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Research Article

Households' willingness to pay for the services of watershed management in lake Hawassa watershed, southern Ethiopia

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Article Info

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Abstract

Watershed provides vast economic benefits within and beyond the management area of interest. But most watersheds in Ethiopia are increasingly facing the threats of degradation due to both natural and man-made factors. To reverse these problems, communities' participation in sustainable management programs is among the necessary measures. Hence, this study assessed the households' willingness to pay for the services of watershed management through a contingent valuation study approach. Double bounded dichotomous choice with open-ended follow-up format was used to elicit the households' willingness to pay. Based on data collected from 275 randomly selected households, descriptive statistics results indicated that most households (79.64%) were willing to pay for the services of watershed management. A bivariate Probit model was employed to identify determinants of households' willingness to pay and estimate mean willingness to pay. Its result shows that age, gender, income, livestock size, perception of watershed degradation, social position, and offered bids were important variables affecting their willingness to pay. The study also shows that the mean willingness to pay for the services of watershed management was calculated to be 58.41 Birr and 47.27 Birr per year from the double bounded and open-ended format, respectively. The study reveals that the aggregate welfare gains from the services of watershed management were calculated to be 931581.09 Birr and 753909.23 Birr per year from double bounded dichotomous choice and open-ended format, respectively. Depending on the double bounded dichotomous format result, the policymakers should design an approach to make households pay for the services of watershed management.
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Keywords: Bivariate Probit model, Watershed management, Services of watershed Management, Willingness to pay

1 Introduction

The economy and environment are now jointly determined systems linked in the process of co-evolution, with the scale of economic activity exerting significant environmental pressure. 1There is a dynamic interdependency between economy and ecosystem, but the fundamental point is that economic systems are underpinned by the ecological system and not vice versa (Bateman and Wills, 1999).

Due to this, in the majority of developing countries, the quantity and quality of environmental resources are decreasing and resulting in more severe floods and droughts (Fikru, 2009). In terms of weather and naturerelated disasters and climate change, Ethiopia was ranked the ninth most climate-vulnerable country in the world (Merkine et al., 2017), and this resulted in diminishing productivity of agriculture and increasing problems in water quality. Specifically, due to this, the natural resources are under influence of many interrelated factors and result in unsustainable farming practices, lower vegetative cover, severe soil loss, and migration of wildlife (Simachew, 2020). The estimated average annual soil loss rate of Ethiopia is to be 42tons/hectare/year which resulted in two percent of crop loss and it may be higher in steep slopes and places where there is lower vegetation cover (Biniyam, 2013).

Watershed is a geographically delineated area that is drained by a stream system. Currently, watersheds in Ethiopia are undergoing severe degradation. Lake Hawassa watershed is one of the watersheds which have faced problem of degradation. During the pre-1974 period, the watershed had high vegetation abundance and richness, low population, high soil infiltration rate, and normal temperature and rainfall. Since 1991, there is accelerated deforestation despite a small portion of planted exotic trees, increased severity of erosion and common gullies, warmer and erratic temperature and rainfall. The major causes for this degradation are inappropriate land-use systems such as extraction of sand and stone, removal of forests and woodlands in upper stream areas, lower adoption of indigenous and introduced soil and water conservation practices (Yericho, 2019; Zenebe, 2013). Soil bund and check dam were implemented by public participation, while soil bund and Fanya-juu were implemented in private land for management of the watershed. The structures were appropriate for the catchment but their layouts were not as standard. In addition, the regular maintenance and management of structures after implementation was also minimal and the effective and efficient management options undertaken in tackling the problem of degradation were also not satisfactory (ibid).

Degradation of the watershed is manifested, in landslides, lower productivity of land, lower crop production and productivity, soil erosion and gullies, deterioration in the quality of the lake, and overuse of natural resources in the watershed (SARI, 2017). In addition, these may result in malnutrition of children, extra loads on women and poor, absence of medicinal plants, lack of water and forage, health problems, and lack of recreation areas (Hagos et al., 2014). Thus, communities within the watershed will be one of the primary beneficiaries from good watershed management thus their involvement in sustainable management is critical (Wolfgramm, 2015). This ensures fair and equitable sharing of costs and benefits as well as co-management of surface and sub-surface water resources for improving water productivity (Gebrehaweria et al., 2017). On top of the reduction of watershed degradation, the integrated management may improve soil productivity and other ecosystem services and ultimately results in the local community's livelihood improvements (Simon, 2016).

One of the environmental friendly approaches of community involvement in sustainable natural resource management is paying for its services and improvements (Sharma et al., 2005). According to the study conducted by Zenebe (2013), the communities within the watershed have the interest to participate and cooperate in the programs which are working on rehabilitation of the watershed, but their participation in terms of payments was not clear. Due to this, this study was conducted to assess households' willingness to pay for the services of watershed management in the study area. The findings of the study can be used as a source of information for policymakers, natural resources, and watershed management-related project implementers to overcome the challenges of watershed degradation.

2 Research Methodology

2.1 Description of the Study Area

Lake Hawassa is one of the eight major Ethiopian Rift Valley lakes, which is situated in Southern Ethiopia. It receives water from only perennial Tikurwuha River and runoff from the catchment areas (Mallampati and Osman, 2015). It is a topographically closed lake in the central main Ethiopian Rift Valley and its watershed has an area of 1436.51 km2 proportion of which is in the Eastern sub-watershed (Mulugeta et al., 2017). The eastern escarpment is found partially in the Central Rift Valley of Ethiopia, at about 263 Km South of Addis Ababa. Geographically, it is located between 38°37'E to 38°42'E and 7°02'N to 7°07'N. The watershed covers an area with a wide altitudinal range of 1690 to 2700 meters above sea level. Plantation forests of exotic species such as different species of Eucalyptus, Grevillea Robusta, Cupressus Lusitanica are common. Homestead agroforestry is commonly practiced in the area (Kebede et al., 2014).

