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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# *ABSTRACT*

*Bamboo forest associated with socio-economic and cultural life of bamboo dependent communities throughout the country. Despite all this importance to the livelihood of the communities, bamboo forests facing man-made and natural challenges. 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. Data for the study were collected from both primary and secondary sources. Multistage random-sampling technique was used in selecting 135 respondent followed by a probability proportional to size. The value-elicitation used was Double bounded dichotomous elicitation format followed by open ended questions. The data were analyzed using descriptive statistics and bivariate probit model. The result of bivariate probit model shows the mean willingness to contribute labor for the conservation of bamboo forest was found to be 14.15 Labors in man-days per year per household. The result from seemingly unrelated bivariate probit model indicate that household's literacy status, income from bamboo forest, contact with extension agents, total cultivated land and access to credit had positive significant effects on willing to contribute labor, while age of the respondent, distance from home to forest, initial bid, follow up bids and dependency ratio had a negative and significant effect on willingness to contribute labor. The study show that the farmer’s in the study area are known 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 back to original position. As policy implications, an effort would be needed to strengthen literacy, increase farmers’ awareness about the importance of conservation practices, credit facilities and increasing the frequency of extension contact is important.*

**Keywords**: Bamboo Forest, Bivariate Probit, Willingness to pay

**Introduction**

Forest provides support for a multitude functions: resistance to catastrophes, food and drink provision, medicines, industrial materials*,* ecological services (protecting wild life, carbon sequestration), leisure, cultural and aesthetic functions, which have important values (Shi, and Wang, 2016). The value of the various functions of a particular forest provided to its stakeholders constitutes an economic value. Thus, considering all the possible functions of forests and the relevant stakeholders’ preferences is relevant 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, timber bamboos 30 m in height (Mulatu and Tadesse. 2006). It is wonder plant, strongest and fastest growing woody plant on earth, with a global trade worth above 2 billion US$ per year (Musau, 2016) also everyday use 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 46No and 47So 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. Harvested; it continues to grow new shoots, without a period of regeneration. And also bamboo used for bamboo-based board applications such as particle boards, medium density fiber board and strand boards and for pulp and paper manufacture (Chaowana, 2013).

Ethiopia took the first place in bamboo potential in Africa comprising 67 percent of the continent’s bamboo forest area (Demissew *et al.,* 2011), deforestation particularly massive bamboo depletion and mass flowering has been taking place in many parts of the country, and now days, it is 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 at present-day is 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 bamboo have been used successfully to rehabilitate degraded land back in to productive, fully functioning ecological systems (Embaye, 2001).This 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 bamboos leaves create natural mulch (Tallamy, 2009).

The bamboo resources of the Mao-Komo special woreda have been quite shrinking from time to time. For instance, in the 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 bamboo resource. In recognition of the problems associated with natural resource degradation, exploring farm house holds willingness to pay is vital for effective and sustainable bamboo resource management (Zhang and Paudel, 2019).

