation leaches down the soil and also has a negative effect on ground water quality (Ashraf *et al*, 2010). Whether the farmers are aware of the poor quality of the lake and willing to pay for the improvement of the water quality are not well understood.

The past management of the water resources and the nature of their exploitations have resulted in resources degradation since value of the water resources had not been readily apparent in economic terms. The challenge in developing payment programs for water resources is the difficulty of translating farmer benefits into actual revenue streams. Because of the characteristics of non-excludability and non-rivalry of water resource, private resource investors would not be directed towards its conservation. The benefits of investment in resource conservation are realized only after it has disappeared. More costly water treatment is one of examples of costs understood only after the lake ecosystem has been degraded.

The improvement program includes control of chemical pollution from the industries and domestic effluents; gully treatment; and soil and water conservation in the watershed. When the resource is improved, it can no longer be treated as public good. The farmers are supposed to pay for the quality improved irrigation water per hectare. The valuation of the benefits of the irrigation water from the perception of users is a critical input for the implementation of the improvement program. Therefore, are the farmers willing to pay for the water quality improvement? If yes, what are the determinants of their willingness to pay for the quality improved irrigation water? The objective of the study is to analyze the economic value of quality improved water resource and the farmers' willingness to pay for irrigation water.

2. Methodology

2.1. Description of the study area

Lake Hawassa is located at $6^0 33'$ – $7^0 33'$N and $38^0 22'$ – $39^0 29'$E in the southern Ethiopia. The surface area of the lake on average is 93.5km^2 with maximum depth of 32.2m and the average depth of 13.6m. The seasonal variation of the lake water level ranges from 0.09m to 1.57m with an average of 0.66m (Halcrow, 2009). Unlike other closed lakes with alkaline characteristics, Lake Hawassa is one of the few fresh closed lakes with its electrical conductivity of 802 µS/cm, and pH=8.6 (Tenalem *et al*, 2007). The freshness of the lake water could be justified as water from Lake Hawassa catchment can flow to lakes of lower altitude (Yemane, 2004).

2.2. Survey Design and Development

A contingent valuation survey instrument was designed as the scenario informs the change in the water resource under valuation. It explains clearly how that change would come about; how it would be paid for; and the larger context that is relevant for considering the change. The question for irrigation use was phrased using the payment vehicle of water price per hectare. The design was to ensure the values expressed by the respondents would be those held for the water resource management. Using random sampling technique, 220 households were selected from irrigation users of Lake Hawassa.

The referendum format is how they would vote if they are faced with environmental improvement and asked to pay for such improvement. This bidding game is believed to approximate a real market setting, in which farmers either buy or do not buy the irrigation water at a specified price, and so is more familiar to respondents. The referendum format facilitates respondents thought processes and encourages them to consider their responses carefully. In using this format, great care was taken in deciding the starting point. The starting points were obtained using open-ended value elicitation method and compared with the actual costs estimated by Halcrow (2009) and updated with the actual cost from the environmental protection authority.

2.3. Empirical Model Specification

The Heckman model was employed in the analysis of the survey data. It is a two equation model: the regression model and the selection model.

Selection equation:

$$\text{Participation} = Z_i\gamma + u_i \quad \ldots\ldots (1)$$

Regression or observation equation:

$$WTP = \beta X_i + \rho_{\varepsilon u}\sigma_\varepsilon \lambda_i(-Z_i\gamma) \quad \ldots\ldots (2)$$

The WTP equation was estimated by replacing γ with probit estimates from the first stage, constructing the λ term, and including it as an additional explanatory variable in linear regression estimation of the WTP equation. The Inverse Mill's ratio [$\lambda_i(-Z_i\gamma)$] was calculated using the formula:

$$\lambda_i(-Z_i\gamma) = \frac{\varphi(-Z_i\gamma)}{1-\phi(-Z_i\gamma)} \quad \ldots\ldots (3)$$

Where, φ denotes the standard normal density function, and

ϕ denotes the standard normal cumulative distribution function

The selection equation was estimated by maximum likelihood as an independent probit model to determine whether to participate and pay using information from the whole sample of supporters and non-supporters. A vector of inverse Mills ratio (estimated expected error) was generated from the parameter estimates. After constructing the Mill's inverse ratio, the payment level of individuals who voted in support of the improvement program was then regressed on the explanatory variables, *x*, and the vector of inverse Mill's ratio from the selection equation by ordinary least squares.