Soil characteristics of the area are very porous, sandy loam, shallow at top and along the slope length of the hills and deep at hill base. Auguring can bedone up to 150 cm without difficulty, but soil is susceptible to erosion by water and grey in appearance (Zenebe, 2013). The production system in the area are mainly mixed farming in which maize, enset, and teff are major crops, and cattle, sheep and goat, and equines are major livestock reared.

2.2 Method of Data Collection

The primary data were collected from selected farm households in the study area through a structured questionnaire. Before the collection of main data, PRA tools such as Focused Group Discussion (FGD) and Key Informant Interview (KII) were conducted to gather information. The participants during KII are experts that have long years of experience in development works within the watershed. During FGD, the participants were member of the kebele administration and selected farmers. During the discussion, the bid values for the services of watershed management were determined and cross-checked with previous studies. Accordingly, four (9, 18, 36, and 72) bid values (in Birr) were determined with their respective higher and lower follow-up bids. A double bounded dichotomous choice elicitation method was used because of its advantages over controlling biases that arise during the CV study. It also minimizes

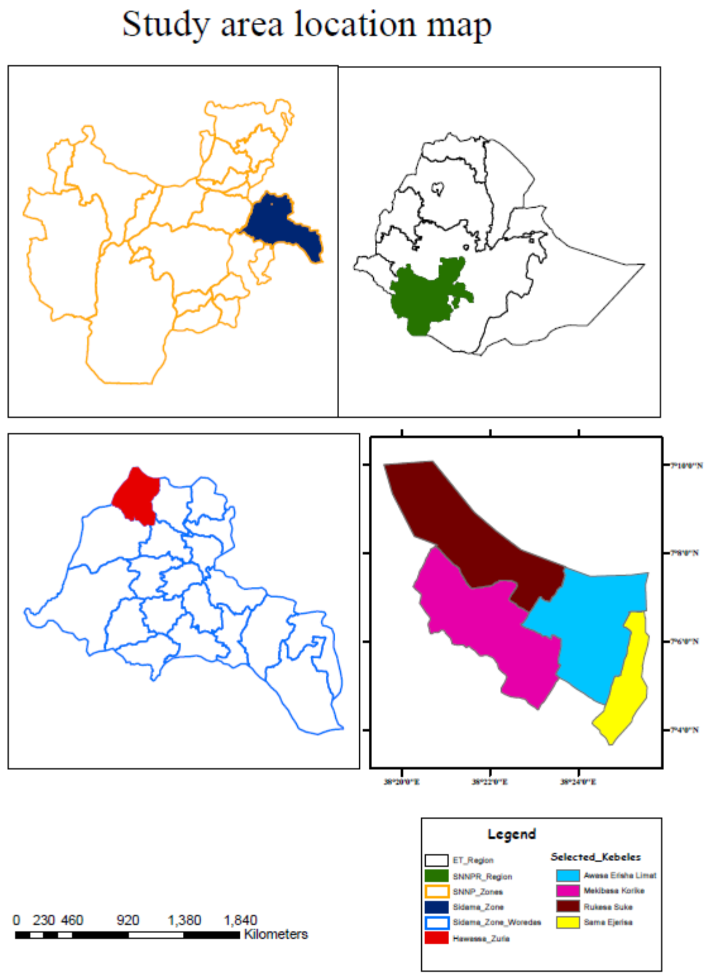

Figure 1:
(Source: Own GIS Mapping (2020))

nonresponses and avoids outliers, and it is more efficient than other elicitation methods. Indeed, it has efficiency gains because additional questions, even when they do not bound WTP completely, further constrain the part of distribution where respondents' WTP lies (Haab and McConnel, 2002).

2.3 Sampling Techniques

From five Lake Hawassa sub-watersheds, Hawassa Zuria Woreda (Dorebafena-Shamena) sub-watershed was selected purposefully because of its severe degradation problem. This watershed includes sixteen kebeles and it has 16931 total households. In this study, four kebeles were selected for final data collection based on the need for watershed management. For sampling, the list of the population was accessed from the woreda office of agriculture and natural resource. The sample size was determined by the rule of thumb that every explanatory variable in the model to have at least 10 (ten) sample respondents. A total of 275 households were selected using simple random sampling techniques. The total number of households were distributed among the four Kebeles in proportion to their size. Households were then selected by using Stat Trek's random number generator procedure .

