Farm Households' Willingness to Contribute Labor for Conservation of Bamboo Forest Ecosystem: The Case of Mao Komo Special Woreda Benishangul Gumuz Regional State, Ethiopia

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Research Article

Abstract

Purpose: *This study was designed for the assessment of farm households' willingness to contribute labor for conservation of bamboo forest ecosystem with the specific objectives of describing farmer's attitude toward bamboo forest protection, exploring the amount of labor, the household's would be willing to contribute for bamboo forest conservation and identifying factors affecting farmers' willingness to contribute labor for bamboo forest conservation.*

Method: *Data for the study were collected from both primary and secondary sources. The multistage random-sampling technique was used in selecting 135 respondents followed by a probability proportional to size. The data were analyzed using descriptive statistics and bivariate probit model.*

Results: *The result of the bivariate probit model shows that the mean willingness to contribute labor for the conservation of bamboo forest was 14.15 man-days per year per household. The result from seemingly unrelated bivariate probit model indicates that household's literacy status, income from bamboo forest, contact with extension agents, total cultivated land and access to credit have positive significant effects on willingness to contribute labor, while age of the respondent, distance from home to forest, initial bid, follow up bids and dependency ratio have a negative and significant effect on willingness to contribute labor. The study shows that the farmers in the study area are knowledgeable about intensive mass flowering of bamboo and massive depletion of bamboo forest and they are willing to participate in the conservation of bamboo forest to regenerate and return to the original position.*

Implications: *An effort would be needed to strengthen literacy, increase farmers' awareness about the importance of conservation practices, ensure credit facilities and increase the frequency of extension contact is important to conserve the bamboo forest in the study area.*

Keywords: Bamboo Forest, Bivariate Probit, conservation, Household, Labor, Ethiopia

1. Introduction

Forest provides support for a multitude of functions: resistance to catastrophes, food and drink provision, medicines, industrial materials, ecological services (protecting wildlife, carbon sequestration), leisure, cultural and aesthetic functions (Shi, and Wang, 2016). The importance of the various functions of a particular forest accorded to its stakeholders constitutes the economic value of the forest. Thus, considering all the possible functions of forests and the relevant stakeholders' preferences should be taken care of in assessing the total economic value of forests (Canchari, and Wang, 2018).

Bamboo is the common term given to a group of over 1500 species of grass varying from small to giant(Mulatu and Tadesse. 2006). It is a wonder plant, strongest and fastest-growing woody plant on earth, with a global trade worth above 2 billion US$ per year (Musau, 2016). Also every day it is used by about 2.5 billion people, mostly for food and shelter (Kibwage, and Misreave, 2011). There are 70 general and 1500 species of bamboo in the world which are widely distributed between 46N° and 47S° in the tropical, subtropical and temperate regions of all continents except Europe (Du, and Mao, 2018).

According to (Azeez, and Orege, 2018), Ethiopia has over one million hectares of highland and lowland bamboo forest which constitutes 67% of African bamboo. The real wealth in many sectors especially in horticulture where it is used as horticultural stands (Sambrani, 2016). It is an indispensable alternative as a biomass resource compared to traditional timber. In comparison to traditional timber, bamboo is a renewable resource. Once harvested, it continues to grow new shoots, without a period of regeneration. And bamboo is also used for bamboo-based board applications such as particle boards, medium-density fiberboard, and strand boards and pulp and paper manufacture (Chaowana, 2013).

Ethiopia, comprising 67 percent of the continent's bamboo forest area, tops the list of countries in bamboo potential in Africa (Demissew *et al.,* 2011). However, deforestation, particularly massive bamboo depletion has been taking place in many parts of the country. Now-a-days, it is a burning issue in Benishangul Gumuz regional state, particularly in Mao -Komo special woreda (EEFR, 2018).

Benishangul-Gumuz has 440,000 hectares of lowland and highland bamboo which are mainly used for subsistence uses such as housing, fencing, kitchen utensils, and agricultural implements and shoots for food (Kassahun, 2004). It is well known that bamboos have been used successfully to rehabilitate degraded land back into productive, fully functioning ecological systems (Embaye, 2001). It provides valuable habitat for numerous species at the soil and tree layer, including spiders, butterflies, birds and other higher life forms including wildlife. Equally, in its natural environment, fallen bamboo leaves create natural mulch (Tallamy, 2009).

The bamboo resources of the Mao-Komo special woreda have been quite shrinking for the last few years. For instance, in 2014, the total area of bamboo in the woreda was estimated at 14789 hectares of lowland bamboo (BARC, 2015). But according to Benishangul Gumuz agricultural office report of 2018, the region possessed only about 13571 hectares of bamboo resources which

is equivalent to 3.08 % percent of the region's bamboo resource. In recognition of the problems associated with natural resource degradation, exploring farm households' willingness to pay is vital for effective and sustainable bamboo resource management (Zhang and Paudel, 2019).
Despite its imperative roles, most environmental experts were still reluctant to ascertain the farmer's willingness to contribute labor to conserve bamboo forests (Ketema, 2013). As suggested by Truneh (2013), exploring farm households' willingness to pay for bamboo forest conservation and factors that influence their willingness to contribute labor are essential to design effective management policies and conservation strategies. To the knowledge of the researchers, no study ascertains farm households' willingness to contribute labor regarding bamboo forest conservation in the study area. Therefore the study was designed to fill up the existing research gap.

1. Literature Review

2.1. Bamboo Resource

Bamboos are a variety of perennial woody grasses. They play an increasing role in ecosystem services, biodiversity conservation, and socio-economic development. They have been recognized to be an important carbon sink and have the potential for mitigating climate change (Song et al., 2011; Dubey et al., 2016; Agarwal and Purwar, 2017). Bamboos have also been proven to have an ecological function of soil and water conservation (Zhou et al., 2005). Bamboo is an irreplaceable habitat for a lot of wildlife, being their food source and escape cover (Schaller, 1985; Kratter, 1997; Reid et al., 2004; Linderman et al., 2005). Due to its versatile application and rapid re-growth, bamboo provides materials for household use, construction, and industries (Kaur et al., 2016; Sofiana et al., 2017), which is an alternative material to wood products facing the environmental concerns. It is a key component in lifting rural people out of poverty by providing job opportunities (Mishra, 2015; Chen et al., 2017). For example, the bamboo weave is a good income-earning opportunity for disadvantaged groups (Das, 2017).

