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# The economic valuation of Gedo Natural Forest conservation benefits, Ethiopia

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## Abstract

Forest ecosystem economic valuation is responsible for ecologically aware and reasonable gains to the country and particularly to the surrounding groups through different means. Thus, the central objective of this study was to analyze the economic valuation Gedo Natural Forest conservation benefits of using the contingent valuation method. Both primary and secondary data were employed in this study. The interview responses of 342 households nominated from three kebeles around Gedo natural forest were collected in purpose and random sampling procedures through a semi-structure questionnaire. The mean willingness to pay calculated by means of Krinsky–Robb technique after running of Seemingly Unrelated Bivariate Probit Regression from the dichotomous choice format and open-ended questions was 24.97 and 23.91 birr per year, respectively. The outcomes of Tobit model show that the total livestock unit, total annual income of the household, and the amount of credit utilization are meaningful variables positively and significantly related to the likelihood of willingness to pay for the conservation benefits of Gedo natural forest. On the other hand, the households' family size, the households' age, and initial bid value were other important variables negatively and significantly influence households' willingness to pay for the conservation benefits of Gedo natural forest. The liable body could, therefore, apply the scenario of willingness to pay in the study area, so that the Gedo natural forest could be conserved, measurable benefit to the households could be practical, and future awareness of respective household could be raised.

**Keywords:** Gedo Natural Forest, Economic valuation, Seemingly unrelated bivariate probit regression, Tobit model, Willingness to pay

## Introduction

Forest environments that comprise approximately 31% of the world's total land-living region (FAO, 2013) are known for its meaningful implications like recreation, water management, nutriment processing, soil conservation, air contamination assimilation and water cleansing which need the public, policy-makers and other stakeholders' considerations as a result of that their values cannot be traded in the collective market. Given these results, administrations and communities challenged by the growth-preservation problem can generate further thoughtful results and strategies that could support their efforts to preserve forests and the environment amenities they offer, and in that way, proclaim social welfare and justifiable improvement (Komeil et al., 2017).

Overemployment, mismanagement, and the contamination of water resources are also results of the direct impact of mishandling of forest resources. Hence, it is important to protect forests zones with a financial reward in surplus of other practices in order to make their conservation economically feasible (Ayenew & Tesfay, 2015).

Ethiopia is remarkable for its different natural resources in general and forest source in particular. Nonetheless, because of the unwise exploitation of the forest gifts of the country which has been established over time, the remaining forest coverage is extremely insignificant for many reasons: cultivation advance, the demand for increasing amounts of construction material, fires, fuel wood, and charcoal. As a result, a collective action of resource management and eco-development standards for continuing and justifiable forest management ought to be encouraging (Amogne, 2014). The latest renewal of wooded areas in the country is so far a surge in forest resources when estimated in economic terms. These forest resources provide several amenities in Ethiopia, and there is an increasing attention to accounting for the varied economic welfare resulting from these forests on a general scale to complement normal economic designators like growth in domestic product (Narita et al., 2018).

Gedo Natural Forestry is a type of rare evergreen forest in the country with 10,000 hectares of land (MEFCC, 2017), where one can see a high figure of plant type diversity and remarkable vegetation stands. This forest is greatly appreciated for its high economic and other environmental services. Despite all these services, forest vegetation removal will seemingly continue for some time to come for the simple reason that forest trees are still the major source of inputs and timber materials for the rural and urban population. Moreover, misused parts by local societies and traditional awareness of the uses of forest plants are other effects of the part. Therefore, the future management approach of Gedo Natural Forest should also focus on multiple-use conservation strategies (Kebede et al., 2014).

The value given to forest amenities by particular societies in the area is usually unidentified in unindustrialized nations (Okumu & Muchapondwa, 2017). Appropriate valuing and estimation is a predictable application if indigenous suppliers explicitly continue to offer their goods and services in on-going return sources (Agrawal et al., 2013). Accordingly, the valuation of environmental resources by setting economic prices for ecological destruction or development permits economists to estimate the optimum, particularly where the market fails to distribute resources optimally. It is also essential to assimilate ecological principles into economic decision-making procedures since failure to do so can have confrontational consequences for not only present generations, but also forthcoming generations (Kolstad, 2000). Therefore, the basic concept of investigating the economic valuation of natural forests is a well-timed study, if the conservational benefit is enhanced.