2.4 Theoretical Framework

Let an individual household's utility function depends on marketable good x and some of the non-marketable services of WSM practices which are valued. The corresponding indirect utility function depends on the individuals' income 'y', the services of watershed management (WSM) practices 'q', and various other arguments including the price of market goods, attributes of market goods, and attributes of an individual that shifts his/her preferences (Hanemann, 1999). For simplicity, we suppress all of these arguments except (q,y). In random utility model (RUM) it assumed that, while a respondent knows his or her preferences with certainty, and does not consider them stochastic, they contain some components that are unobservable to the econometric investigator and are treated by the investigator as random. These unobservable could be characteristics of households or attributes of WSM practices services can stand for both variation in preferences among members of a population and

Table 1: The sample number of households from each kebeles

Kebeles	Number of households	Sample households
Sama Egersa	549	46
Rukessa Suke	717	60
Makibassa Korke	1278	106
Uddo Wotate	754	63
Total	3278	275

Source: Own computation from woreda office of agriculture.

measurement error. For now, we represent the stochastic component of preferences by ε without yet specifying whether it is a scalar or a vector, and we write the indirect utility function as $v(q, y, \varepsilon)$. Thus, the individual is confronted with the possibility of securing a change from q_0 to $q_1 > q_0$. We assume the household regards this as an improvement, so that $v(q_1, y, \varepsilon) > v(q_0, y, \varepsilon)$.

The household is told this change will cost *Birr A*, and he or she is then asked whether they would be in favor of it at that price. By the logic of utility maximization, the household answers 'yes' only if:

$$v(q_1, y - A, \varepsilon) \geq v(q_0, y, \varepsilon),$$

and 'no' otherwise. Hence,

$$\Pr(\text{response is 'yes'}) = \Pr\{v(q_1, y - A, \varepsilon) \geq v(q_0, y, \varepsilon)\}.$$

An equivalent way to express this same outcome uses the compensating variation measure, which is the quantity C that satisfies:

$$v(q_1, y - C, \varepsilon) = v(q_0, y, \varepsilon).$$

Thus, $C = C(q_0, q_1, y, \varepsilon)$ is the household's maximum willingness to pay (WTP) for the change from q_0 to q_1. It follows that he/she answers 'yes' if the stated price is less than this WTP, and 'no' otherwise. Hence, an equivalent condition to the one above is:

$$\Pr(\text{response is 'yes'}) = \Pr\{C(q_0, q_1, y, \varepsilon) \geq A\}.$$

In a random utility model (RUM), $C(q_0, q_1, y, \varepsilon)$ itself is a random variable. While the household's WTP for the change in q is something that he/she knows, it is something that the investigator does not know and treats as a random variable.

2.5 Methods of Data Analysis

2.5.1 Descriptive statistics

Descriptive statistics were used to analyze the socio-economic characteristics of respondents. These are means, percentages, and frequency distributions. Different characteristics of sample respondents were compared to the desired characteristics. Ch-squared and t-test were used to test whether or not there is a strong relationship between the dummy and continuous variables, respectively with households' willingness to pay for the services watershed management.

2.5.2 Econometric Model

Assuming that each household has some unobserved true point valuation for the services of watershed management in question, at the moment the first dichotomous choice contingent valuation (CV) question is posed. Let this unobserved value be Y_{1i}, and the first offered threshold assigned arbitrarily to this individual be denoted by t_{1i}. We will assume that the individual will state that they are willing to pay the offered amount ($I_{1i} = 1$) if $y_{1i} \geq t_{1i}$. They will be unwilling to pay this amount ($I_{1i} = 0$) if $y_{1i} < t_{1i}$.

Now let the unobserved valuation y_{1i} consist of a systematic component $X_{1i}\beta_1$, which is a function of vector X_{1i} of observable attributes of the respondent, plus an unobservable random component ε_{1i} (distributed $N(0, \sigma)$), which absorbs all unmeasured determinants of the value of the resource to the individual. Once an individual has been randomly assigned their initial offered value, the follow-up offer will take on one of two alternative predetermined values (one higher and one lower). The probability of receiving the predetermined higher offer is just the probability of responding "yes" to the first willingness-to-pay (WTP) question and vice versa.

We must, therefore, develop the model in the context of the joint distribution of (y_{1i}, y_{2i}). We assume a Bivariate Normal Distribution, BVN$(X_{1i}\beta_1, X_{2i}\beta_2, \sigma, \sigma, \rho)$, for these two implicit valuations. There are four possible pairs of responses to these questions: $(I_{1i}, I_{2i}) = (1, 1)$, $(1, 0)$, $(0, 0)$, $(0, 1)$.

Using $Y_1 = X_{1i}\beta_1 + \varepsilon_1$, this condition can be expressed equivalently as:

$$\frac{\varepsilon_1}{\sigma_1} > \frac{t_1 - X_{1i}\beta_1}{\sigma_1},$$

where $\frac{\varepsilon_1}{\sigma_1}$ is a standard normal random variable. Similarly, using $Y_2 = X_{2i}\beta_2 + \varepsilon_2$, this condition can be expressed equivalently as:

$$\frac{\varepsilon_2}{\sigma_2} > \frac{t_2 - X_{2i}\beta_2}{\sigma_2},$$

where $\frac{\varepsilon_2}{\sigma_2}$ is also a standard normal random variable.

Denote the standardized normal error $\frac{\varepsilon_1}{\sigma_1}$ as z_1 and $\frac{\varepsilon_2}{\sigma_2}$ as z_2. The analysis can proceed in terms of probabilities associated with regions in the domain of the standard bivariate normal distribution, where the pair (z_1, z_2) is distributed BVN$(0, 0, 1, 1, \rho)$ (Cameron and Quiggin, 1994).

Accordingly, the equation becomes:

$$\text{WTP}_{ij} = \mu_i + \varepsilon_{ij},$$

where WTP_{ij} represents the jth respondent's willingness to pay, and $i = 1, 2$ represents the first and second answers. μ_1 and μ_2 are the means for the first and second responses, and ε_{ij} are unobservable random components.