2.2. Natural Resource Types and Conservation and Rehabilitation of Natural Resources

According to Graven (2018), environmental resources are renewable when they can reproduce and grow. However, for some renewable resources, the continuation and volume of their flow depend crucially on human intervention. Managing renewable resources presents a different challenge from managing non-renewable resources, though they are equally significant. According to Tietenberg (2003), the challenge for non-renewable resources involves allocating dwindling stocks among generations while meeting the ultimate transition to renewable resources. In contrast, the challenge for managing renewable resources involves the maintenance of an efficient sustainable flow. Restoring the forest cover can take place through reforestation, natural regeneration or assisted natural regeneration (Simula, 2009).

2.3. Valuation of Natural Resources

Improvement in resource allocation requires that the benefits of a decision exceed its costs, which in turn requires the measurement of benefits and costs (Smith, 2018). Economists have devised empirical tools for estimating the benefits and cost of public action so as to meet the demand for measurement. These tools are typically called valuation methods (Yearley, 2018). The total value or benefits of some environmental improvements like forest conservation can be classified in to use value and non-use value. Use value encompasses actual use, planned use or possible use of the good in question. It can be classified as direct, indirect and option value. Direct use is the most obvious value category, as the economic benefits can be calculated by making use of market information (Himes-Cornell, 2018).

The outputs of the resource can be openly used such as a forest that may yield annually a certain amount of wood that can be sold or used for heating and construction; pastures provide space for some livestock (Bakkegaard, 2016). Indirect use of natural recourses relates to functional benefits that the outputs of the improvement provide to social benefit from ecosystem functioning (*e.g.* erosion protection, carbon sequestration). Option value refers to individuals' willingness to pay for the future use of the resource (*e.g.* future clean surface and groundwater, to enable future use of pastures). According to Bateman *et al*. (2001), non-use value can form a significant part of the total value of an environmental good. It is especially important when the good being valued has few or no substitutes. As noted earlier, it is important to use a valuation method, such as contingent valuation, that can also capture the non-use value component.

3. Materials and Methods

3.1. Study Area:

The study is conducted in Mao-Komo woreda, Benishangul-Gumuz Region of Ethiopia [Fig.1]. Mao-Komo is bordered on the west by Sudan and South Sudan, on the north by the Assosa Zone and on the east and south by the Oromia Region. The district has a total population of 50,061, of whom 25,055 are men and 25,006 women. 3,392 or 6.78% of the population are urban inhabitants. A total of 9,844 households were counted in this woreda, which results in an average of 5.08 persons to a household, and 9,503 housing units (Central Statistical Agency of Ethiopia (CSA, 2007). Mao-Komo has agro ecology which is 85% lowland and 15% midland and the altitude of the woreda ranges up to 2300 m.a.s.l.

The area is characterized by a comparatively one long rainy season stretching from March to October and one distinct dry season extending from November to February. The average annual rainfall of the woreda ranges between 1350-1400 mm, most being received between May and September with the highest in July and August (MWAO, 2018). The minimum and maximum temperature of the woreda ranges from 12^{o}c to 35^{o}c, respectively.

The hottest period extends from January to May, the peak being March whereas the coolest periods occur from June to November, the lowest being August. Estimated area of 1,792.66 square kilometers; Mao-Komo has a population density of 10.4 people per square kilometer which is less than the Zone average of 19.9the total forest cover is 135071ha of which 11,460 ha of natural forest and 2111 ha of man-made plantations (MWAO, 2018).

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3.2. Sampling Techniques

Mao Komo woreda were purposively selected based on the availability of bamboo forest in the area. For this study**,** a multi-stage random sampling technique was implemented to select a sample from the population. In the first stage, out of the 32 Kebeles of Mao Komo bamboo producers' special woreda, Kebeles that are bordering the bamboo forest (Lake Forest) were purposively selected. In the second stage, the eight Kebeles were stratified into two equal groups on the basis of the origin of the households i.e. whether they are native or settlers. In the third stage, a total of four Kebeles, two Kebeles from each stratum was randomly selected. Those four sample Kebeles are Ganshuba and Damshir from the settler group and Bang Targo and YahaMasara from the natives. Finally, 135 sample households were selected randomly based on probability proportional to the size.