All the preceding works by other scholars have concentrated only on estimating the likelihood of respondents' willingness to pay for forest environments, but have failed to examine the actual amount of cash they could sacrifice that is associated with their characteristics, which are the significant variables (Amirnejad et al., 2006; Hafer & Ran, 2022; Ramli et al., 2017; Sattout et al., 2007). Consequently, this study is distinct in that it presented both the likelihood of the households' willingness to pay and the real cash they would sacrifice for Gedo Natural Forest, which is in a straight line with important

variables. Therefore, this paper makes an effort to examine the economic valuation of Gedo Natural Forest conservation benefits and identify the elements that determine willingness to pay for Gedo Natural Forestry.

## **Methodologies**

### **Description of the study area**

This work has been undertaken in the Cheliya District, West Shoa Zone of Ethiopia, around the Gedo Evergreen Natural Forest. This forest is a part of the National Forest Priority Areas in the country (MEFCC, 2017), located roughly in the interval of 90 01'–90 02' N latitudes and 370 25'–370 16' E longitudes, and about 188 km west of Addis Ababa (Kebede et al., 2014).

### **Type of data, sources and approaches of data collection**

Primary and secondary data together were employed for this work. The primary data were taken from households' representatives using a semi-structured survey by means of direct interview in the study area. The FGD (focus group discussion) was added as well to improve the quality of the survey. Secondary data were also taken from the Zonal Forest and Air Resource Authority Bureau and other pertinent sources. This secondary data served as a pre-requisite for primary data because it offers information pertinent to sample sizes and the general population. Additionally, it aids in the formulation of primary data collection methods. It consequently gives the researcher some early clues regarding the kind of data they would want to gather.

A pre-test approach was completed in order to fix groups of bids and order new fitting questions for 30 representative households living in the three kebeles around Gedo Natural Forest. As we have used the double-bound dichotomous choice format, the most repeatedly stated values were taken as an initial bid. Then, the five different initial bid amounts (10, 15, 20, 25, and 30 birr) were provided to household heads to state their willingness to pay. Pairs of prices were decided for the double-bound dichotomous format by taking the first price twice if the initial answer was "Yes" and a partial of it if the answer was "No" (Cameron & Quiggin, 1994). For that reason, the groups of offered prices for our purpose are, (10, 5, 20), (15, 7.5, 30), (20, 10, 40), (25, 12.5, 50), and (30, 15, 60).

### **Methods of sampling and sample size**

This study has taken the two-stage sampling method into account. Primarily, three kebeles, Sokondo, Refiso-Alenga, and Jarso-Dire, around the forest area were positively preferred for their closeness and potential to preserve the natural forest, Gedo Forest. Next, sample households from each kebele were selected randomly.

A simple formula delivered by Yamane (1967) was employed for our purpose to validate the desired sample size at 0.5 degree of variability, 5% precision level and 95% level of confidence:

$$n = \frac{N}{1 + N(e)^2}.$$

$N$  is the total number of households that could conserve the forest,  $n$  is the sample size, and  $e$  is the accuracy level. There are 2350 family units in the vicinity to conserve (WSZFARAO, 2020). Hence, the required sample size is equal to 342 people.

### Methods of data analysis

The percentage and frequency were the descriptive statistics calculated to identify the segment of willing and non-willing households in the area.

The respondents' mean willingness to pay after the double-bounded draw out technique was computed by Seemingly Unrelated Bivariate Probit Regression (SUBPR) model.

Subsequent to the procedure of Haab and McConnell (2002), the econometric modeling for the designing of double-bounded data is specified as:

$$WTP_{ij} = \mu_i + U_{ij},$$

here,  $WTP_{ij}$  = is the  $j$ th household's WTP and  $x = 1, 2$  denotes initial and next answers;  $\mu_1, \mu_2$  = is the mean price for initial and next answer, and  $U_{ij}$  = implicit random factor.  $\mu_{ij} = X_{ij}\beta$  = the mean to be influenced by the households' characteristics.

The mean willingness to pay and 95% confidence intervals are computed by parametric bootstrapping method settled by Krinsky and Robb (1986) after running regression of the full model. Consequently, the mean willingness to pay value of Gedo natural forest ecosystem could be computed as follows:

$$\text{Mean WTP} = \frac{\bar{X}\beta'}{\beta_o},$$

here,  $\bar{X}$  = vector of row for the sample means which consist of 1 for the constant term,  $\beta'_{(k-1 \times 1)}$  = vector of column for predicted coefficients,  $\beta_o$  = coefficient on the bid variable,  $\beta'$  = coefficient on the constant term.