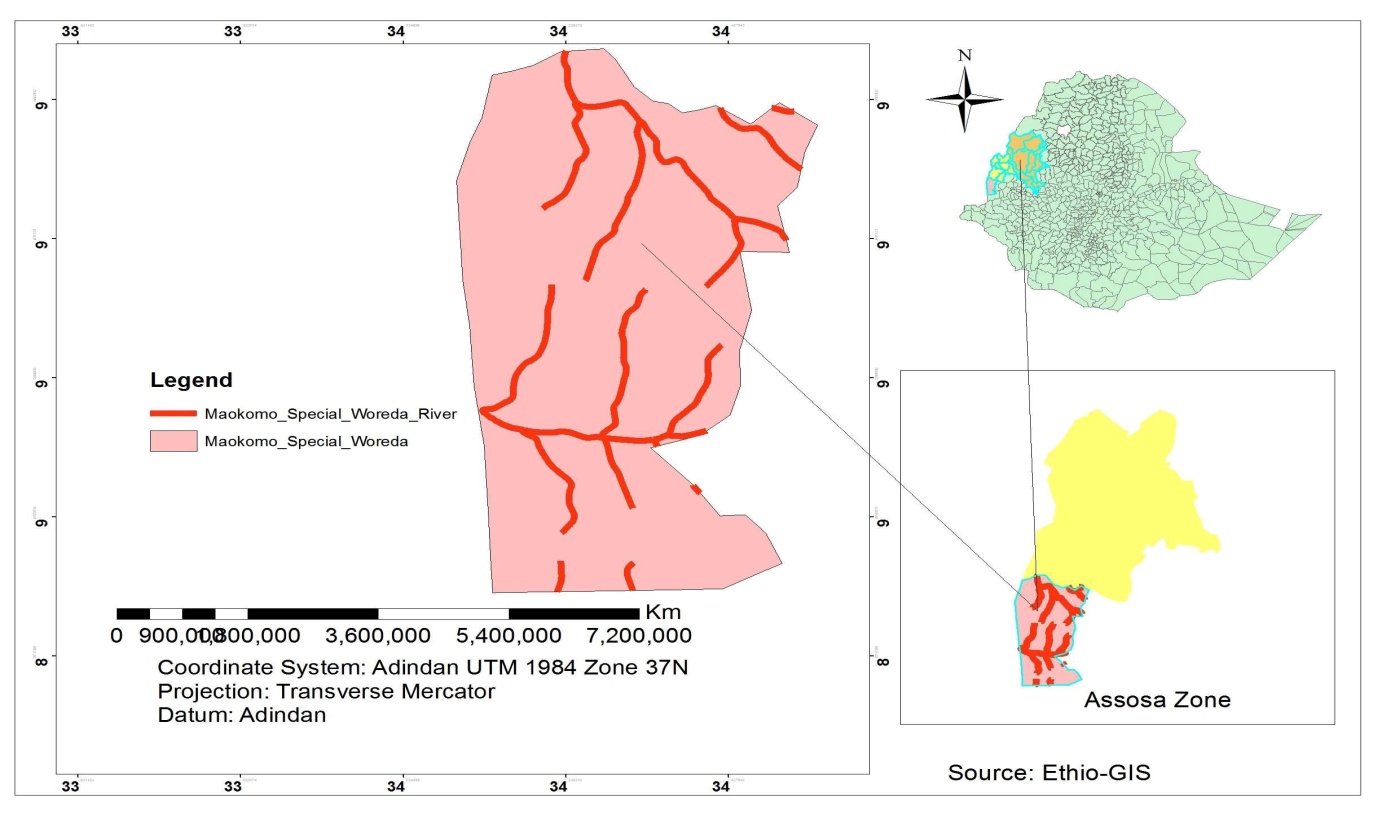
Despite its imperative roles, most environmental experts were still reluctant to ascertain farmer’s willingness contribute labor to conserve bamboo forest (Ketema, 2013). As suggested by Truneh (2013), exploring farm households’ willingness to pay for bamboo forest conservation and factors that influence their willingness to contribute labor are essential to design effective management policies and conservation strategies. To the knowledge of the researcher no study ascertain farm house hold willingness to contribute labor regarding bamboo forest conservation in the study area. Therefore the study was designed to assess farm household’s willingness to contribute labor for bamboo forest conservation.

**Materials and Methods**

*Study Area*: The study is conducted in Mao-Komo woreda, Benishangul-Gumuz Region of Ethiopia. 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 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](https://en.wikipedia.org/wiki/Central_Statistical_Agency_(Ethiopia)) of Ethiopia (CSA, 2007).

Mao-Komo has an 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 12oc to 35oc, 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.

Mao Komo has 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).