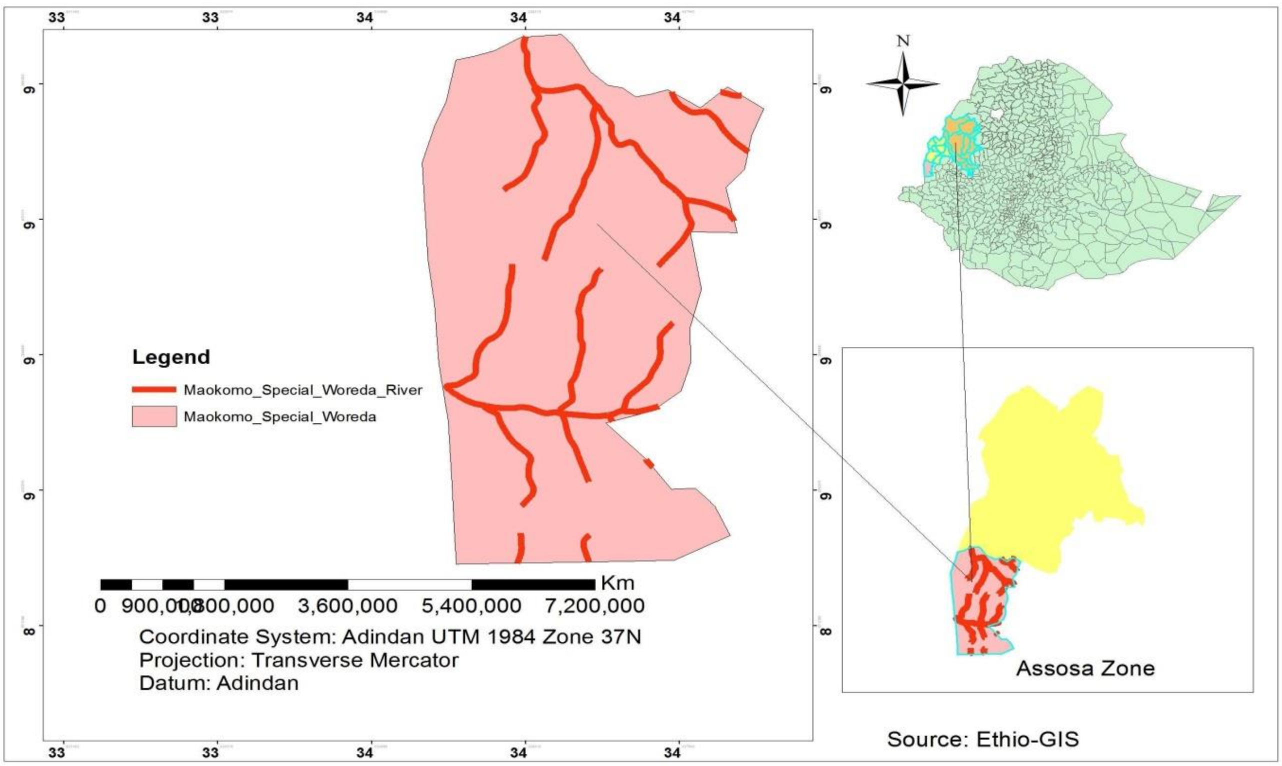

Fig.1: Location map of the study area

3.3. Sample Size Determination

A simplified formula provided by Yamane (1967) was used to determine the required sample size at 95% confidence level, 0.5 degrees of variability and 8 % level of precision.

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

Where **n** is the sample size, **N** is the population size (total Bamboo producer of households), and **e** is the level of precision. The selected kebeles has a total of 1007 number of bamboo producer households. Hence, the desired sample size is equal to:

$$n = \frac{1007}{1+1007(0.08)2} = \mathbf{135}$$

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3.4. Sources and Methods of Data Collection

Quantitative primary data were gathered accompanied by a face to face interview. Focus group discussion and key informant interviews were also made as part of the data collection method for qualitative primary data. Moreover, secondary data were collected from journals, books and agriculture offices of the Mao-Komo woreda. Similarly, quantitative data were collected employing a semi-structured questionnaire.

The questionnaire was translated into the local language (Oromo Language) to ease the data collection process. Then, well-trained enumerators who have good experience in the survey were employed to gather the data required for this study. Dichotomous choice format CVM studies are preceded by a pretest survey of the small sample population. The discussion by Hoyos and Mariel (2010) indicated that the pretest survey with open-ended questions can help to provide some information on the bounds of respondents' WCL. As a result, the pretest survey was conducted before the actual survey. For this purpose, 15 households were randomly selected for the pretest before the actual survey. In addition to the pretest survey, focus group discussion and key informant interviews were held to determine initial bids in terms of cash and labor using open-ended contingent valuation format.

3.4.1. Dependent variable

Farmer's decision to pay or not for bamboo forest conservation at different bid categories is the dependent variable of the model. Hence the dependent variables of the model are $\mathbf{Y_1}$, and $\mathbf{Y_2}$ in which both of them have a dichotomous nature measuring the willingness of a farmer to pay for conservation Practices. They are represented in the model by **1** for a willing household and by **0** for an unwilling household**.**

3.4.2. Methods of Data Analysis

3.4.2.1. Descriptive Analysis

Descriptive statistics (arithmetic means, percentages, standard deviations, and frequency distributions) was used, to have a clear understanding of the socio-economic, institutional and demographic characteristics of the respondents and their willingness to contribute labor (WCL). Chi-square test and an independent sample t-test were employed to know the statistical relationships of explanatory variables on the willing and unwilling farmers.

3.4.2.2. Econometric Analysis

The determinant factors were identified by employing seemingly unrelated bivariate probit (Equations 6a and 6b below) which is a variant of the bivariate probit model. Mitchell and Carson (1989) advocated the use of robust estimators as a way to control the problem of non-normality and outliers and the potential bias associated with these sources, which were also employed by Ayana (2017). This form of regression is also used to reduce the problem of heteroscedasticity.

The bivariate probit model is employed to explore the amount of labor; the households (HHs) would be willing to contribute to bamboo forest conservation. The bivariate normal density

function is appealing to statisticians in the sense that it allows the non-zero correlation, while the logistic distribution does not (Cameron and Quiggin, 1994).
These two correlated willingness to contribute labor (WCL) equations (equations 6a and 6b below) with jointly distributed normal error terms are simultaneously modeled as single bounded. This model provides information on what variables are crucial for each of the responses to the WCL question. They further state that estimation of the mean WCL is feasible using the bivariate probit CV model since bivariate normal probability density functions allow for zero and non-zero correlation
To developing a model that will predict whether or not a particular household will have either a WCL of zero or one for bamboo conservation practice, economists assume that there exist some underlying, unobservable (latent) variable and utility index, such variable is determined by certain variables including the characteristics of the household. If the latent variable exceeds some threshold level then the household will indicate a positive WCL (Haab and McConnell, 2002).According to Haab and McConnell (2002) the indirect utility for respondent j can be written as
$u_j = u(l, z_j, q)$ -(1)
Where U_i is the utility of the household j, l is a vector of respondent's labor endowment, Z_j is a vector of households' socio-economic characteristics and q vector is of Bamboo conservation quality as perceived by the farmer.
Formally, WTP is defined as the amount that must be taken away from the person’s income or/and labor to obtain other goods or services. If the household answer was "Yes", the amount of original labor he/she has been reduced by the amount of the bid (Bj). When the respondent answer was “yes” to a required payment of Bj or will accept the randomly assigned initial bid the following condition has to be satisfied.
$U_i (lj - Bj,zj, q^*) > u0 (lj,,zj,q)$ - (2)
Where, $B_j$is the amount of labor contribution in bidding and q* as the quality after the Bamboo conservation practices were undertaken while q as the quality before the Bamboo conservation practices were undertaken.
Therefore, the probability that a household will decide to pay for bamboo conservation is the probability that the conditional indirect utility function for the proposed intervention is greater than the conditional indirect utility function for the status quo.
$\Pr(yes_j) = (u1 (l_j - B_j, z_j, q^*) + \varepsilon 1_j > u_0 (l_j, z_j ,q,)+ \varepsilon_{0j})$ - - - - - - - - - - -(3)
Where ε_{0j}, $\varepsilon 1j$ are the error terms which are assumed to be normally distributed with mean zero and constant variance.
The utility functions are usually unobservable and the Utility function of the i^{th}household which is assumed to be a function of observable household characteristics, resource endowment and environmental quality, X_{ti}, and a disturbance term ε_{ti}can be specified as;
$U_{ti}= f (X_{ti}) + \varepsilon_{ti}$, t = 0, 1 i = 1 2 …..n - (4)
The focus in this model is on the factors that determine the probability of accepting the initial bid. The i^{th}farm household head will be willing to accept the initial bid when $u_{1i} \geq u_{0i}$. Therefore, the choice problem can be modeled as binary response variable Y, Where