The Tobit model was also employed in this study to analyze the determinants of willingness to pay and the maximum cash value that respondents would pay for Gedo natural forest ecosystem conservation and management.

The Tobit model could be derived subsequent to Johnston and Dindaro (1997),

$$MWTP_i^* = X_i\beta + \varepsilon_i \quad i = 1, 2, 3 \dots N,$$

$$MWTP_i = MWTP_i^*, \text{ if } MWTP_i^* > 0,$$

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

where  $MWTP_i$  = the greatest value  $i$ th household would pay;  $MWTP_i^*$  = variable that is an implicit when it is fewer than or equal to 0;  $X_i$  = determinants of willingness to pay vector;  $\beta$  = unidentified factors vector;  $\varepsilon_i$  = disturbance terms with mean zero and common variance  $\sigma^2$  and that are distributed normally and independently.

Moving on same way of Maddala (1997), the variation in the likelihood of willingness to pay when explanatory variable varies is:

$$\frac{\partial F(t)}{\partial X_i} = f(t) \frac{\beta'}{\sigma}$$

The variation in the extent of willingness to pay between individuals who are willing to pay in terms of variation in independent variable is:

$$\partial E(MWTP_i/MWTP_i^* \neq 0) = \beta' \left[ 1 - t \frac{f(t)}{F(t)} - \left( \frac{f(t)}{F(t)} \right)^2 \right]$$

$\beta'$  is the tobit maximum likelihood estimate vector,  $F(t)$  is the cumulative normal distribution of  $T$ ,  $f(t)$  is the normal curve derivative value at a certain point,  $t$  is the T score for the area under normal curve, and  $\sigma$  is the standard deviation of the disturbance term.

**Description of variables and working hypothesis**

The endogenous variables in this study were:

WTP: It is respondents’ willingness to pay for the conservational benefits of Gedo Natural Forest ecosystems. It is an artificial variable that assumes 1 if the respondent is willing to accept the offered bids and 0 otherwise.

MWTP: The amount of cash that households were requested to answer their top amount of cash for the conservational benefits of Gedo Natural Forest ecosystems. It is a numeric variable measured in cash (birr) (Table 1).

**Results and discussion**

**Willingness to pay for Gedo Forest conservation benefits**

Five types of set bid values (10, 5, 20), (15, 7.50, 30), (20, 10, 40), (25, 12.5, 50), (30, 15, 60) for the consistent valuation query were given during the pilot survey. Subsequent to the answers obtained after households’ heads was requested for their willingness to pay

**Table 1** Descriptions and expected signs of the explanatory variables. Source: Self-computation, 2020

Variables	Description of variables	Type of variable	Measurement	Sign
DSRCE	Distance from the forest ecosystem	Continuous	Hour	–
EDUC	Level of education the household head attend	Continuous	Class year	+
FARMSIZ	Total farm size	Continuous	Timad (0.25 ha)	+
FAMSIZ	Family size	Continuous	Adult equivalent	–
TLU	Total livestock in tropical livestock unit	Continuous	Count	+
INCOM	Total annual income of the household head	Continuous	birr	+
IBID	Initial offered bid	Continuous	birr	–
AGE	Age of the household head	Continuous	Year	±
ENVAW	Environmental awareness created	Dummy	1 if the household was participated in awareness created, 0 otherwise	+
SEX	Household head’s sex	Dummy	It takes 1 if male, 0 otherwise	+
CREDTUT	Credit utilization	Continuous	birr	+
BENSAT	Forest benefit satisfaction	Dummy	1 if satisfied with the forest benefit, 0 otherwise	+

for conservational benefits of Gedo Natural Forest, the data elucidated that 90.35% were willing to pay for conservational benefits of Gedo Natural Forest and 9.65% were not willing to pay for the conservational benefits of Gedo Natural Forest (Table 2).

All the answers of zero willingness to pay were simply for a financial reason. The preceding studies (Etensa, 2014; Tolera et al., 2017) were measured such a response as non-protest reaction. Accordingly, we could not consider as protest votes and we could not skip from the calculation of mean willingness to pay.

As Table 3 indicates, the joint frequencies of distinct responses, 23.39% answered "Yes–No", 41.23% answered "Yes–Yes" for the initial and following bids equally, 12.57% responded "No–No", and 22.81% reacted "No–Yes".