After running a regression of the dependent variable (yes/no indicator) on the constant and the independent variable consisting of bid values, the mean WTP is determined as follows, depending on the normality assumption of the WTP distribution (Haab and McConnell, 2002):

$$\text{MWTP} = -\frac{\alpha}{\beta},$$

where MWTP is the mean willingness to pay for the services of watershed management, α is the intercept of the model, and β is the coefficient of bid values.

The independent variables used to compute MWTP are the initial (Bid1) and follow-up willingness-to-pay values (Bid2). After that, from two regression outputs, the average value is calculated to estimate the mean willingness to pay.

2.6 Definition of Variables and Hypothesis

The dependent variable: The dependent variable is a binary choice variable (WTP1 and WTP2) measuring the willingness of households to pay for the services of watershed management. The response 1 represent willing households who responded 'yes' for offered bids, and 0 otherwise. Independent variables: The following variables were hypothesized to determine the households' willingness to pay for watershed management. These are explained below.

Age: This is a continuous independent variable. According to previous studies, young household heads may have a longer planning horizon and may be more likely to invest in watershed management activities like SWC practices than older age (Gebrelibanos, 2012). So, it is hypothesized that it negatively affects WTP for the services of watershed management

Gender: It is the sex of the household head which is measured as a dummy variable taking a value of 1 for male-headed household and 0 otherwise. Male-headed households are more willing to pay for the services of watershed management than female-headed households (Calderon et al., 2013; Gebrelibanos, 2012). So, it is hypothesized that the probability of male-headed respondents' WTP is more than female-headed respondents.

Extension contact: It is a discrete variable depending on the number of households' yearly contact with the extension agent. The variable hypothesized that it increases awareness of the services of watershed management and increases willingness to pay (Gebrelibanos, 2012). Initial and follow-up bids: these are continuous variables and measured in cash and included in the regression analysis to check whether starting bias exists or not. For every increase in bid amount, holding other variables constant, households willingness to pay for the services of watershed management decreases.

Educational status: It is a continuous variable representing the number of years that the respondent household spent in school. This variable has a positive and strong relationship with WTP because as the education level of household heads increases, willingness to pay for WSM practices increases because education provides information about watershed degradation and its effect (Calderon et al., 2013; Gebrelibanos, 2012). So, it is hypothesized to positively affect willingness to pay for watershed management.

Distance from the mountain: This is a continuous variable measured in kilometers and expected to affect willingness to pay for the services of watershed management negatively because if the household is far from the upland mountain within the watershed, he or she is less willing to pay for the management of watershed including upland mountain rehabilitation.

Household income: It is a continuous variable and measured in Ethiopian Birr and contains the amount of income that the household collected last year from agriculture like livestock and crop production. The households' WTP increases with a unit increase in agricultural income assuming other variables constant (Calderon et al; 2013, Lewis et al., 2017). So, it is hypothesized that it has a positive effect on a households' willingness to pay for watershed management.

Family size: It is a discrete variable and indicates the number of people living in one house. It is hypothesized that; the higher family size has a negative effect on WTP for the services watershed management because the larger number of households need more money for their expenses; including expenses for schooling and clothes for children. Hence, affects WTP negatively.

Landholding: It is a continuous variable and indicates the size of land in hectares owned by farm households. It is hypothesized that farmers who own large plots are more willing to pay for watershed management than the smaller ones. Because farmers who own large plots generate higher income than the smaller ones (Gebrelibanos, 2012) and thus expected to benefit more from watershed management. .

Total livestock unit: It is a continuous variable indicating the number of livestock that respondent households have in terms of tropical livestock unit (TLU). TLU is one of the wealth indicators and should have a positive contribution to a willingness to pay (Gebrelibanos, 2012). It is hypothesized that it has a positive effect on WTP for watershed management.

Farming experiences: This is a continuous variable. This variable represents the total number of years the respondent household head has spent on farming. Wider knowledge and experiences will be gained on the issue of watershed degradation with longer experience in farming (Calderon et al., 2013). So, it is hypothesized that it has a positive effect on respondents' willingness to pay for watershed management.

Perception of watershed degradation: It is a dummy variable that takes the value 1 if the respondent household perceived watershed degradation and 0 otherwise. It is hypothesized that the household that has perceived the problem of watershed degradation are more willing to pay than farmers who haven't perceived watershed degradation (Gebrelibanos, 2012).

Social position: This is a dummy variable that takes 1 if households have a certain position within the community, and 0 otherwise. Those positions are being a member of kebele administration and recognized elder. So, it is hypothesized that it has a positive effect on the respondent's WTP for watershed management

3 Results and discussion

3.1 Socio-economic characteristics of sample households

This analysis is based on data collected from 275 sample households. Overall, the descriptions of the socio-economic characteristics of sample households are presented below. Table 2 and 3 show the summary statistics of dummy and continuous variables, respectively. According to the result of the chi2 test, willingness to pay is associated with gender, social position, and perception of watershed degradation are .

Gender: A great majority of non-willing households (83.93%) were female headed households while male-headed households constitue a great majority (85.8%) of the households who were willing to take offered bids for watershed management . The Chi-square test reveals that there is a significant difference in willingness to pay between male and female household heads at a 1% probability level. This might be due to differences in access to information about natural resource management.

Social position: Concerning social position, 66.5% have no position in the community and 33.45% have a position in the community. Close to 90% of the non-willing households have no any social position in the community. On the other hand, the group that accepted the offered bid is relatively better distributed between those with social position (60.7%) and without social position (39.3%). Based on chi-square test analysis, there is a strong relationship between social position and willingness to take offered bids. This also might be due to differences in access to information.