Y_i = {1, if U (l_j - B_j, z_j, q*) + ε_{1j}> U_0 (l_j,,z_j, q,) + ε_{0j} and 0, otherwise -- (5)

When the dependent variable in a regression model is binary, the analysis could be conducted using linear probability or Logit or Probit models (Pindyck and Rubinfeld, 1981). Bivariate Probit models are estimated for the double bounded models, for efficiency and follow-up approach comparison (Tim *et al.*, 2007). According to Cameron and Quiggin (1994) a Bivariate Probit model was specified as follows:

$\boldsymbol{Y_1 = \alpha_1 + \beta_1\ B_1 + \sum_{i=1}^{n} \beta_i x_i + \varepsilon_1}$-- (6a)

$\boldsymbol{Y_2 = \alpha_2 + \beta_2\ B_2 + \sum_{j=2}^{m} \beta_j x_j + \varepsilon_2}$ -- (6b)

E (ε_1/ x_1, x_2) = E (ε_2/ x_1, x_2) = 0

Var (ε_1/ x_1, x_2) = E (ε_2/ x_1, x_2) = 1

Cov (ε_1, ε_2/ x_1, x_2) = ϱ - - -- -- - -- - - -- - - -- - -- -- - -- -- - - - --- - - -- -(7)

Where: y_1*= i^{th} respondent unobservable true WCL at the time of the first bid offered. WCL = 1 if y_I* ≥ β_{i0} (initial bids), 0 otherwise

Y_2* = i^t respondent implicit underlying point estimate at the time of the second bid offered.$x_1$and x_2= the first and second bids offered to the respondents, respectively. ε_1, and ε_2= error terms for the first and second above equations, respectively.B_1 and β_2 = Coefficients of the first and second bids offered, respectively. ϱ is the correlation coefficient, which is the covariance between the errors for the two WCL function

The most general econometric model for the double-bonded data comes from the formulation (Tim *et al.*, 2007).

WCL_{qi} = μ_q+ ε_{qi}---- -- - -- -- - - -- --- - - - -- - - -- -- - - - -- --- - - - -- - - - -- - - - - -- -(8)

Where WCL_{qi} represents the i^{th} respondent's willingness to pay, and q = 1, 2 represents the first and second response. The $\mu_1$and μ_2 are the means for the first and second responses.

To build the likelihood function, from the probability of observing each of the possible two-bid response sequences (yes-yes, yes-no, no-yes, no-no). For instance, the probability that respondent j answers yes to the first bid and no to the second is given by;

Pr (yes, no) = pr (μ1 + ε_{1i}≥ B_1, μ_2+ ε_{2i} < B_2) - -- - - - - -- -- - -- - - -- - -- - ---- - -- -- -- - - -----(9)

The other three response sequences can be constructed in the same way.

Hence, the i^{ih}contribution to the likelihood function is:

Li (μ/B) = pr (μ_1 + ε_{1i} ≥ B_1, μ_2 + ε2i < B_2)^{YN} * pr (μ_1 + ε_{1i}> B_1, μ_2 + ε_{2i} ≥ B_2)^{YY}

Pr (μ_1 + ε_{1i}< B_1, μ_2 + ε_{2i}< B_2)^{NN} * pr (μ1 + ε1i < B1, μ2 + ε2i > B2)^{NY} -- --- (10)

Where YY = 1 if the response is (Yes, Yes) and 0 otherwise, YN = 1 if the response is (Yes, No) and 0 otherwise, NY = 1 if the response is (No, Yes) and 0 otherwise and NN = 1 if the response is (No, No) and 0 otherwise. B1 = is the initial bid randomly offered to the respondents. B2 = is the second bid randomly offered to the respondents.

This formulation is referred to as the bivariate discrete choice model. If the error terms are assumed to be normally distributed with means 0 and constant variances of σ_{12} and σ_{22} then $WTCL_{1i}$ and $WTCL_{2i}$ have a bivariate normal distribution with means μ_{1i} and μ_{2i} and variances σ_{12} and σ_{22} and correlation coefficient ϱ. The likelihood function for the Bivariate Probit model can be derived as below (Tim *et al.*, 2007).

The probability of a no-no response is

$Pr\ (\mu_{1+}\ \varepsilon 1i < B^1,\ \mu_{2+}\ \varepsilon_{2i} < B^2)\varphi\ \varepsilon_{1i}\ \varepsilon_{2i}\ (\frac{B1-\mu1}{\alpha1}, \frac{B2-\mu2}{\alpha2}, \rho$
The probability of a yes-no response is
$Pr\ (\mu_{1+}\ \varepsilon 1i \geq B^1,\ \mu_{2+}\ \varepsilon_{2i} < B^2)\varphi\ \varepsilon_{1i}\ \varepsilon_{2i}\ (\frac{B1-\mu1}{\alpha1}, \frac{B2-\mu2}{\alpha2}, \rho$
The probability of a no-yes response is
$Pr\ (\mu_{1+}\ \varepsilon 1i < B^1,\ \mu_{2+}\ \varepsilon_{2i} > B^2)\varphi\ \varepsilon_{1i}\ \varepsilon_{2i}\ (\frac{B1-\mu1}{\alpha1}, \frac{B2-\mu2}{\alpha2}, \rho$
The probability of a yes-yes response is
$Pr\ (\mu_{1+}\ \varepsilon 1i > B^1,\ \mu_{2+}\ \varepsilon_{2i} > B^2)\varphi\ \varepsilon_{1i}\ \varepsilon_{2i}\ (\frac{B1-\mu1}{\alpha1}, \frac{B2-\mu2}{\alpha2}, \rho$
Defining y_{1i} = 1 if the response to the first question is yes, and 0 otherwise, y_{2i} = 1 if the response to the second question is yes, and 0 otherwise, d_{1i}=2 y_{1i} -1, and d2i= 2 y2i -1, the i^{th} contribution to the Bivariate Probit likelihood function is
$L_i\ (\frac{\mu}{\beta} = \emptyset \varepsilon_{1i}\varepsilon_{2i}\ (d_{1i}\ (\frac{B1-\mu1}{\alpha1}, d_{2i}(\frac{B2-\mu2}{\alpha2}, d_{1i}d_{2i}\rho$
Where Φ $\boldsymbol{\varepsilon_1 i}$, $\boldsymbol{\varepsilon_{2i}}$ is the standardized bivariate normal cumulative distribution function with zero means, unit variances, and correlation coefficient **ϱ.**
The mean WTP from bivariate probit model was computed using the formula specified by (Haab and Mconnell, 2002) that is,
Mean WTP = - α/β - - -- - -- - - - - - - -- - - - - - - - -- - - - - - - - -- - - - - - - - - - - (12)
α is a coefficient for the constant term, and β is a coefficient for offered bids to the respondents

4. Results and Discussions

4.1. Demographic and Socio-Economic Characteristics of the Sample Households

86.6 percent of sampled households were willing to contribute labor and 13.3% were not willing whereas 93.3percent of the respondent is willing to pay cash. The remaining 6% of the respondents are not willing to pay cash at all. From table 3 below farmer's willingness to pay for cash is more than their willingness to pay in kind. So it is important to identify the factors which affect farmers' willingness to contribute labor which is one of the objectives of the study.