**Mean and total willingness to pay for benefits of Gedo Forest conservation**

The outcomes from Table 4 show the valued correlation coefficients of the two equations in the bivariate probit model. The projected result, 0.79, indicates that the dual variables are principally and confidently associated, which implies the likelihood of variables being dependent on each other. The null hypothesis, which predicts all parameters

**Table 2** Willing and non-willing to pay response distribution for conservation of Gedo Natural Forest. Source: Author’s computation, 2021

Responses to WTP	Frequency	Percent
Yes	309	90.35
No	33	6.65
Total	342	100

**Table 3** Sample households’ joint answer frequency. Source: Author’s computation, 2021

Mutual answer	Frequency	Percent
Yes–No	80	23.39
Yes–Yes	141	41.23
No–No	43	12.57
No–Yes	78	22.81
Total	342	100.00

**Table 4** Seemingly unrelated bivariate probit model estimated results. Source: Author’s estimation, 2021

Variables	Coefficients	Std. dev.	Z-value
First bid answer			
First bid	0.0771492***	0.0095743	– 8.06
Constant	1.926507***	0.2134967	9.02
Final bid answer			
Final bid	– 0.0624618***	0.0048056	– 13.00
Constant	1.881201***	0.1312948	14.33
Rho	0.79	0.0860537	

No. of sample = 342; Wald  $\chi^2$  (2) = 224.60; log-likelihood = -355.24642; Prob >  $\chi^2$  = 0.000; likelihood-ratio test of rho = 0:  $\chi^2$  (1) = 25.2393; Prob >  $\chi^2$  = 0.0000

\*\*\*1% significance level

to be equal to zero, is precluded at a 1% level of significance by the Wald test (Wald  $\chi^2(2) = 224.60$ ), which also ratifies the soundness of the value of the estimate and the goodness-of-fit. The regression outcome also discovered that the coefficients of both offered bids are negative and significant at a 1% level of significance. This shows that, as the initial and next bid increase, the respondents' willingness to pay for the conservational benefits of natural forestry declines.

The mean WTP was valued using the Krinsky–Robb technique based on first and final willingness to pay for offered price answers from the double-bounded choice format after running the results of the Seemingly Unrelated Bivariate Probit model. This method was developed by Krinsky and Robb (1986), and we favored it because it is found to be robust and copy confidence intervals with the Krinsky–Robb procedure.

The results of Table 5 indicated that the mean willingness to pay for the conservational benefits of Gedo Natural Forest for the first and second statements of equality is birr 24.97 and birr 30.12 per year, respectively. This output is very significant at a 1% level of significance. Supplementary, the estimated mean willingness to pay for open-ended requests is 23.91 birr per year. When the means are evaluated, the mean willingness to pay in a double-bounded choice format is greater than that of an open-ended choice format in which respondents are free riders. An analogous result was obtained by Getachew (2018). Similarly, Tolera et al. (2017) revealed the reality that the initial equation ought to be used in calculating mean willingness to pay for the reason that the following statement of equality parameters is likely to have other disturbances with respect to fastening partiality as the households are expected to receive the hint after the initial price while determining their willingness to pay. Consequently, 24.97 birr per household per year calculated after the initial statement of equality has been used in this study to evaluate the mean willingness to pay if the situation of conserving Gedo Natural Forest is recognized in the study zone. In line with this, the cumulative willingness to pay for year-round conservation of Gedo Natural Forest from open-ended and double-bound requests is estimated at 5,076,630.98 and 5,301,692.82 birr, respectively. This was completed by considering the multiplication of mean willingness to pay, the sum of households in the area, and the proportion of respondents with "Yes" answers to the question of willingness to pay for the Gedo Natural Forest conservation.