 ***Location map of the study area***

*Sampling Techniques:* Mao Komo woreda were purposively selected based on availability of bamboo forest in the area. For this study, a multi-stage random sampling technique was implemented to select sample from 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) was purposively selected. In the second stage, the eight Kebeles was 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 Yaha Masara from the natives. Finally, 135 sample households were selected randomly based on probability proportional to the size.

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

**n =**

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 kebele has a total of 1007 number of bamboo producer households. Hence, the desired sample size is equal to:

n =**=135**

## Sources and Methods of Data Collection

Quantitative primary data were gathered accompanied by a face to face interview. Focus group discussion and key informant interview were also made as part of data collection method for qualitative primary data. Moreover, secondary data were collected from journals, books and agriculture office of the Mao-Komo woreda. Similarly, quantitative data were collected employing 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 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 pretest before the actual survey. In addition to the pretest survey, focus group discussion and key informant interview were held to determine initial bids in terms of cash and labor using open-ended contingent valuation format. As a result, 2, 4, 6 and 8 man-days per annum followed by open-ended questions were used as a starting bid for the actual survey. After the bids were designed, the respondents were asked a yes/no question to elicit their willingness to contribute. If his/her answer was yes, the next higher amount was asked to state their answers. Finally, the respondents were asked their maximum willingness to contribute labor in man days both for the bounded and unbounded values using open-ended questions to state the maximum amount they are willing to pay. If his/her answer was no, the next minimum amount followed by open-ended question was also employed to solicit his/her maximum amount.

## Dependent variable

Farmer’s decision to pay or not for bamboo forest conservation at different bid categories is dependent variable of the model. Hence the dependent variables of the model are **Y1,** and **Y2** 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 a non-willing household**.**

## Methods of Data Analysis: Both descriptive statistics and econometric models was used to analyze the data

### 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 respondent and their willing 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 non-willing farmers. The chi-square test is conducted to compare some qualitative characteristics of the willing and non-willing conservation of bamboo; and t-test is run to see statistical difference between the two groups’ means of the willing and non-willing’ categories with respect to continuous explanatory variables.

### Econometric Analysis: The determinant factors were identified by employing seemingly unrelated bivariate probit (Equations 6a and 6b below) which is variant of 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 household’s (HHs) would be willing to contribute for 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).

The two correlated willing to contribute labor (WCL) equations (equation 6a and 6b below) with jointly distributed normal error terms are simultaneously modelled 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 a 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 some positive willing to contribute labor (WCL) for bamboo conservation practice, economists assume that there exists 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 declare a positive WCL (Haab and McConnell, 2002).According to Haab and McConnell (2002) the indirect utility for respondent j can be written as

uj = u (l, zj, q) - - - - - - - - - - - -- - - - - - -- -- - -- - - - - -- - --- - - -(1)

Where Ui is the utility of the household j, l is vector of respondent's labor endowment, Zj is vector of households' socio-economic characteristics and q vector is 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.

Ui (lj - Bj,zj, q\*) > u0 (lj,,zj,q) - - -- -- -- - -- - -- - - -- - -- - - --- -- - - - (2)

Where, Bj 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 (yesj) = (u1 (lj - Bj, zj, q\*) + ɛ1j> u0 (lj, zj ,q,)+ ɛ0j) - - - -- - -- - - --(3)

Where ε0j, ε1j 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 ith household which is assumed to be a function of observable household characteristics; resource endowment and environmental quality, Xti, and a disturbance term ɛtIcan be specified as;

Uti= f (Xti) + ɛti, 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 ithfarm household head will be willing to accept the initial bid when u1i≥ u0i. Therefore, the choice problem can be modeled as binary response variable Y, Where

Yi = {1, if U (lj - Bj, zj, q\*) + ɛ1j> U0 (lj,,zj, q,) + ɛ0j 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:

------------------------------------------------------ (6a)

------------------------------------------------------ (6b)