Perception of watershed degradation: From the total households interviewed, 74.55% of respondents perceived the problem of degradation and 25.45% did not perceive it. As expected a large majority (82.2%) of households willing to pay for watershed management perceived the problem of degradation. For the non-willing group, there was not a large difference in the proportion of households that perceived (55.4%) and didn't perceive (44.6%) the problem of degradation. The chi-square test statistics also show that there is a strong relationship between perception of watershed degradation and willingness to pay.

According to the t-test, there is no significance difference between willing and non-willing households in terms of age, education status, family size, distance from the mountain, landholding, and farming experiences. But TLU and annual farm income are significantly different between willing and non-willing households.

Tropical Livestock Unit (TLU): On average, respondents have 3.6 TLU of livestock. The t-test statistics also show that there is a significant mean difference in livestock size between the willing (3.78) and the non-willing (2.91) households.

Farm income: The average annual farm-level income of respondents is 3310 Ethiopian birr. The mean annual income of willing respondents is signficantly greater than non-willing respondents. This might be due to the direct influence of income on the amount of payment for watershed management.

3.2 Description of Households' Willingness to Take Initial and Follow-up Bids

Table 4 shows that one of the four initial bids were presented for each of the respondents – 9 Birr (22.91%), 18 Birr (25.82%), 36 Birr (26.91%), and 72 Birr (24.36%). Out of 275 respondents, 20.4% respondents were non-willing and 79.6% were willing to take initial bids and contribute to the implementation of watershed management as indicated in Table 5. This was based on randomly asking them to respond to pre-determined initial bids

In terms of willingness to take the initial bids, households' probability to say 'yes' for offered bids percentage decreases as the bid amount increases. This implies the respondents answer positively as the bid amount goes down. In addition, out of 275 respondents, positive responses for higher follow-up bids were 35.64% and negative answers were 24.73% as indicated in Table 5 below.

Therefore, even though the payment amount is high, a large number of the households were interested to pay more to halt watershed degradation problems. The reverse is true for lower bid amounts. This might be due to households' annual level of income. This implies that the severe problem of degradation pushes respondents to take offered bids.

3.3 Determinants of Households' Willingness to Pay

Thirteen (13) explanatory variables were used in the bivariate probit model to identify determinants of willingness to pay based on the hypothesis made (Table 6). The result of the model shows that the probability of chi-square distribution (162.61) with less than the tabulated counterfactual is 0.000, which is less than1significance level. This implies the variables included in explaining WTP for WSM practices fit the bivariate probit model at less than 1probability level. Also, it means that the joint null hypothesis of coefficients of all explanatory variables included in the model was zero should be rejected. This implies the data fits the model. As indicated in Table 5, out of thirteen (13) variables used in the model, seven (7) variables affecting households' willingness to take initial bids were significant at less than 1% and 5% significant levels. These are age,

Table 2: Categorical Variables and Their Distributions

	Category		Statistics			
Variable	Group	N	Col 1	Col 2	Col 3	Col 4
Have position 6	-	-	10.71	86	39.27	92
	-	-	33.45	-	44.63***	-
Perception of WS degradation	Not Perceived	31	55.36	39	17.81	70
	Perceived	25	44.64	180	82.19	205
			74.55	-	33.14***	-
Physical property of land	Not Prone	13	23.21	53	24.20	66
	Erosion prone 43	76.79	166	75.80	209	76.00
					0.024	-
Awareness on role of forest	Not Aware	3	5.36	9	4.11	12
	Aware	53	94.64	210	95.89	263
			95.64	-	0.17	-

Table 3: Description of discrete and continuous variables by the willingness to pay status

Continuous and discrete variables	Non-willing (N=56)		Willing (N=219)		t-test	Total mean
	Mean	St. Err	Mean	St. Err		
Age	36.45	1.29	33.87	0.66	1.76	34.39
Education Status	5.38	0.54	5.21	0.27	-0.28	5.24
Family size	5.54	0.37	5.81	0.19	-0.66	5.75
Distance from mountain	3.38	0.38	3.2	0.22	0.38	3.24
Land holding	0.79	0.05	0.84	0.03	-0.71	0.83
Farming experiences	18.19	1.41	19.69	0.865	-0.85	19.39
TLU	2.91	0.22	3.78	0.11	-3.46***	3.60
Farm income	3158.93	0.43	3348.86	0.29	-3.11**	3310.18

** and *** imply statistical significance at less than 5% and 1% levels. Source: Own survey, 2020.

gender, initial bid, farm income, livestock size, perception of watershed degradation, and social position. Age and initial bid affect negatively and the remaining five (5) variables affect the willingness to pay for watershed management positively. In addition, four (4) variables were affecting households' willingness to take follow-up bids at less than 1% significant level. These are gender, follow-up bid, perception of watershed degradation, and social position. Follow-up bid affects WTP negatively and the remaining three (3) variables affect the willingness to pay for watershed management positively.

Age of household head: It had a negative and significant effect on households' willingness to pay for the services of watershed management at less than 1% level of significance. The major reason for the negative effect of age on willingness to pay is that the older aged households may have a short planning time horizon and reduce WTP for future sustainable management of watershed. Thus, older age households were less likely to pay for WSM practices as they expect they would benefit less from investment in WSM compared to young household heads. This negative relationship between age and investment in natural resource conservation is also consistent with the finding of Calderon et al. (2013) and Gebrelibanos (2012). Keeping other variables constant, on average the age of household head has been found to reduce the probability of accepting offered initial bid by 1.7 percent.

