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Research Article

Households' Willingness to Pay for the Conservation of Debre-Libanos Monastery Forests, North Shewa Zone, Ethiopia: Evidence from a Contingent Valuation Method

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Abstract

This study examined households' willingness to pay (WTP) for the conservation of the Debre-Libanos monastery forests in the North Shewa Zone of the Oromia Region, Ethiopia, which hold ecological and cultural significance but face growing threats from human activities. Using primary data collected from 215 households, a Tobit regression model was employed to identify factors influencing the maximum WTP amount, while a seemingly unrelated bivariate probit model was used to estimate the average WTP. The Tobit model results indicate that household sex, education level, annual income, perception of conservation benefits, and participation in training positively affect the maximum WTP, whereas age and initial bid price show a negative influence. The bivariate probit estimation reveals that the average household WTP for forest conservation is 33.52 Ethiopian Birr per year, suggesting that despite income constraints, local communities place substantial value on conserving the monastery forests. These findings provide important policy insights by demonstrating that community members are willing to financially support conservation efforts, which can guide policymakers, forest managers, and conservation practitioners in designing effective forest management programs, allocating resources efficiently, and promoting community-based conservation strategies. Furthermore, the results highlight the need for awareness creation, conservation training, and income-enhancing measures to strengthen household participation and ensure long-term sustainability. Overall, this study contributes to the literature on environmental valuation in Ethiopia and underscores the role of economic approaches such as contingent valuation in supporting evidence-based forest conservation initiatives.

Keywords

Contingent Valuation, Forest Conservation, Seemingly Unrelated Bivariate Probit Model, Tobit Model, Willingness to Pay, Ethiopia

1. Introduction

The rich forests in Ethiopia's landscape serve as homes for hundreds of animal and plant species and are rich in numerous natural resources. I interestingly, considerable stretches of forests are located in the vicinity of monasteries, thus enhancing the environmental richness of the nation [1]. In this regard, it is important to mention the forest located near to Debre-Libanos monastery, which is an important historical and religious site. At present, however there are a number of

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threats to the survival of these forests, including encroachment, deforestation and unsustainable land-use [2].

The monastery's forests are very scared as they are places of worship of GOD, burial, and religious festivals. Besides these forests being important for religious purposes, they are also important in the sense that they are the existing, sometimes endemic, ecosystems for many species of plants and animals. They are also a renewable source of timber for constructing church buildings, and furnish traditional herbs and food to the monks. The yield of this is suitable for the congregation because of the peaceful atmosphere they provide and also helps in teaching the ordinary children of the church. These forests also improve the beauty and spirituality of the surrounding churches, provide ink and dye materials, make money and scent the surroundings. Additionally monastery forests are important in ecological conservation through water conservation, controlling soil erosion, serving as seed banks for indigenous plant species, promoting varied flora and fauna, and providing habitat for important pollinators [3-6].

Considering the significant impact of forests on ecosystem stability, biodiversity conservation and ecosystem service, it is essential to look for innovative conservation solutions, for example, by measuring households' willingness to pay for the conservation of forests around the Debre-Libanos monastery. Willingness to pay for forest conservation provides information about the relative importance of forests in comparison of other values as well as a snapshot of overall national or regional attitudes towards forest conservation; information which if used correctly can allow policy makers and conservation organizations to better target resources, to design incentive programs more efficiently, as well as to recruit local communities into sustainable resource management. Using a unique methodology, this research seeks to provide more robust empirical evidence on households' willingness to pay for conservation of Debre-Libanos monastery forests. It answers specific questions, namely weather households' are willing to pay for the protection of their monastery forests, and if so how much and what drives their maximum willingness to pay. These findings will help in designing the most appropriate conservation strategy, policy recommendation and community engagement programs for sustainable forest management.