Table 1: Distribution of willing and non-willing respondent for cash and labor

Means of payment	Willing		Non-willing		Total	
	N	%	N	%	N	%
Labor in man-days	117	86.6	18	13.3	135	100
Cash(birr)	126	93.3	9	6 %	135	100

4.2. Perception of household head

Among the total respondents 59.26 % have agreed to contribute labor for bamboo forest conservation, they further reported that they have got the training by the woreda agricultural office and non-governmental organizations such as Farm Africa on the impact of bamboo forest degradation and its consequence on economic, social and its environmental impact. There was a statistically significant difference among the willing and unwilling respondents in both bids in terms of perception of bamboo forest conservation activities.

4.3. Participation in natural resource conservation

On the other hand about 57.03 % of the sample farmers reported that they had participated in natural resource conservation activities such as soil and water conservation and in constructing fire break for bamboo forests. The result also indicated that there was an insignificant difference between willing and non-willing farmers on the basis of their participation in natural resource conservation activities in both the first and second bid.

4.4. Farmers' attitudes towards the protection of bamboo forest ecosystem

About 50.82 % of households expressed that bamboo forest system is important to their households; about 23.77 % of households said that it is very important while 14.75 % and 10.66% of the households said bamboo forest ecosystem is less important and not important at all to their households respectively.

These households were also asked to express their interest in the bamboo forest by saying at what level they perceived that the current status of bamboo forest system is worth discussion and about 9.84% of households reported that bamboo forest ecosystem is a serious issue worth discussion while 20.49% and 51.64 % said that the current status of the bamboo is a critical and very serious issue worth discussion respectively. In addition, 10.66 % and 7.37 % of households perceive that the current status of the bamboo is a less serious and not important issue worth discussion respectively.

The households' knowledge about who is responsible for the conservation of the forest including bamboo forest is among factors that can explain their attitudes towards its protection. About 40.16% of households (40.16%) believe that the responsibility of protecting and conserving environment and forest is for all the stakeholders while 28.69 % of households put this responsibility to the whole community. Besides, 23.77 % of them consider that it is the government's responsibility and only 7.38% of respondents give that responsibility to private interest groups.

4.5. Farmers' dependence on bamboo forests

In the study area bamboo forest is used as a means of lively hood for most of the respondents. Respondents were asked to list the major use and benefits they are getting from bamboo. The major uses reported include: for construction (97.69 %), fencing (85.20), for firewood (100%), making furniture (83.6), as a source of income (40.1%) and as a source of food (29.95). Respondents were also asked about their knowledge of other benefits of bamboo and 73.85% of them knew one or more benefits in addition to the direct benefits which can be obtained from the existence of bamboo forests whereas 26.15% reported that they do not know any additional benefits of the resource.

4.6. Analysis of farmers' opinion for better conservation of bamboo forests

About 64.75% of the respondents suggested that rules and regulations that govern the conservation and rehabilitation process in which the representatives of the community actively participate should be designed and strong measures should be taken on those who are deforesting it. Out of the sample households, about 66.39 % suggested a clear demarcation on the flowered bamboo forest so as to control encroachment into the forest in search of additional land and 59.8 % of the farmers expressed their view that the government should be active in coordinating and teaching the community to participate in the conservation and rehabilitation of bamboo. About 54.9 % of the respondents believed that the government should provide bamboo seeds and seedlings and about 42.6 % of them suggested that the government should reduce investment and other programs that cause deforestation of the bamboo forests.

4.7. Perceived main causes of the degradation of the Bamboo forest

Out of the total respondents, about 26.23% replied that they have seen such mass flowering of bamboo in their lifetime and the rest73.77 % have not seen such a phenomenon in their lifetime. This could be an indicator that the mass flowering of bamboo occurs after a long time interval. About 13.93 of the farmers responded that rehabilitating the bamboo forests to their original condition is possible which could be encouraging to implementation of conservation and rehabilitation programs. Almost all of the respondents (98.5%) perceived that conservation and rehabilitation of bamboo are necessary which may indicate the dependency of the community on it.

One of the problems associated with the mass flowering of bamboo forests is the increase in breeding rate which results in an outbreak of rats and rodents of different species (HKI, 2011). About 39.34 of the respondents reported that they have seen an unusual outbreak of rats near the bamboo forests and cause damages on the crops grown near the bamboo forests. According to the Woreda agricultural office, the damage caused by rats on the different crops was estimated at about Birr 114807 and the number of people affected was estimated at 8124 in the 2018/2019 production season (MWAO, 2018).

4.8. The contingent valuation survey results

From the survey result 13.3 % of the total households were not willing to contribute labor for the conservation of bamboo forest. The specific reason reported was the shortage of labor in the household.

Four sets of bid prices that were identified from the pilot survey were used for the study as discussed in the methodology part. These are (2, 4, 1), (4, 8, 2), (6, 12, 3) and (8, 16, 4) man-days per year which were proportionally distributed to the survey questionnaires stated as starting point bid through focal group discussion. Out of the total respondents, about 40 percent responded "Yes" for the first and second bid in terms of labor. When we look at the "Yes" and "No" distribution for the first and second bids across the initial bids, as the initial bid gets higher the frequency of "Yes" responses for labor bids decreases.

4.9. Factors affecting willingness to pay (WTP) for the conservation of bamboo forest

Before running the econometric model, the presence of outlying, multicolinearity and heteroscedasticity problems were tested. The result showed that there was no serious

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multicollinearity problem between the variables. Similarly, to correct the heteroscedasticity problem, the robust standard errors were used. Thus, the explanatory variables which affected WTCL were discussed as follows.