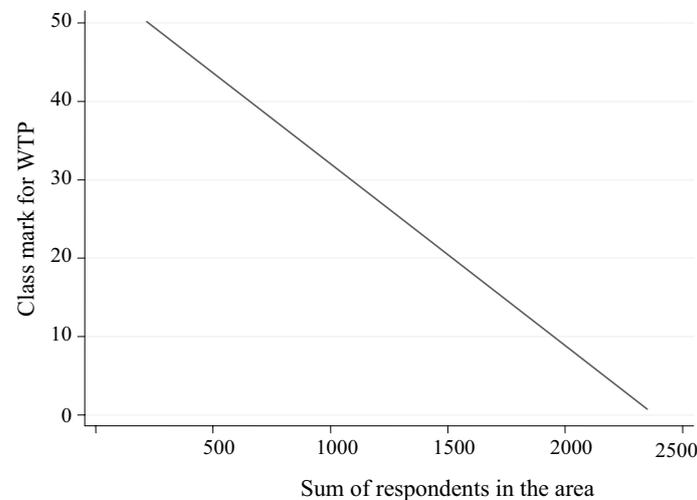
#### Estimated demand for conservational benefits of Gedo Forest

Figure 1 indicates a demand curve that developed the relationship between the amount of willingness to pay for each annum for Gedo Forest and the number of households. Accordingly, the number of respondents who are willing to pay for the conservational benefits of Gedo Natural Forestry decline as the value of offered bid gets advanced. This

**Table 5** The mean willingness to pay for Gedo Natural Forest conservational benefits. Source: Author's estimation, 2021

Procedures	WTP	Lower bound	Upper bound	Achieved significance	Mean	Variation
Mean for Equation 1	24.97	22.92	27.52	0.0000	0.18	4.6
Mean for Equation 2	30.12	27.81	32.76	0.0000	0.16	4.95

H0: WTP  $\leq$  0 vs. H1: WTP > 0



**Fig. 1** Projected demand curve for the conservational benefits of Gedo Natural Forest. Source: Own design, 2021

describes that, keeping other factors constant; increasing the offered bid has a preventive consequence on the demand for the conservational benefits. This is consistent with the study of Endalew and Assefa (2019).

#### **Determinants of willingness to pay for Gedo Forest conservational benefits**

The Tobit model was employed to identify the households' willingness to pay determinants for the conservational benefits of Gedo Natural Forest. The outcomes from the model show that the households' willingness to pay is influenced by six variables that were found to be statistically significant out of twelve independent variables involved in the model. The outcomes of the Tobit model and its marginal effects are presented in Tables 6 and 7, respectively.

##### ***Family size***

This variable has a predicted negative sign and is statistically significant at the 10% probability level. This means that an increase in the total family size by a single adult equivalent decreases the likelihood of being willing to pay for the conservational benefits of Gedo Natural Forest by 12.90%, keeping the consequence of unlike influences persistent. Likewise, when the family size of the respondent increases by an adult equivalent, the sum of money a respondent is willing to pay for the conservational benefits of Gedo Natural Forest may decline by 0.31 birr, holding other influences persistent. This is due to the fact that a large family requires a relatively large amount of money to feed the family and become resilient to the idea of paying for forest conservation. Thus, households with large family sizes are hesitant to pay before guaranteeing the source of adequate food.

##### ***Total livestock unit (TLU)***

Total livestock unit has positive association with the likelihood of willingness to pay for conservational benefits of forestry and significant at 1% probability level. The results indicate that for an extra rise of total livestock unit, the likelihood of respondents'

**Table 6** Determinants of willingness to pay results from the Tobit model. Source: Author's computation, 2021

Variables	Coefficients	Standard error	t-values
Education (class year)	0.0471356	0.1404949	0.34
Family size (adult equivalent)	− 0.3139676*	0.184538	− 1.70
TLU	1.627725***	0.353129	4.61
Farm size (timad, 0.25 ha)	− 0.1828531	0.16715	− 1.09
Distance from the forest (hour)	− 1.064053	0.8050482	− 1.32
Annual income (birr)	2.904969***	0.193832	14.99
Age (year)	− 0.0952768**	0.0433755	− 2.20
Sex (1 = male)	0.3244216	1.313321	0.25
Satisfaction level (1 = yes)	− 0.2988719	1.342397	− 0.22
Credit utilization (birr)	4.699895***	1.196844	3.93
Awareness created (1 = yes)	2.105355	1.711143	1.23
Initial bid (birr)	− 0.0953039*	0.05578	− 1.71
Constant	5.191545	3.531435	1.47

No. of observation: 342; log-likelihood = − 1092.3212; F (12, 330) = 71.29; Pro > F = 0.000; pseudo-R<sup>2</sup> = 0.1773; lower threshold = 0.0000 upper threshold = + infinity

\*\*\*, \*\*, \*1%, 5% and 10% significance level, respectively

**Table 7** The amount of willingness to pay from the results of marginal effects of independent variables. Source: Author's computation, 2021