E (ɛ1/ x1, x2) = E (ɛ2/ x1, x2) = 0

Var (ɛ1/ x1, x2) = E (ɛ2/ x1, x2) = 1

Cov (ɛ1, ɛ2/ x1, x2) = ρ - - -- -- - -- - - -- - - -- - -- - -- - -- - - - --- - - -- -(7)

Where: y1\*= ithrespondent unobservable true WCL at the time of the first bid offered. WCL = 1 if yI\* ≥ βi0 (initial bids), 0 otherwise

Y2\* = it respondent implicit underlying point estimate at the time of the second bid offered.x1and x2= the first and second bids offered to the respondents, respectively. ɛ1, and ɛ2= error terms for the first and second above equations, respectively.Β1 and β 2 = Coefficients of the first and second bids offered, respectively. ρ is correlation coefficient, which is the covariance between the errors for the two WCL function

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

WCLqi = μq+ εqi---- -- - -- -- - - -- --- - - - -- - - -- -- - - - -- --- - - - -- - - - - -- - - - -- -(8)

Where WCLqi represents the ith respondent's willingness to pay, and q = 1, 2 represents the first and second response. The μ1and μ2 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 + ε1i≥ B1, μ2+ ε2i < B2) - -- - - - -- -- - -- - - -- - - -- - ---- - -- -- -- - - -----(9)

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

Hence, the iih contribution to the likelihood function is:

Li (μ/B) = pr (μ1 + ε1i ≥ B1, μ2 + ε2i < B2) YN \* pr (μ1 + ε1i> B1, μ2 + ε2i ≥ B2) YY

Pr (μ1 + ε1i< B1, μ2 + ε2i< B2) 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 σ12 and σ22 then WTCL1i and WTCL2i have a bivariate normal distribution with means μ1i and μ2i and variances σ12 and σ22 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 (μ1+ ε1i< B1, μ2+ ε2i< B2 ε1i ε2i ( ,

The probability of a yes-no response is

Pr (μ1+ ε1i≥B1, μ2+ ε2i< B2 ε1i ε2i ( ,

The probability of a no-yes response is

Pr (μ1+ ε1i<B1, μ2+ ε2i>B2 ε1i ε2i ( ,

The probability of a yes-yes response is

Pr (μ1+ ε1i>B1, μ2+ ε2i>B2 ε1i ε2i ( ,

Defining y1i = 1 if the response to the first question is yes, and 0 otherwise, y2i = 1 if the response to the second question is yes, and 0 otherwise, d1i=2 y1i -1, and d2i= 2 y2i -1, the ith contribution to the Bivariate Probit likelihood function is

Li (=ε1iε2i (d1i (d2i(d1id2i

Where Φ **ε1i, ε2i** 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 = - - - -- - -- - - - - -- - - - - -- - - - - - -- - - - - - - - - - - (12)

α is a coefficient for the constant term, and β is a coefficient for offered bids to the respondents

**Results and Discussions**

## 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 has willing to pay cash. The left 6% of the respondent has no willingness to pay cash at all. From the 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 farmer willingness to contribute labor which is one specific objective 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 |

**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 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 non-willing respondents in the both bid in terms of perception on bamboo forest conservation activities.

**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 insignificant difference between willing and non-willing farmers on the basis of their participation in natural resource conservation activities in both first and second bid.

**Farmers’ attitudes towards the protection of bamboo forest ecosystem:** Farmers’ attitudes towards the protection of bamboo forest. 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 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. In addition, 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.

### Farmers' dependency 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 source of income (40.1%) and as 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.

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.

**Perceived main causes of the degradation of Bamboo forest**: Out of the total respondents about 26.23% replied that they have seen such mass flowering of bamboo in their life time and the rest73.77 % have not seen such a phenomenon in their life time. This could be an indicator that 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 is necessary which may indicate the dependency of community on it.