3. Results and Discussion

3.1. Households Responses to Contingent Valuation of irrigation water

The contingent valuation results show that 77 percents of the respondents voted in support of the improvement program. These respondents reflected their preferences specifying the value of irrigation water per hectare ranging from Birr100 to Birr550 with the average value of Birr283.53 per hectare, where US$1 = Birr 18 during the survey instrument. From the respondents who stated their preferences to participate in the lake quality improvement, about 37 percents expressed the monetary value of Birr250 per hectare followed by 29 percents of the respondents who stated Birr300 per hectare. About 17 percents revealed their participation stating the monetary value of Birr350 and higher per hectare. From the responses it was found that the farmers with large farm size and who produce various crops two or more times per year state relatively higher payment level for the quality improvement of the irrigation water. These respondents were also found to administer small family members, which were below the average family size of the total respondents, and earn relatively higher annual income.

About 23 percent of the respondents preferred to remain neutral in the proposed improvement program. These respondents justified as they could not afford any payment at the time of the survey instrument. The majority of the respondents who preferred to remain neutral were found to administer relatively large family size. The status of their annual income shows that they earn below Birr30,000. These respondents were also found to benefit the lake as irrigation source for less than five years and also faced challenges in using irrigation like high price of fuel, break of hose, carrying water with bucket due to high price of motor pump.

3.2. Econometric Analysis of the households' WTP for Irrigation water

In the two-step estimates of Heckman model, the first step was the households' decision on whether to participate in the proposed improvement program. The second step was the households' decision on their valuation (WTP). Since rho ( ) was different from zero, standard regression techniques applied to the first equation on irrigation provided biased results. The coefficient on the inverse Mill's ratio, which was statistically significant, confirmed the presence of selection bias. In such case, Heckman selection model allows using information from non-participating households to improve the estimates of the parameters in the regression model, and hence provides consistent and asymptotically efficient estimates. Regression of the estimated inverse Mill's ratio ( ) on the parameters of the valuation equation, which tests for collinearity, indicated an insignificant level of correlation. Thus the two-step selection model was appropriate for estimating the participation and valuation decisions for the quality improvement of the irrigation water.

The LR chi square, which measures the overall significance of the model, with the null hypothesis that all coefficients were zero was rejected at 1% significance level showing that at least one of the coefficients was different from zero. The pseudo R^2 was 0.6783, which revealed 67.83 percent of variation in the participation in the resource improvement program was explained by the variables included in the model. The adjusted-R^2 (0.4028) revealed the valuation was explained by the explanatory variables by 40.28 percent. This adjusted-R^2 value seems low but in social researches the R^2 value can be small even less than 20 percent due to various factors that would not be able to capture at the time of survey instrument to explain the variation of the dependent variable with the proposed explanatory variables. The value (0.4028) is therefore accepted to explain the variation of the dependent variable. The overall significance level of Heckman selection (Probit) at 1% implies that the model was acceptable to explain the relation between WTP and its explanatory variables.

The participation equation shows that males, farmers with large irrigated land size, educated households, the household who has reached the age of majority, and who earn higher annual income are more likely to participate in the lake quality improvement program; whereas, farmers with large family size are less likely to participate in the resource improvement program (Table 1). The valuation results reveal males, farmers who irrigate large farmland, the household with more years of education, those who use the lake for multiple purposes, older farmers, and households with high annual income attach higher WTP amount for the proposed improvement program. The factors for attaching less WTP amount for the quality improvement of the irrigation water are related to marital status and family size (Table 1).