Table 2: Seemingly unrelated Bivariate Probit estimates of willingness to pay(WTP)

Variable	WTP Initial Bid (labor in man-days)			WTP Second Bid (labor in man-days)			Marginal effect		
	Coef.	Robust Std.Err	p>/z/	Coef.	Robust Std.Err	p>/z/	Dy/dx	Robust Std.Err	**p>/z/**
Bid 1	-.184529	.0529	0.009				-.0355217	0.0044402	0.003
Bid 2				-.1704267	.0527109	0.001	-.0420298	.01184	0.000
Age	.0355955	.0153745	0.021	-.000472	.0143332	0.03	-.0067363	-0.003192	0.012
Sex	.8442481	.5690167	0.138	.5656759	.4894554	0.248	.3061623	0.210276	0.112
Level of education	.2274686	.1242341	0.06	.0613885	.0949334	0.518	.0589307	.03042	0.053
Access to credit	-.4722813	.3453852	0.171	.4987125	.3311546	0.132	.0396717	0.0180325	0.031
Cultivable land	.0784916	.0639951	0.220	.202709	.0907514	0.026	.0651019	.02289	0.004
Distance	-.0387936	.138154	0.779	.2830559	.1599786	0.077	-.0623374	0.0178106	0.001
Extension contact	.6084934	.5419544	0.262	.6901436	.437328	0.115	.2848814	.14864	0.055
Inc.from bamboo	-2.20e-06	.0000173	0.899	.0000405	.0000207	0.051	9.58e-06	.00001	0.067
livestock in TLU	.1098657	.0661968	0.097	.1900841	.0690908	0.006	.0680285	0.0453523	0.127
Non -farm income	-.0000798	.0000753	0.289	.0000744	.0000629	0.237	2.98e-06	.00002	0.894
Farmer's percept.	.6581451	.5201183	0.206	.0254814	.4937303	0.959	.1389539	.17165	0.418
Family size	.0194972	.0452683	0.667	-.0433077	.0465923	0.353	-.0069268	.01622	0.669
Dependency ratio	-.0808408	.1325136	0.542	-.043307	.0465923	0.353	-.0492164	-0.0061520	0.007
Inc.from agriculture	-.0000726	.0000821	0.377	.0001185	.0000744	0.111	.0000152	.00003	0.570
Origin of household	-.639563	.5128697	0.212	.4837039	.4837039	0.288	.0267498	.17152	0.876
Cons	1.868279	0.162459	0.005	-2.044268	.5379652	0.007			

Number of obs = 135
Wald chi2(32) =197.46
Log pseudo likelihood=-74.235018 Prob > chi2 = 0.0000P***
Note: Bid1/Bid2[1]=Bid1 is used in the first model whereas Bid2 is used in the second model

Source: Own Survey, 2018

4.10. The distance of the respondent from the bamboo forest

As expected this variable showed a negative relation with the WTP for forest conservation. This is because the farther the family residence and the more inaccessible the benefits from the forest is, the lower the probability of WTCL for the conservation of this bamboo forest. The result agrees with the works of Yoeu and Pabuayon (2011). The marginal effect value one hour increase of the respondent from the bamboo forest boundary decreases the probability of accepting the first bid values by 6.2 %, keeping other factors constant at their mean.

4.11. Access to credit (CRED)

The result showed the positive and significant effect with the household WCL keeping other effects constant, household who had access to credit were more willing to contribute labor in man days than those without access to credit by the amount of 3.9 %. This may be due to those farmers took credit have more hopefull to get high forest resource product from their bamboo production to pay credit and as well as family consumption by investing more labor for bamboo conservation unless they sell their asset to pay the credit. The finding was inconsistence with the findings of Desta (2012) which have a negative relationship.

4.12. Age of the household head

Age of the household headhad a negative and significant effect on households willing to contribute labor (WCL) at 5% significant level. This may be an older age that may shorten the planning time horizon and reduce the WCL. On the other hand, young farmers may have a longer planning horizon and, hence, may be more likely to be willing for conservation. Besides, older aged household heads are more likely to have a money shortage and reduce willingness to pay for bamboo forest conservation. That is holding other things constant, a one year increase in household head age leads to decrease the probability of accepting the first bid by 0.6% the result is consistent with other studies done by Solomon (2004), Anemut (2007), Ayalneh and Birhanu (2012) and Alem*et al*. (2013).

4.13. Income from the bamboo forest

Income from the bamboo forest of the respondent was found to have a positive and significant relationship with the households' WCL at 10 %level of significance. This positive effect indicated that respondents with higher income from the bamboo forest were more likely to say **yes** to the first bids than households with lower income. This may be due to the fact that individuals that were accustomed to higher income from the bamboo forest are more likely to invest in bamboo by expecting high income than others. Keeping all other factor remains constant when income from bamboo forest increase by one unit, respondent willingness to contribute labor increase by 9 units. This value is in line with the work of (Turufat and Muhdin, 2017).

4.14. The education level of the respondents (EDUC)

The education level of the respondents (EDUC) is positively and significantly related to willingness to contribute labor (WCL) at 10 % i.e. respondents with more years of schooling are likely to be willing to offer labor in man-days for conservation practices. One possible reason could be that the literate individuals are more concerned about forest conservation practices. The result also revealed that holding other things constant, a unit increase in years of schooling of the respondents, increases the probability of accepting the first bid as well as the follow-up bid by about 5.8 %. The finding was similar to findings by (Alemu*et al*., 2004; Babu and Suryapakash, 2004; ChukwuoneandOkorji, 2008)

4.15. Total Cultivable Land

The result from the model bivariate probit model showed that cultivable land owned was found to positively affect the willingness of respondents to contribute to the conservation and rehabilitation of bamboo forests at a 1% significance level. The reason for this is that farmers having more cultivable land to use for crop production may have less desire to expand their holding by encroaching into the forest territory in search of additional land. This result is consistent with the results of Tefera (2006). The marginal effect of this variable shows that a unit increase in the cultivable land size of the household increases the probability of being willing to pay the first bid prices by 6.5% keeping other factors constant.

4.16. Contact with extension agents

From the model this dummy variable was positive effect as expected and significant 10 % significant level. this because respondents those contact with extension agent are expected to be knowledgeable on the conservation and strategy and they know forest development strategy and forest law which enable them to contribute more for conserving forest particularly bamboo forest in the area. The marginal effect result shows that the probability of being willing to pay for both bid labor in man-day for farmers who have contact with extension agents increases by 28 %, *ceteris paribus (*Ansong and Rocket, 2014).