Gender of household head: This variable is found to have a positive effect on willingness to pay for watershed management. The result of the bivariate probit model shows that male-headed households were found to have more likely to say 'yes' for offered initial and follow-up bids than female-headed households. This is because agricultural activities are most of the time performed by males and it is known that they have a better awareness of watershed degradation. Concerning its joint marginal effects on willingness to pay, the probability of male- headed households saying 'yes' for offered initial and follow-up bids were more than 51 percent compared to female-headed households.

Initial bid and follow-up bids: Initial and follow-up bids offered were found to negatively and significantly affect WTP. This implies the households' probability to say 'yes' for offered bids increases

Table 4: Distribution of amount of initial bids

Bid1 (ETB)	Frequency	Percentage	Willingness responses	
			No (%)	Yes (%)
9	63	22.91	14.29	85.71
18	71	25.82	14.04	85.92
36	74	26.91	24.32	75.68
72	67	24.36	28.36	71.64
Total	275	100.00	20.36	79.64

Table 5: Response rates of follow-up questions

Initial bids	Follow-up bids (ETB)		Responses for Higher Follow-up		Responses for Lower Follow-up	
(ETB)	Follow-up	Bids	No	Yes	No	Yes
9	20	4	12	38	9	4
18	40	10	18	29	11	13
36	72	18	19	19	18	18
72	140	36	19	12	19	17
Total	–	–	68 (24.73%)	98 (35.64%)	57 (20.73%)	52 (18.91%)

with a decrease in the bid amounts. This is consistent with economic theory, as price level increases demand decreases. With respect to its marginal effects, as bid amount increases by a unit, keeping other variables constant, on average the probability of willingness to take both bids for watershed management decreases by 0.3 percent.

Farm Income: The annual farm-level income of household head was found to positively and significantly affect willingness to pay for WSM practices at less than 1% probability level. This implies that the probability to say 'yes' for offered bid amount increases with increase in the annual farm income of the household head, which is consistent with economic theory. Keeping the effect of other explanatory variables constant, a unit increase in annual farm income of household increases the probability to say 'yes' for offered initial bids is 5.9 percent. This implies that households say 'yes' to offered bids, if and only if the amount of bid is less than they can afford to pay.

Tropical livestock unit (TLU): The size of livestock ownership was found to positively and significantly affect willingness to pay at less than 1% probability level. This implies increased possession of livestock increases willingness to pay because it is one of the wealth indicators and should have a positive contribution to willingness to pay. This finding is in line with a study conducted by Gebrelibanos (2012). Its marginal effect implies when possession of tropical livestock unit increases by a unit keeping other variables constant, it increases the probability of saying 'yes' for offered initial bids by 7.7 percent.

Perception of Watershed degradation: Perception of watershed degradation was found to positively and significantly affect willingness to pay for WSM, which is consistent with prior expectations. That is the probability of willingness to pay by households that perceived the problem of watershed degradation is higher than the households who do not perceive the problem of watershed degradation. In addition, the joint marginal effect shows the likelihood to say 'yes' of households who perceived the watershed degradation problem is 34.4 percent more than households who have not perceived. This result is consistent with the study of Gebrelibanos (2012) for the relationship between perception of soil erosion and WTP.

Social position: Households who have any position in kebele or community have been found to positively and significantly affect willingness to pay for WSM. The result is consistent with the findings of Genene and Anteneh (2015) which indicated that farm households who have a social position have better access to different capacity- building training and social affairs in the community which creates a better awareness of the management of resources. The joint marginal effect reveals that households who have a social position in the community were 52.7 percent more likely to say 'yes' for the offered first and second willingness to pay questions.

3.4 Estimation of Mean Willingness to Pay

One of the aims of this study was to estimate the amount of willingness to pay. The bivariate model was applied to estimate MWTP by using response dummy variables for two responses and their respective bid amounts. Table 7 shows the bivariate probit model result of two responses of willingness to pay questions

LR test of rho=0: chi2(1)=10.3701   prob¿chi2=0.0013.

In the above bivariate probit model output, rho is positively and significantly different from zero at less than a 1% probability level, implying there is a positive correlation between the two responses.

In addition to this, the correlation coefficient of the error term is less than one which implies the random component of WTP for the first

Table 6: Explanatory variables affecting the households' willingness to pay

Variables	WTP1 Coeff (St. Err)	WTP2 Coeff (St. Err)	WTP1 marginal effects	Joint marginal effects
Age	-0.051 (0.014) ***	-0.003 (0.009)	-0.017	-0.013
Gender	1.14 (0.298) ***	1.41 (0.24) ***	0.406	0.51
Extension contact	-0.027 (0.02)	-0.016 (0.014)	-0.009	-0.01
Initial (follow-up) bid^2	-0.012 (0.005) **	-0.009 (0.003) ***	-0.004	-0.003 (-0.003)
Education	-0.052 (0.039)	-0.006 (0.026)	0.017	0.013
Distance from mountain	-0.045 (0.038)	0.042 (0.031)	-0.015	0.003

Note: Initial bid was used for WTP1 estimation and follow-up bid was used for WTP2 estimation.