Table 1: Heckman's two-step sample selection model results

Parameters	*Participation model [Coefficient (SE)] Heckman's two-step (Probit)*	*Valuation model [Coefficient (SE)] Heckman's two-step (OLS)*
Farm-size	2.4064(1.2555)*	0.6865(0.2273)***
Irrigation-years	-0.0094(0.0590)	-0.0132(0.0075)
Crop-on-rain-fed	-0.4697(0.4819)	-0.0663(0.0742)
Irrigation-problem	0.0025(0.4421)	-0.0557(0.0399)
Gender	1.1344(0.6701)*	0.2920(0.1171)**
Age	0.0831(0.0286)***	0.0264(0.0077)***
Marital-status	-0.4043(0.6010)	-0.1322(0.0622)**
Family-size	-0.8495(0.1901)***	-0.2725(0.0771)***
Education	0.3356(0.0935)***	0.1037(0.0322)***
Occupation	-0.5042(0.6835)	–
Income	1.4019(0.3454)***	0.4923(0.1311)***
Use-type	0.0250(0.4175)	0.1523(0.0445)***
Inverse-mills	–	-8.1723(2.7669)***
Constant	-2.8911(1.6372)*	4.3298(0.3392)***
Sample size	220	170
Log likelihood	-37.9283	–
R^2	0.6783	0.4452
Adjusted-R^2	–	0.4028

***1% significance level, **5% significance level, *10% significance level with two tailed tests

Farm size: The sign is positive and significantly determine the valuation of the lake in terms of irrigation water. The farmers who irrigate larger farm size are more likely to participate in the quality improvement program and attach higher monetary value for the improved irrigation water per hectare. The farmers with large farm size can produce various crops with irrigation and earn higher income by growing crops two or more times in a year. This finding is consistent with that of Tang *et al*. (2013) who indicate that households with more irrigated farmlands are willing to attach higher value for irrigation water. Zhang *et al*. (2014) obtain similar result in the analysis of the farmers' willingness to pay for Lake Wetland. This is explained by economies of scale comparing large farm size with low farms and the irrigation cost is likely to be low with large farms.

Gender: This variable has a positive sign and significantly influences the participation and valuation of the quality improvement program. This can be explained by the fact that male farmers have more access to outdoor activities like irrigation development, fishing and other benefits of the lake as compared to females. As a result males are willing to pay more than females for the improved water per hectare.

Age: The positive sign for age shows that the older farmers who used the lake for irrigation for longer period have realized the current low quality of the lake and possible impact on irrigation development. These farmers are found to participate and pay for the irrigation used per hectare when the lake is improved. Zakaria *et al*. (2013) also reveal age to positively and significantly influence the farmers' willingness to pay for improved irrigation service.

Family size: It is negative and significant at 1% level in both participation and valuation of the improved water. This implies that farmers with large family size on average tend to attach low value for irrigation water. This can be explained by the fact that the farmers who administer large families face financial shortage to pay for irrigation water per hectare. Tang *et al*. (2013) find negative sign for family size in irrigation water with 10 % of significance level, and explain that the benefit of irrigation per person is less in the family with large size as compared to small family size farmers per hectare. Negatively influence of family size on irrigation water is also observed in the study of Tiwari (1998) in determination of economic value of irrigation water.

Marital status: The negative sign for married farmers on the valuation can be explained in relation with the family members who could not help their parents in irrigation development. In such case the irrigation labor rests on the household head. In the family with more dependent members the budget allocation for family administration and use of irrigation in charge per hectare can be challenging.