2. Research Methodology

2.1. Study Area, Sampling and Sample Size

The research was carried out within the forests of the Debre-Libanos monastery, located in North Shewa Zone of Ethiopia. This particular selection was not only because of the area's cultural significant but also due to its ecological importance and ongoing conservation efforts. A two stage sampling technique was employed to obtain representative sample of households. Initially, three kebeles (the smallest administrative unit in Ethiopia) that surround the monastery forests were purposively chosen based on their proximity to these forests. However, in the second stage, sample households were selected through a systematic random sampling approach derived from the updated list of households in each selected kebele the distribution of the sample was proportional to the population size of each *kebele* (namely, *Chagel, Wusha Gedel and Set Debr*).

Structured household survey was used to collect household data, focused on socio-economic characteristics, environmental awareness, household values and willingness to pay for forest conservation practice. Employing contingent valuation methods, the survey aimed to gauge households' willingness to pay financially towards the conservation of the monastery forests by presenting hypothetical scenarios. However, this study is anchored on data from 215 randomly selected households residing around the monastery (obtained through face to face interview employing a semi structure questionnaire format). Although the methodology appears sound, the result may vary because of the different socio-economic backgrounds of the participants involved.

2.2. Analytical Estimation Methods

The study employed contingent valuation method (CVM) to estimate mean willingness to pay for forests conservation. CVM is effective in directly capturing individuals' willingness to pay or accept compensation for environmental changes and offers flexibility in valuing a wide range of non-market goods and services [7]. Before the survey, the questionnaire was pretested with 20 respondents to refine its clarity and identify issues. Based on this three bid values (30, 50 and 100 ET. Birr per year) were selected for a double-bounded dichotomous choice format. These bids were randomly assigned to households. In the double-bounded format, if the respondent accepted the initial bid, the second bid was doubled; if declined, it was halved. Afterward, respondents were asked their maximum willingness to pay using an open-ended question (Figure 1).

The applicable econometric model to estimate the determinants of WTP data depends on the type of CV elicitation ways [8]. The dichotomous choice approach has become the plausible system of elicitation for CV interpreters. The other three styles of CV elicitation ways (open- ended, bidding game, and payment card) have been shown to suffer from incitement comity problems in which check repliers can impact implicit issues by revealing values other than their true WTP [9].

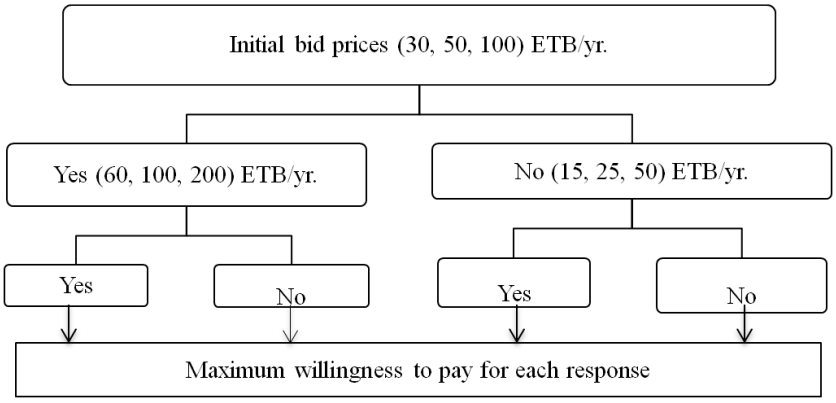

Figure 1. *Double-bound elicitation technique.*

2.2.1. Determinants of Willingness to Pay for the Conservation Practice

This study employed a double-bounded dichotomous choice elicitation technique followed by an open-ended question format. Hence, the Tobit/censored regression model is the appropriate and frequently used model to analyse the determinants of WTP [10]. It is even more appropriate when the dependent variable (maximum WTP) is censored from below (i.e. large number of zeros in the dependent variable) as in the case of the current study. In this study, considerable numbers of households (32%) were not willing to pay at all, referring that their maximum willingness to pay is zero.