Explanatory variable	Probability change	Change among forest users(birr)	Total change
Education (class year)	0.0000194	0.0466814	0.0470928
Family size (adult equivalent)	− 0.1290273	− 0.3109418	− 0.3136822
TLU	0.6689256	1.612039	1.626246
Farm size (timad, 0.25 ha)	− 0.0000751	− 0.1810909	− 0.1826869
Distance from the forest (hour)	− 0.0004373	− 1.053799	− 1.063086
Annual income (birr)	0.0119382	2.876973	2.902328
Age (year)	− 0.0391547	− 0.0943586	− 0.0951902
Sex (1 = male)	0.0001401	0.3211534	0.3241104
Satisfaction level (1 = yes)	− 0.0001173	− 0.2961077	− 0.2986134
Credit utilization (birr)	0.0193146	4.654602	4.695623
Awareness created (1 = yes)	0.0012776	2.076689	2.102416
Initial bid (birr)	− 0.0391658	− 0.0943854	− 0.0952173

willingness to pay for the conservational benefits of Gedo Forest will increase by 66.89%, keeping the other factors constant. Correspondingly, when the amount of livestock kept by a household rises by one total livestock unit, the extent that a respondent is willing to pay for the conservational benefits of Gedo Natural Forest may increase by 1.61 birr, keeping the effects of other variables constant. This is because livestock has enormous economic vitality and advances the capability of households to pay.

#### **Total annual income**

As predicted, the total annual income is significant at 1% probability level, and has a positive effect. The result specified that an increase in the household's annual income by

a thousand birr raises the likelihood of willingness to pay for conservational benefits of Gedo Natural Forest by 1.2%, *ceteris paribus*. In analogous to this, when the total annual income of a respondent rises by a thousand birr, the volume of money a respondent willing to pay for the conservational benefits of Gedo Natural Forest increases by 2.87 birr, holding other factors constant. The respondent with extra income takes better capability to pay for utilizing the conservational benefits that can be derived from the forest than their counterpart part of lower income. This result is consistent report of Endalew and Assefa (2019), Seifu and Alemu (2017), and Ejeta et al. (2019).

### **Age**

The age of household head has been found to be significant at 5% probability level and undesirably associated to the willingness to pay for Gedo Forest. The outcome of marginal effect states that a year rise in the age of the respondent declines the possibility of willingness to pay for the conservational benefits of Gedo Forest by 3.91%, holding the effect of other variables constant. Correspondingly, when household's age decreased by a year, the volume of money a respondent is would pay for the conservational benefits of Gedo Forest could decrease by 0.094 birr, *ceteris paribus*. To protect their environment in general and the forests in particular, the younger generation is better able to create and is more ready to pay. Older households are unaware of the payment issue since they are afraid to make money from their future productivity. This is interrelated to the matter that older people take to keep the habit they had before, and therefore they are less likely to support idea of paying for some anticipated benefit. This is comparable with the result of Resende et al. (2017), and contradicting with the finding of Getachew (2018).

### **Credit utilization**

The amount of credit utilization is found to be significant at 1% significance level and desirably related as anticipated. The model outcome specifies that, keeping other factors unchanged, a thousand birr rise in the households' amount of credit utilization raises the likelihood of the respondents' that they would pay for the conservational benefits of Gedo Natural Forest by 1.93%. Likewise, as the amount of credit utilization of households rises by a thousand birr, the extent of that the respondent could pay for the conservational benefits of Gedo Natural Forest increases by 4.65 birr, keeping the other factors constant. The credit utilization is the foundation of income that boosts the capability of the households to participate in production, and then raises potential of paying for the preservation of natural forest.

### **Initial bid**

The first offered bid was negatively interrelated with the likelihood of willingness to pay of the households for the conservational benefits of Gedo Natural Forest and found to be important at 10% probability level. This is interpreted as a one birr rise in the amount of initial bid offered will lessens the likelihood of the households' willingness to pay for the conservational benefits of Gedo Fores by 3.91%, other factors keep on unchanged. Correspondingly, a single birr increase in the quantity of initial bid price declines the extent that the respondents would pay for the conservational benefits of Gedo Natural Forest by 0.094 birr, *ceteris paribus*. This is analogous to the statement that the demand for a

specific consumer declines as the amount charged increases, according to the definition of the economic concept. Comparable result was found by Seifu and Alemu (2017).