4.17. Offered initial bids (BID1/2)

Offered initial bid (BID1) had a negative and significant relation to WCL for bamboo forest conservation at 5% significant level while second bid (BID2) to follow up bid at 1% significance level with a willingness to pay for conservation practices. This implied the probability of a yes response to the initial bid increased with a decrease in the offered initial bid for both initial and follow up bids. The marginal analysis indicated that as the starting bid price and follow up increases by one unit, the probability of household' WCL for bamboo forest conservation practices decrease by 3.5 % and 4.2 % respectively. This is consistent with the findings of (Tiruneh, and Ketema, 2013)

4.18. Dependency ratio

Dependency ratio had a statistically significant and negative effect on willingness to contribute in terms of labor. The result demonstrated that a large number of dependents within the household decrease the willingness of households to contribute labor for conservation activities because an increase in the number of dependents puts pressure on active family members to fulfill their basic needs. In support of the finding, Nigussie, Adisu, Desalegn, and Gebreegziabher (2016) confirmed that households with high dependency ratio might not be able to participate in programs and projects due to time, labor and/or financial constraints. Additionally, Kumar and Srivastava (2017) explained that an increase in dependency ratio increases the number of dependents which leads to shortages of working hands to generate income from diversified activities to fulfill the basic needs of household members. The marginal effect of the model indicated that the willingness to pay of the respondents decreases by 4.9% for a unit increase in the number of dependents. This finding is in line with the result of the previous study (Zewdu and Yemsirach, 2004).

4.19. Aggregate Mean WTP and Demand curve

The mean WTP of the respondents for the conservation of bamboo forests was calculated using the formula specified by Haab and McConnel (2002) which is specified in equation (12) in the methodology part. The coefficients $\boldsymbol{\alpha}$ and $\boldsymbol{\beta}$ were estimated by running the bivariate probit model using the first bids and second bids as explanatory variables. Accordingly, the mean WTCL estimated from the initial bid and the follow-up bid values ranged from 14.15 labors in man-day to14.81 man-days for labor per year per household, and willing to contribute labor (WTCL) from the open-ended question was 6.67 man-days in labor per year per household.

According to Haab and McConnell (2002), the researcher must decide which estimates from the double bounded question to use so as to calculate the mean WCL. They explained that parameter estimates from the first equation are generally used in computing mean WCL. The reason behind this is the fact that the second equation parameters are likely to contain more noise in terms of anchoring bias as the respondent is assumed to take the clue from the first bid while forming his WTCL for the second question. This was also applied by Ayalneh and Birhanu (2012). Hence14.15 man-days per year per household estimated from the first equation were used in this study to estimate the mean WCL.

The annual aggregate WCL of rural households for the conservation of bamboo forests was estimated by multiplying the number of households (1007) by the mean WTCL per year per household. Therefore, the annual aggregate WCL was estimated to be14249.05 man-days in labor. The demand curve for mean aggregate demand was constructed by non-parametric statistics. During the main survey respondent`s maximum WTCL for open-ended questions ranged from Birr 0 to 34 per month for the proposed project, i.e. the WCL for the open-ended question is a continuous dependent variable and we Can regress it on its determinant variables using OLS to draw the aggregate demand curve for the forest protection. The other alternative is calculating the class intervals using simple statistics for the maximum WCL as follows:

$K = 1+3.322(\log N)$.

Where K represents the number of WTCL classes

N is the total number of respondents (N = 135)

$K = 1+3.322(\log 135) = 8$

So that we have approximately 8 class of WCL interval and the width of the class is determined by the ratio of range to WCL class. The aggregate WTCL of the sampled respondents with the non-parametric approach is calculated using the mean WTCL of total sample respondents and aggregate WTCL of all the total households living in four Kebeles is approximated by multiplying the total number population and non-parametric mean WTCL. The total sample respondents non-parametric mean of open-ended maximum WTCL can be calculated using the formula (Habb and McConnell, 2002):

MWTCL=$\frac{\sum(MWTPi)(ni)}{N}$

Where, MWCL = Mean willingness to contribute labor in man-days for the total respondents

$MWTCL_i$ = ithMean WTCL (WTCL midpoints i.e. column-2 in table…..)

ni = Number of respondents WTCL the ith amount (column-3)

N = Total number of sample respondents (N= 135)

Table 3: Non-parametric estimation of WCL for Bamboo forest ecosystem conservation for Labor in man-day

Class boundary (1)	Average WTCL/year (2)	Frequency (3)	Total number of HHS(4)	Total WTCL/year (5)	Total HHS WTCL at least that amount (6)
0-4.25	2.125	59	440	935.2	1007
4.25-8.5	6.375	31	256	1632	627
8.5-12.75	10.625	23	190	2018.75	371
12.75-17	14.875	11	91	1353.625	181
17-21.25	19.125	6	50	956.25	90
21.25-25.5	23.375	3	25	584.375	40
25.5-29.75	27.625	1	8	221	15
29.75-34	31.875	1	8	255	10
Sum		135	1007	7956.2	
Mean willingness to contribute labor= 6.67					

The table indicates that as the amount of labor offered for forest conservation (WCL) increases from 2.125 to 31.875 labor in man-days the number of households' willingness to Contribute labor decreases definitely thus the demand curve slopes downward. This agrees with economic theory demand for normal goods or services is inversely related to its price, thus taking forest protection as a normal good its demand decreases as labor contribution in man day (WCL) increases and the demand curve slopes downward.