Following [11] the Tobit model can be specified as:

$$MWTP^{*} = \beta_0 + \beta' x_i + \varepsilon_i \quad (1)$$

$$MWTP_i = MWTP_i^{*} \text{ If } MWTP_i^{*} \neq 0$$

$$= 0 \text{ if } MWTP_i^{*} \leq 0$$

where: $MWTP_i$= maximum willingness to pay of each replier; $MWTP_i^{*}$ = an idle variable which is observed only if it is greater than zero (indicating that there may be households' with negative outcomes on the dependent variable); x_i = Explanatory variables affecting WTP for the conservation; β' = coefficients of explanatory variables to be estimated and ε_i = error term that is independently and normally distributed with mean zero and common variance δ^2. The model parameters will be estimated by maximizing the Tobit likelihood function.

The interpretation of the coefficient of the Tobit regression model result is not straight forward as the coefficients of an uncensored linear model. Hence, the marginal effects[1] of the variables were estimated both for the probability to pay and the maximum amount they are willing to pay [12].

2.2.2. Mean Willingness to Pay

In the double bounded dichotomous choice elicitation format, the bivariate probit model was employed to estimate the level of mean WTP of the collected data. But, when the estimated correlation coefficient of the error terms in the bivariate probit model are assumed to follow standard bivariate normal distribution with zero mean and distinguishable from zero or unit variance, then the appropriate system of equation/model can be estimated as Seemingly Unrelated Bivariate Probit (SUBVP) model [13]. Therefore, this study employed a SUBVP model to estimate the mean WTP for the conservation. Following the estimation of the determinants of WTP, the model to estimate the mean WTP for double-bounded data i can be specified more formally as follows:

$$WTP_{ij} = \mu_i + \varepsilon_{ij} \quad (2)$$

where: WTP_{ij} is the j^{th} respondent's WTP and i=1, 2 represent first and second bid responses; μ_1 and μ_2 refer to the mean value for the first and second responses of the willingness to pay; ε_{ij} = unobservable random component, setting $\mu_{ij} = x_{ij}\beta_i$ allows the mean to be depending upon the respondents' characteristics. We have also re-estimated equation (2), including all other explanatory variables to assess the robustness of the finding.

Following [14], after running a regression of dependent variable (yes/no indicator), on the list of independent variables and the bid levels, the mean WTP value from closed-ended contingent valuation response can be determined as: Mean WTP = $-\frac{\alpha}{\beta}$ where: Mean WTP is the mean willingness to pay for the conservation; α= the intercept of the

1 The effect of explanatory variables on participation and the amount of WTP can be decompose (Scott Long, 1997). The marginal effect of an explanatory variable on the expected value of the dependent variable is: $\frac{\partial E(MWTP_i)}{\partial x_i} = F(Z)\beta'$ where $\frac{\beta' x_i}{\delta}$ is denoted by z, [11]. The change in the probability to be willing to pay as independent variables x_i changes is: $\frac{\partial F(Z)}{\partial x_i} = F(Z)\frac{\beta'}{\delta}$. Likewise, the change in the amount of WTP with respect to a change in explanatory variable among individuals who are willing to pay is: $\frac{\partial E(MWTP_i / MWTP_i^{*} \neq 0)}{\partial x_i} = \beta' \left[1 - Z\frac{f(z)}{F(z)} - \right]\left(\frac{f(z)}{F(z)}\right)^2$ where, F(z) is the cumulative normal distribution of Z, f(z) is the value of derivative of the normal curve at a given point (i.e., unit normal density), Z is the Z score for the area under normal curve, β' is the vector of Tobit maximum likelihood estimates.

model, β= slope coefficient of the bid values.

3. Results and Discussion

3.1. Descriptive and Inferential Statistics

Tables 1 and 2 summarize the awareness of forest conservation and socio-demographic characteristics of the households by the willingness to pay for the conservation practice. The results show that a significantly large number of male-headed households (80.9%) were willing to pay for monastery forest conservation, contrary to only 15.6% of female-headed households. Likewise, households who get credit services were significantly more willing to pay for monastery forest conservation than otherwise.