Variable	**Coefficient (SE)**	**Coefficient (SE)**	**Marginal Effects**
Farm Income	0.18 (0.039) ***	-0.015 (0.024)	0.059
Family size	-0.0035 (0.055)	-0.05 (0.043)	-0.001
Farm size	-0.039 (0.272)	-0.18 (0.202)	-0.057
TLU	0.235 (0.073) ***	-0.06 (0.057)	0.077
Farming experience	-0.019 (0.013)	-0.016 (0.009)	-0.007
Perception of WS degradation	0.766 (0.296) **	0.727 (0.224) ***	0.273
Social position	1.88 (0.29) ***	0.60 (0.20) ***	0.568
Cons	-5.38 (1.38) ***	-0.397 (0.86)	0.527

Observations = 275
Loglikelihood = -193.29
Wald χ^2 (26) = 162.61
Prob ¿ χ^2 = 0.000

*** and ** are significance at 1% and 5% respectively.

question is not perfectly correlated with the random component of follow-up questions. According to the formula of Habb and McConnell (2002) , the estimated willingness to pay is 58.41 Ethiopian birr per year for WSM practices. This double- bounded willingness to pay ranges from 57.42 to 59.4 birr per year.

In addition to the double bounded dichotomous choice elicitation method, an open-ended format was used to cross-check the estimated value by two formats. Accordingly, from the open-ended format mean maximum willingness to pay per year is 47.27 birr, which ranges from 0 to 300 birr per year. This result is different from the double bounded question, which has a mean WTP is 58.41 birr per year. Table 8 reveals that 89.45% of households were willing to pay some amount of birr for WSM and only 10.55 percent were not willing.

During the survey, each willing respondent was asked to state the reasons for their maximum willingness to pay. Out of 246 willing households, 46 (18.69%) stated that they think the watershed management is worth the bid amount asked, and 200 (81.31%) stated they did not afford to pay more than the amount they are willing. The possible reason for this might be their annual level of income.

In most valuation of environmental services studies, some respondents were not interested to pay and participate in the management of natural resources due to many reasons. Similarly, in this study, out of the 275 sample respondents, 29 (10.55%) were not willing to pay some amount of birr for WS management. From them, 16 (55.17%) responded that the government should pay for it and are considered as protest zero bidders, which were excluded from the estimation of aggregate demand estimation and 12 (41.38%) and 1(3.45%) responded they can't afford to pay and they do not use the good, respectively are considered as true zero bidders. Hence, these protest zeros are considered as free riders on services of watershed management.

3.5 Welfare Measure and Aggregation of WTP

Aggregation of willingness to pay for environmental resources is important in the CV study. Random sampling technique with face-to-face interviews was used in this study and protest zero responses were excluded from the estimation of aggregate benefit for watershed management services.

Table 10 reveals aggregate willingness to pay for watershed management. This was calculated by multiplying the mean willingness to pay from open-ended and dichotomous choice responses result by the total number of populations within a watershed with 16931 households. Accordingly, the total willingness to pay from dichotomous choice responses is 931581.1 birr per year whereas, from the open-ended format, the total willingness to pay is 753909.2birr per

Table 7: Mean willingness to pay from double bounded dichotomous responses

Dependent variables	Explanatory variables	Coefficients	St. Error	Z-value	P-value
WTP1	Bid1	-0.012	0.0033	-3.69	0.000
	Cons	0.689	0.138	5.00	0.000
WTP2	Bid2	-0.0085	0.0024	-3.59	0.000
	Cons	0.5049	0.131	3.87	0.002
Anthro		0.429	0.141	3.05	0.002
Rho		0.404	0.118		

LR test of rho=0: chi2(1)=10.3701 prob¿chi2=0.0013.

Table 8: Table 8. Open-ended willingness to pay responses

Maximum WTP in Birr	Mean	St. Error	Min	Max	Obs	Non-willing (=0)	Willing (¿0)
47.27	45.04	0	300	275	10.55	89.45	

year. This implies the result from dichotomous choice is greater than the open-ended format.

4 Conclusion

The result of the study revealed that the majority of households were concerned about the problem of watershed degradation in the study area and the households in the area were willing to pay for watershed development. The bivariate probit model was employed to identify the effect of explanatory variables on households' willingness to pay for WSM. In the model, the age of the household head and offered initial and follow-up bids were significantly and negatively affecting WTP for WSM. On the other hand, gender, income, tropical livestock unit, perception of watershed degradation, and social position were found to positively and significantly affect willingness to pay for WSM. With this, the mean willingness to pay for WSM was calculated to be 58.4 Birr and 47.3 Birr, from the double bounded format and open-ended format, respectively per annum. Indeed, the aggregate welfare gain from watershed management in the study area was estimated to be 931581.09 and 753909.23 Birr from the double bounded dichotomous choice format and open-ended format, respectively per annum. This shows that the value of WSM from an open-ended format was underestimated as compared to a double bounded format. This indicates that there may be the existence of free- riding problems and a lack of base for households for valuing WSM in an open-ended format. This implies that, in the valuation of environmental resource services, using a double bounded dichotomous choice format is preferable to an open-ended format. In general, the study found the higher gain from services of WSM in the study area from a double bounded dichotomous format.

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Conflict of interest

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References

[1] Abebe, S.T., Daygnew, A.B., Zeleke, V.G., Eshetu, G.Z., and Cirella, G.T. (2019). Willingness to pay watershed management.

[2] Armsworth, P., Gomez-Bagethun, E., Cornelissen, H., Eppink, F., Farley, J., Loomis, J., Pearson, L., Perrings, C., and Polasky, S. (2010). Economics of ecosystem and biodiversity: The ecological and economics foundations. Economics of valuing ecosystem services and biodiversity.