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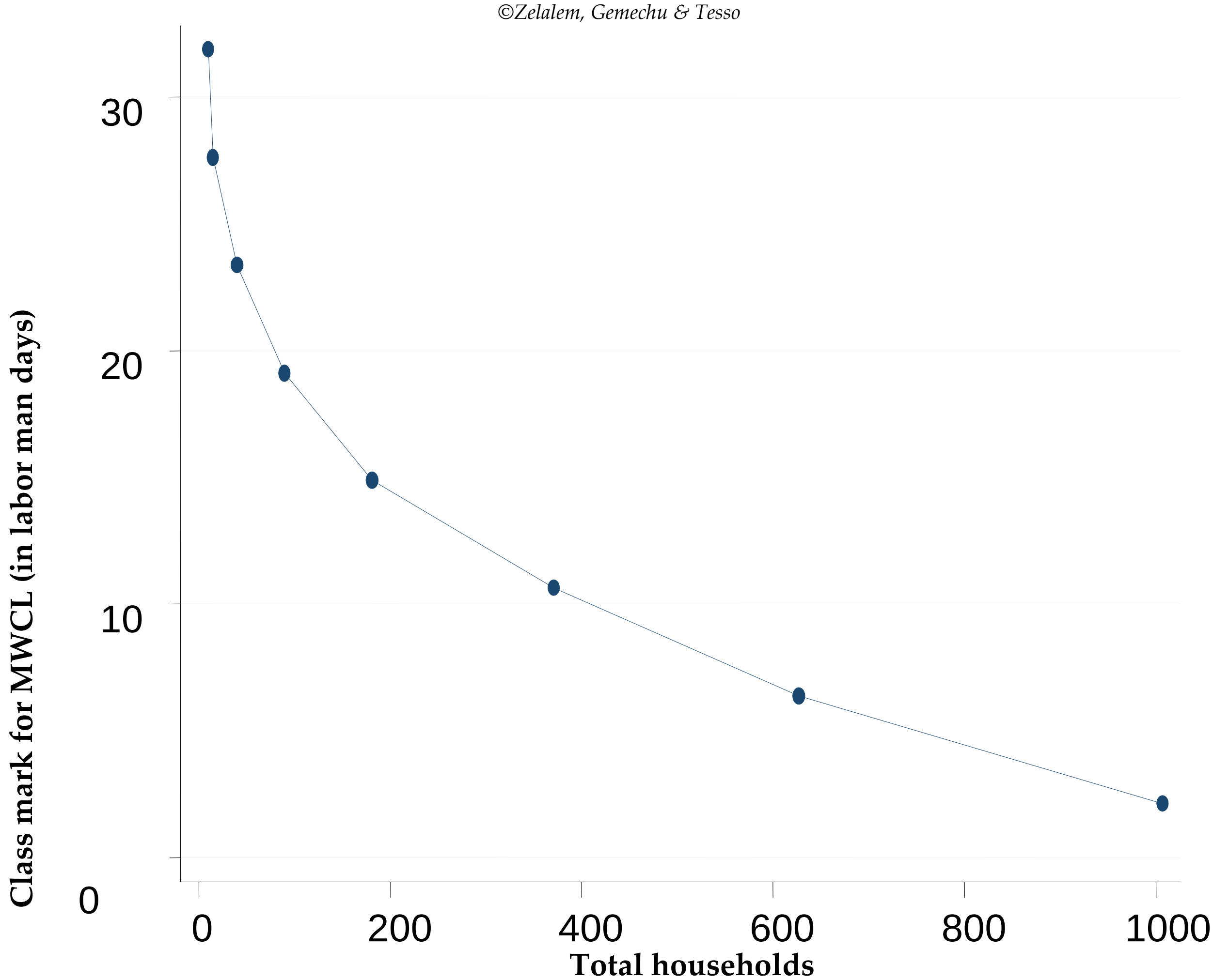

Fig. 1: Estimated demand curve for bamboo forest conservation

5. Conclusions

Non-timber forest products (NTFPs) such as bamboo constitute an important source of livelihood for millions of people from forest fringe communities across the world. In Ethiopia, NTFPs are associated with the socio-economic and cultural life of forest-dependent communities inhabiting in wide ecological and geo-climatic conditions throughout the country. Thus their conservation has attracted considerable global interest in recent years. Hence the main objective of this study was to explore the household's (HHs) willing to contribute the amount of labor for bamboo forest conservation. Describing farmers' attitudes toward bamboo forest conservation and identifying factors affecting their willingness to contribute the labor using the contingent valuation method in the Mao Komo District.

The study used both primary and secondary data. The survey responses of 135 households selected in a multi-stage sampling technique (purposive and random sampling techniques) through a semi-structured questionnaire from the four *Kebeles* of Mao Komo District were analyzed using both descriptive statistics and Econometric models in the study.

The elicitation method used was a double bounded format with an open-ended follow-up question. To elicit farmers' willingness to contribute Labor for the bamboo forest conservation, and the researcher administered the survey using an in-person interview. Four choice sets, (2, 4, 1), (4, 8, 2), (6, 12, 3), and (8, 16, 4) were also provided to each respondent for the choice experiment part to determine their WTCL for bamboo forest conservation.

A bivariate Probit model was used to estimate the mean WCL for the conservation of bamboo forests was calculated using the formula specified by Haab and McConnel (2002) which is specified in equation (12) in the methodology part. Therefore, the mean willingness to contribute labor from the double bounded dichotomous question was ranged from 14.15 labors in man-day to14.81 Labor in maydays per year per household, and Willing to contribute labor (WCL) from the open-ended question was 6.67 man-days Labor in maydays per year per household Thus, in this study, the mean willingness to contribute Labor from dichotomous choice questions is more than open-ended questions. The aggregate welfare gain from the conserved bamboo forest in the study area from the double bounded dichotomous choice format and open-ended format was estimated to be14249.05 and 6716.69 in labor in man-days per year.

The study found that the value of bamboo forest conservation from open-ended format was relatively underestimated as compared to the double bounded format. This may be due to a lack of base for answering WCL questions under open-ended Format. Thus, in estimating the value of environmental resources like forest conservation, it is important to use CVM in the form of a double bounded elicitation format than other elicitation methods. On the other hand, the estimated aggregate demand for bamboo forest conservation is similar to the demand of the household to most economic goods under normal conditions which indicates as the payment increases, the number of households willing to contribute that amount declines.

The contingent valuation method used seemingly unrelated bivariate probit (Equations 6a and 6b in methodology) which is variant of bivariate probit model to identify the key determinants of farmers' willingness to contribute labor for bamboo forest conservation. The important variables identified in this study to determine farmers' willing to contribute labor (WCL) for bamboo forest conservation are household's literacy status, income from bamboo forest, contact with extension agents and, total cultivated land and access to credit had positive significant effects on WCL, while, age of the respondent, distance, initial bid, follow up bids and dependency ratio had a negative and significant effect on willingness to contribute labor.

In general, the study found the willingness of the farm households' labor contribution for bamboo Forest conservation. It also traced the determinants of willingness to contribute labor in terms of man-days in the study area. Thus, appropriate forest resource evaluation will make the community more aware of the economic, social and environmental contribution which will lead them to conserve, rehabilitate and efficient management of the bamboo forest ecosystem.

Conflicts of Interest: The authors declare no conflict of interest.

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Authors' contribution: Shafe Zelalem, Dr. Adeba Gemechu and Dr. Admasu Tesso conceived the idea and collected data; Shafe Zelalem[1]analyzed the data; All the authors participated in writing the paper.

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