Table 1. Summary of categorical explanatory variables by willingness to pay status.

Variable	Categories	Willing (%)	Not willing (%)	x^2 (p-value)
Sex	Male	80.9	19.1	56.508***
	Female	15.6	84.4	
Credit service	Yes	96.2	3.8	21.532***
	No	63	37	
Perception	Yes	88.4	11.6	100.271***
	No	15.7	84.3	
Training	Yes	83.4	16.6	68.961***
	No	17.5	82.5	
Occupation	Yes	71.3	28.7	0.002
	No	71	29	

Note: ***, **and * significant at p<0.01, p<0.05 and p<0.1 respectively

Table 2 also demonstrates that households who are willing to pay for monastery forest conservation are younger, educated, and have more assets than their counterparts. Others can also be explained using the same fashion. However, we cannot draw any conclusion as these differences can be partially or totally due to other confounding factors.

Table 2. Summary of descriptive statistics for continuous explanatory variables.

Variable	Willing	Not willing	Total mean	t-value
	Mean	Mean	Mean	
Age	44.90	48.82	46.03	3.70***
Education level	2.10	1.93	2.06	0.32
Household size	6.22	5.45	6.00	3.13
Total annual income	23327.45	11898.06	20005.58	8.70*
Distance to forest	1.49	1.48	1.49	0.10

Note: * and *** refer to 10% and 1% significance level respectively

As described in the methodology section, a pre-test/pilot survey from households was done to identify the initial sets of bids. Based on the pilot survey, 30, 50, and 100 birr per year of monastery forest conservation were identified as initial bids.

Then, the follow-up bid was doubled if they response is "Yes" and halved if it is "No".

Following the CVM elicitation technique, the bid prices were proportionally and randomly distributed among the respondents. The data collected using a double bounded dichotomous choice format CVM elicitation procedure followed by an open-ended question is presented in Table 3. The results show that 28% of sample respondents accepted both BID_1 and BID_2 while 40% of reject both bids, i.e. responds No-No for the given bids.

Table 3. *Offered bid values and joint frequencies of discrete choice responses.*

BID_1 & BID_2 Responses	Frequency	Percentage
Yes - Yes	60	27.90
Yes - No	23	10.70
No - Yes	46	21.40
No - No	86	40.00
Total	215	100

Source: Own survey, 2023

3.2. Determinant Factors of Maximum Willingness to Pay

Tobit/censored regression model identified key determinants of households' willingness to pay (WTP) (Table 4) for monastery forest conservation. The sex of household head was positively associated with WTP, with male headed households' more likely to pay, showing a 13.9% higher probability and an additional Birr 25.54 per year compared to female headed households', possibly due to difference in spending priority or awareness. Age, on the other hand, had a negative relationship with WTP, with older household heads being less willing to pay, as they may be more conservative or resistant to change; a one year increase in age decreased the probability of willingness to pay by 0.8% and reduced the payment amount by 1.38 Birr/year. Educational level positively affected WTP, as each additional year of increased the likelihood of WTP by 1.1% and payment amount by 2.09 Birr/year, likely due to better analysis of the benefits and costs of conservation.

Table 4. *Determinants of maximum willingness to pay: Tobit model.*

Variables	Coeff.	Std. Err	t-value	Change in probabilities of being willing	Change among willing respondents
Sex	41.16*	17.06	2.41	0.139*	25.54*
Age	-2.22**	0.82	-2.72	-0.008**	-1.38**
Education	3.37*	1.50	2.24	0.011*	2.09*
Household size	2.00	3.36	0.60	0.007	1.24
Annual income	0.002***	.001	4.45	0.0015***	0.0019***
Credit service	11.39	11.98	0.95	0.039	7.065
Perception	50.53**	14.43	3.50	0.171**	31.357**
Distance to forest	1.89	11.68	0.16	0.006	1.175
Occupation	6.87	9.86	0.70	0.023	4.26
Training	33.20*	15.17	2.19	0.113*	20.60*
Initial bid	-0.99***	0.17	-5.79	-0.003***	-0.617***
Number of observations = 215					
LR chi2 (11) = 85.81; Prob > chi2 = 0.0000 Log likelihood = -1217.7316					

Notes: ***, **, * Significant at 1%, 5% and 10% probability level of significance.