[3] Bateman, I.J., and Willis, K.G. (1999). Valuing environmental preferences. Theories and practices of the contingent valuation methods in the US, EU, and developing countries.

[4] Biniyam, T. (2013). Valuing the Economic Benefit of Controlling Off-site Effects of Soil Erosion: Empirical evidence from the Eastern Highland of Ethiopia. MSc Thesis, Addis Ababa University, Addis Ababa, Ethiopia.

[5] Calderon, M., Anit, K.P.A., Palao, L.K.M., and Lasco, R.D. (2013). Household's willingness to pay for integrated watershed services of Layawan watershed in Oroquieta City, Philippines. *Journal of Sustainable Development*, 6(1). ISSN 1913-9063, E-ISSN 1913-9071.

Table 9: Table 9. Reasons for not willing and willing to pay

Reasons for willingness to pay	Freq.	Perc.	Reasons for not willing to pay	Freq.	Perc.
I think it is worth that amount	46	18.69	I do not use the good	1	3.45
I couldn't afford more	200	81.31	I can't afford to pay	12	41.38
			The government should pay	16	55.17
Total	246	100	Total	29	100

Table 10: Table 10. Aggregate willingness to pay

Elicitation procedure	Total No of samples HHs	No of protest	HH with of protest zero	Proportion protest zero	Expected valid	HHs with responses	Mean WTP	Total WTP
Double bounded Dichotomous	16931	275	16	0.058	981.998	15949	58.41	931581.09
Open ended	16931	275	16	0.058	981.998	15949	47.27	753909.23

[6] Cameron, A.T., and Quiggin, J. (1994). Estimation using contingent valuation data from a "dichotomous choice with follow-up" questionnaire. *Journal of Environmental Economics and Management*, 27(3), 218–234.

[7] Fikru, A.M. (2009). Assessment of adoption of soil and water conservation practices in the Koga watershed, Highland of Ethiopia. MSc Thesis.

[8] Gebrehaweria, G., Dereje, A.A., Girmay, G., Meredith, G., and Simon, L. (2017). An assessment of integrated watershed management in Ethiopia. *International Water Management Institute (IWMI) Working Paper*.

[9] Gebrelibanos, G.G. (2012). Household's willingness to pay for soil conservation practices in Adawa Woreda, Ethiopia. Contingent valuation study.

[10] Genene, T.M., and Anteneh, F. (2015). Experiences and challenges of integrated watershed management in central zones of southern Ethiopia. *International Journal of Current Research*, 7(10).

[11] Haab, T.C., and McConnell, K.E. (2002). Valuing environmental and natural resources: The econometrics of non-market valuation. *New Horizon in Environmental Economics*.

[12] Hagos, G., Temesgen, G., and Abrham, M. (2014). Wetland Degradation in Ethiopia: Causes, Consequences, and Remedies. *Journal of Environment and Earth Science*, 4(11). ISSN 2224-3216 (Paper), ISSN 2225-0948 (Online).

[13] Hanemann, W.M. (1999). The economic theory of WTP and WTA. The theory and practice of the contingent valuation method in the US, EU, and developing countries.

[14] Kebede, W., Tefera, M., Habtamu, T., and Alemayehu, T. (2014). Impact of Land Cover Change on Water Quality and Stream Flow in Lake Hawassa Watershed of Ethiopia. *Agricultural Sciences*, 5, 647–659. Published Online July 2014 in SciRes.

[15] Mallampati, P., and Osman, M.K. (2015). CCME Water Quality Index and Assessment Physico-Chemical Parameters of Lake Hawassa, Ethiopia.

[16] Merkine, M., Aklilu, B., and Debebe, D. (2017). Integrated watershed management as ecosystem balance and climate change: Ethiopia. *Civil and Environmental Research*, 9(9). ISSN 2224-5790 (Paper), ISSN 2225-0514 (Online).

[17] Mulugeta, D., Diekkruger, B., and Roehrig, J. (2017). Linkage between water level dynamics and climate variability: The case of Lake Hawassa hydrology and ENSO phenomena. *Climate*, 5(21). DOI:10.3390/cli5010021.

[18] Southern Agricultural Research Institute (SARI). (2017). Enhancing model integrated watershed management around Lake Hawassa and Gilgel Gibe III Hydro-electric power, Southern Ethiopia. Southern Agricultural Research Institute. Unpublished document.

[19] Sharma, B.R., Samra, J.S., Scott, C.A., and Wani, S.P. (2005). Watershed Management Challenges: Improving Productivity, Resources, and Livelihoods. Colombo, Sri Lanka: International Water Management Institute, xiv + 336 p.

[20] Simachew, B.W. (2020). Natural Resource Degradation Tendencies in Ethiopia: A Review. *Environmental System Research*.

[21] Simon, L. (2016). Comprehensive impact assessment of watershed management interventions in Ethiopia.

[22] Wolfgramm, B. (2015). Pathways to effective integrated watershed management. *IWSM Policy Brief No.2*. University of Bern, Center for Development and Environment (CDE), Bern, Switzerland.

[23] Yericho, B.M. (2019). Technical viability of physical soil and water conservation structures implemented in Lake Hawassa Watershed, Southern Ethiopia.

[24] Zenebe, M.G. (2013). Watershed degradation and the growing risk of erosion in Hawassa Zuria District. *Journal of Flood Risk Management*.