One of the problems associated to mass flowering of bamboo forests is the increase in breeding rate which results in outbreak of rats and rodents of different species (HKI, 2011). About 39.34 of the respondents reported that they have seen 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 number of people affected was estimated at 8124 in 2018/2019 production season (MWAO, 2018).

The contingent valuation survey results: From the survey result 13.3 % of the total households were not willing to contribute labor for conservation of bamboo forest. The specific reason the report was Shortage of labor in the household and disability were their specified reasons for their non-willingness.

Four sets of bid prices which 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 sated 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 .

**Factors affecting willingness to pay (WTP) for conservation of bamboo forest**

Before running the econometric model, the presence of outlying, multi co linearity and heteroscedasticity problems were tested. The result showed that there was no serious 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 | 0.2102763 | 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 |
| Total 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 |
| Contact with extension agent | .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 = 0.0000**  **P\*\*\*** |  |
|  |  |

**Note: Bid1/Bid21=Bid1 is used in first model whereas Bid2 is used in second model**

**Source: Own Survey, 2018**

**Interpretation of model out comes**

**Distance of the respondent from bamboo forest;** As expected this variable showed 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 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 decrease the probability of accepting the first bid values by 6.2 %, keeping other factors constant at their mean.

**Access to credit (CRED):** the result showed 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 hope full 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 to findings by (Desta, 2012) which have negative relationship.

**Age of the household head:** had negative and significant effect on households willing to contribute labor (WCL) at 5% significant level. This may be older age may shorten 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, an 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).

**Income from bamboo forest** of the respondent was found to have positive and significant relationship with the households’ WCL at 10 %level of significance. This positive effect indicated that respondents with higher income from 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 bamboo forest is more likely to invest on 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).

**Education level of the respondents (EDUC)** is positively and significantly related to willing to contribute labor (WCL) at 10 %. That is, respondents with more years of schooling likely to be willing to offer labor in man days for conservation practices. One possible reason could be that literate individuals were 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 about5.8 %. The finding was similar to findings by (Alemu *et al*., 2004; Babu and Suryapakash, 2004; ChukwuoneandOkorji, 2008)

**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 for the conservation and rehabilitation of bamboo forests at 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 inconformity with the results of Tefera (2006).The marginal effect of this variable shows that a unit increase in 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.

**Contact with extension agents:** from model this dummy variable was positive effect as expected and significant 10 % significant level. this because respondents those contact with extension agent are expect 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).

**Offered initial bid (BID1/**) had negative and significantly relation to WCL for bamboo forest conservation at 5% significant level .while second bid (BID2) to follow up bid at 1% significance level with willingness to pay for conservation practices. This implied the probability of a yes response to the initial bid increased with 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)

**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 put 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 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).

## 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 and 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 the computing mean WCL. The reason behind 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 in (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 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 open ended question is a continuous dependent variable and we Can regress it on its determinant variables using OLS to draw 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 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=

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

MWTCLi = ith Mean 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 slops downward.

This agree 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 slops downward.

**Class mark for MWCL (in labor man days)**

0

10

20

30

0

200

400

600

800

1000

Total house holds

Figure 1: Estimated demand curve for bamboo forest conservation

**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 socio-economic and cultural life of forest dependent communities inhabiting in wide ecological and geo-climatic conditions throughout the country. Thus their conservation have attracted considerable global interest in recent years.hence the main objective of this study were to explore the amount of labor; the household’s (HHs) would be willing to contribute for bamboo forest conservation practices. Describing farmer’s attitude 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-structure 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 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.

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 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 lack of base for answering WCL questions under open ended Format. Thus, in estimating the value of environmental resource like forest conservation, it is important to use CVM in the form of double bounded elicitation format than other elicitation method. 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 usedseemingly 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 founds the willing of farm house hold labor contribution for bamboo Forest conservation and determinants of willingness to contribute labor in 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 lead them to conserve, rehabilitate and efficient management of the bamboo forest system that makes them beneficiary and more profitable.

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