Households' annual income positively influenced WTP for monastery forest conservation, with a 1,000 Birr increase in income associated with a 0.15% higher probability of WTP and an average increase of 1.90 Birr in payment. This aligns with previous studies, such as those on farmers' WTP for irrigation [15]. Awareness of the benefits of forest resources also had a significant positive impact, with informed households being 17.1% more likely to pay for conservation. Ad-

ditionally, training on forest conservation increased WTP, as trained households were more likely to pay for the practice. Conversely, the initial bid price negatively affected WTP, with each unit increase in the bid price reducing the likelihood of willingness to pay by 0.30%, consistent with the low of demand.

3.3. Estimated Mean Willingness to Pay

A Seemingly Unrelated Bivariate Regression (SUR) model was used to estimate the mean WTP for the monastery forest conservation, with bid prices as independent variables. The results revealed that both the initial and second bid prices were significant and negatively related to WTP, indicating that higher bid prices reduce the likelihood of WTP. The mean WTP for the first and the second bid prices using a double bounded dichotomous choice of CVM format, ranged from 28.05 to 38.98 Birr per year at a 95% confidence interval.

Table 5. Mean willingness to pay: Seemingly unrelated bivariate probit model.

Variables	Coefficients	Std. Err	p-value
WTP BID_1			
BID_1	-0.016997 ***	0.001875	0.000
Constant	0.4767494	0.0969176	0.000
WTP BID_2	-0.0122311 ***	0.0012643	0.000
BID_2	0.4767519	0.0969151	0.000
Constant			
Rho = 1 Log likelihood = -256.06455 LR test of rho=0			
chi2(1) = 57.1275 Prob > chi2 =0.0000			
Mean WTP = $-\frac{\alpha}{\beta}$ = 28.05 ET Birr to 38.98 ET Birr/yr. at 95% confidence interval			

As indicated in Table 5, the mean WTP for monastery forest conservation practice amount can be estimated as follows:

$$\text{Mean WTP} = \left((-\frac{\alpha 1}{\beta 1}) + -(\frac{\alpha 2}{\beta 2})\right)/2 = \left(-(\frac{0.4767494}{-0.016997}) + -(\frac{0.4767519}{-0.0122311})\right)/2 = 33.515$$

Ethiopian birr per year of monastery forest conservation practice.

where $\alpha 1$ and $\alpha 2$ are the coefficient of the constant term for bid one and bid two responses respectively; $\beta 1$ and $\beta 2$ are the coefficients of the initial bid and the second bid, respectively.

4. Conclusion and Recommendation

This research investigates households' willingness to pay for the conservation of Debre-Libanos monastery forest and examines the factors influencing WTP. Data was collected from 215 households using a contingent valuation method with double bounded dichotomous choice format, followed by an open-ended format. A seemingly unrelated bivariate probit model was applied to estimate the mean WTP, which averaged around 34 Birr/year. The Tobit regression results identified several significant factors affecting WTP, including household sex, age, education, income, perceptions, training, and initial bid prices. Overall, the results suggest that the assessment of willingness to pay provides important insights for policymakers and forest managers in designing appropriate conservation interventions, allocating resources effectively, and ensuring sustainable forest management.

Abbreviations

CVM	Contingent Valuation Method
BID	Bid Price
FAO	Food and Agricultural Organization
SUBVP	Seemingly Unrelated Bivariate Probit
WTP	Willingness to Pay

Author Contributions

Tadele Anagaw Zewdu is the sole author. The author read and approved the final manuscript.

Conflicts of Interest

The authors declare no conflicts of interest.

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