Education: The positive sign for participation and valuation of the irrigation water per hectare can be explained as the farmers with relatively higher educational background understand the environmental problems and therefore be willing to participate in the lake cleanup program attaching higher monetary amount for the possible costs in the proposed improvement. These farmers value the lake not only in terms of use value but also non-use values like watching beautiful birds and other wild animals inhabited in and surrounding the lake. Creating good environment to the surrounding community is another non-use value that the farmers with more years of education realize beyond the irrigation use of the lake. Mwakaje *et al*. (2013) explain that educated people better perceive the future risk of reduced water and hence significantly influence the WTP for the improved irrigation water.

Income: The positive sign and significant effect of income shows that the farmers with higher annual income are more likely to participate in the improvement program and pay higher amount for the quality improved irrigation water per hectare. This result reflects the household's ability to pay for the proposed improvement. The positive sign and significance level agree with the findings of Tang *et al*. (2013) on willingness to pay for irrigation water. This result is also consistent with that of Mwakaje *et al*. (2013) on farmers WTP for watershed services.

Use type: The positive sign and significant influence of the valuation reflects that the respondents who use the lake for many purposes in addition to irrigation development put higher monetary amount for the quality improved lake resource. These respondents were found to be benefited in fish consumption, watering their cattle and washing household equipments in addition to irrigation development. These respondents stated that the lake quality was decreasing from year to year and predicted that the various uses of the lake might not sustain unless the corrective measures are taken at the right time, and they reflected their willingness to pay higher amount for the quality improved irrigation water.

3.2.1. Parametric WTP estimates for irrigation water

The parametric WTP estimate is based on the determinants that affect the households' willingness to pay for the proposed improvement. This approach describes the behavioral tendencies of the respondents taking the socio-economic characteristics in to consideration. According to Amponin *et al*. (2007), the parametric technique estimates the preference function that would allow the calculation of the willingness to pay value given the estimated parameters. The parametric mean WTP was computed incorporating the variables that significantly influence the valuation as:

$$WTP = {}_{o} + {}_{1}farm\ size + {}_{2}gender + {}_{3}age + {}_{4}marital\ status + {}_{5}family\ size + {}_{6}education + {}_{7}income + {}_{8}use\ type + {}_{9}inversemills \quad \ldots (4)$$

In the OLS regression, inverse Mill's ratio was added as additional explanatory variable. Incorporating the coefficients and their respective mean values into equation (4), the calculated parametric MWTP becomes Birr311.44. Comparing this value with non-parametric WTP (Birr283.53) results, it is found that the parametric approach yielded higher mean WTP amount than the non-parametric estimates. This finding is in agreement with that of Amponin *et al*. (2007) where they find the higher parametric mean WTP as compared to non-parametric approach in the study of willingness to pay for watershed protection by domestic water users. Since the parametric approach provides more economic information in the calculation of mean WTP, the farmers' WTP for improved water is preferably calculated using the parametric approach, and hence the mean WTP for improved lake resource in terms of irrigation water becomes Birr311.44 per hectare (US$17.30 per hectare).

4. Conclusion

Domestic wastes, industrial effluents, and sedimentation resulting from deforestation are the environmental problems that are degrading the water resources of Lake Hawassa. Whereas, less awareness on the water conservation, less buffering zones, and inadequate municipal waste management are the major causes for the Lake Biodiversity degradation and ecological distributions.

The mean WTP for the irrigation water is Birr311.44 per hectare (US$17.30 per hectare). The valuation of irrigation water reveals farmers have a positive willingness to pay to ensure the water resource improvement so that their willingness to participate in support of the proposed improvement and higher amount for the improved irrigation water per hectare can be used as potential revenue for the lake resources management.

The determinants of the farmers' willingness to pay higher value for the improved irrigation water per hectare are farm size, gender, age, education, income, and multiple uses of the lake while marital status and family size are the factors influencing the farmers to attach low amount for the lake in terms of irrigation water per hectare. Therefore, the decision-makers should incorporate the economic value of the water resource as one of the major inputs for implementation of an integrated watershed management program.

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