### **Summary and conclusions**

Natural forests are an economic source that has plenty of worth in enlightening and preserving the environment. Therefore, the examination of the economic valuation of Gedo Natural Forest conservation benefits by employing the contingent valuation method was the core objective of this study.

Both primary and secondary data were employed for this study. The econometric models and descriptive statistics were employed for the analyzing of the survey responses of 342 households selected from three kebeles around Gedo natural forest that were collected in purposive and random sampling procedures through a semi-structure form. Binary constrained format administered with an open-ended enquiry was a technique employed to draw out the willingness to pay of the households for the conservational benefits of Gedo natural forest. In this regard, five sets of bids, (10, 5, 20), (15, 7.5, 30), (20, 10, 40), (25, 12.5, 50), and (30, 15, 60), were delivered to each respondent to decide what they would pay for the conservational benefits of Gedo forest.

The mean willingness to pay for the conservational benefits of Gedo forest was examined by taking into account the Seemingly Unrelated Bivariate Probit Regression model. The then figured mean willingness to pay from the dichotomous choice setup by means of Krinsky–Robb system was 24.97 birr per year. On the other hand, the mean willingness to pay from open-ended requests was 23.91 birr per year. The cumulative (aggregate) benefit gain expected from the conservation of Gedo natural forest from the open-ended and double-bounded choice setup was figured to be 5,076,630.98 and 5,301,692.82 per year, respectively. As a result, the aggregate value from dichotomous choice format is superior to the open-ended format. This confirms the undervalued outcome from open-ended format that is the consequence of the free riding observation in replying to willingness to pay for naturally given supply and the forest predominantly.

Factors that determine willingness to pay and the maximum amount of money that household would pay for the conservational benefits of Gedo natural forest ecosystem has been analyzed by the Tobit model in this study. Accordingly, the total livestock unit, total annual income of the household, and credit utilization were important variables meaningfully and positively related to the likelihood of willingness to pay for the conservational benefits of Gedo forest. The households' family size, the households' age, and initial offered bid price were other key variables negatively and significantly affect the willingness to pay of the households for the conservational benefits of Gedo natural forest.

Generally, the present study came up with the result of the households' mean willingness to pay, factors that determine willingness to pay, and the actual amount that the households would pay in terms of significant exogenous variables for the conservational benefits of Gedo forest. Therefore, if the situation of willingness to pay turn into effective in fitting way in the study area, the Gedo natural forest could be conserved and managed by providing measurable welfare to the households, and makes possible the respective households to be more aware in the future.

## Recommendations and future research

It is important to develop a reliable method of ensuring food security for households with large family sizes before putting the willingness to pay scenario for Gedo forest conservation into action.

Farm households in the area need to be encouraged to raise a sufficient number of high-quality oxen so they may enhance their output and income. The government could accomplish this by providing targeted training on contemporary oxen management techniques.

When creating policies, it's important to take households' income patterns into account for the conservation of the Gedo natural forest. The responsible entities should also design income-generating initiatives that assist the elder and disadvantaged farm households in the research area. It is also suggested that older farmers be supported through education, outreach, raising awareness, and other initiatives to help them take advantage of the Gedo Natural Forest, which is being preserved.

Farmers should be given reasonable and affordable credit in order to increase their ability to invest in farming techniques and other necessities, earn higher returns and willingly pay to conserve the forest. The provision of this service should be based on the demands and effectiveness of the local community.

The managerial implication of this study is to assist public operators in identifying adjustments in both environmental quality and economic growth. It also economically assists policy-makers in setting standards and objectives related to ecosystem services, developing approaches to evaluating competing policy issues, designing incentives that encourage ecosystem service protection, and evaluating policy outcomes. Furthermore, studying forest economic valuation aids in the adjustment of forest resources to national standards.

This study, however, was limited to focusing on forest valuation utilizing local community responses by the contingent valuation method only. As a result, future research could indeed integrate information from visitors, residents, and other stakeholders. As a result, different resource valuation methods, both direct and indirect valuation methods, will be required in the near future for forest resource valuation.

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### Author contributions

The study was done individually. The author read and approved the final manuscript.

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### Availability of data and materials

The datasets used and/or analyzed during the current study are available from the corresponding author on reasonable request.

## Declarations

### Ethics approval and consent to participate

During data collection, respondents gave verbal consent for the data collectors and showed their willingness to fill the dispatched questionnaires.

### Consent for publication

Not applicable.

### Competing interests

The author declares that there are no competing interests.

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