Contingent valuation analysis of rural households' willingness to pay for frankincense forest conservation

Mesfin TILAHUN[1, 2 *], Erik MATHIJS[1], Bart MUYS[3], Liesbet VRANKEN[1], Jozef DECKERS[4]
Kidanemariam GEBREGZIABHER[1, 2], Kindeya GEBREHIWOT[5], Hans BAUER[5]

[1]Division of Agricultural and Food Economics, Department of Earth and Environmental Sciences, K.U.Leuven, Celestijnenlaan 200E box 2411, BE-3001 Leuven, Belgium.
[2]Department of Economics, Mekelle University, P.O.Box 451, Mekelle, Ethiopia.
[3]Division of Forest, Nature and Landscape, Department of Earth and Environmental Sciences, K.U. Leuven, Celestijnenlaan 200E box 2411, BE-3001 Leuven Belgium.
[4]Division of Soil and Water Management, Department of Earth and Environmental Sciences, K.U. Leuven, Celestijnenlaan 200E, BE-3001 Leuven, Belgium.
[5]Department of Land Resources Management and Environmental Protection, Mekelle University, P.O.Box 231, Mekelle, Ethiopia.
*Corresponding author: *E-mail:* mesfintila@yahoo.com or mesfintilahun.gelaye@student.kuleuven.be

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Abstract: *Frankincense from Boswellia papyrifera forest (BPF) is a traded non timber forest product (NTFP) used in pharmaceutical, food, cosmetic and chemical industries. However, the resource in northeastern Africa is under continuous degradation and requires conservation measures. Data from a discrete choice contingent valuation study are used to assess the factors influencing rural households' willingness to pay (WTP) and willingness to contribute labor (WTCL) for BPF conservation in Ethiopia. The standard probit, bivariate probit and interval data models were used for modeling respondents' WTP and WTCL. We found household income as the most important factor affecting WTP whereas number of household labor is the most important factor affecting WTCL. Mean lower bound annual WTP of US$ 4.68 and WTCL of 7.03 days per household were estimated. This study indicated that despite Ethiopia is a low income country, people are willing to contribute for conservation of the resource.*

Key words: Willingness to pay; Boswellia papyrifera; Conservation; Contingent valuation

1. Introduction

Boswellia papyrifera (Del.) Hochst is an economically important tree species growing in the Sudanian and Sahelian regions of Africa (White 1983). Frankincense from this tree is used as input in pharmaceutical (Michie and Cooper 1991; Arizza et al. 2008), food (Ford et al. 1992), perfume and cosmetics industries (Tucker 1986), and as a traditional medicine (FAO 1995). It is widely used for rituals in different religions (FAO 1995) and as a fragrance during coffee ceremonies in Ethiopia. Moreover, the collection of frankincense is a source of income to rural people and the country gets foreign currency from exporting the product. According to data from Central Statistical Authority of Ethiopia, the country exported 14978 tons of resins (mainly Frankincense, Myrrh, and Gum Arabic) over the period 2003-2007 with a total value of US$ 21.53 Million. Despite the economic, cultural values its ability to grow on degraded sites and its ecological importance for combating desertification (Stiles, 1988) its population in East Africa has been degraded due to deforestation, free grazing, and over tapping (Ogbazghi et al., 2006; Negussie et al., 2008). A number of studies argued that commercialization of NTFPs can promote conservation and sustainable management of tropical forests while improving rural livelihoods (Belcher and Schreckenberg, 2007). However, Arnold and Pérez (2001) criticized this argument on the fact that NTFP extraction often involves overuse and extreme degradation of forest resources. With the current trend of degradation, which is partly due to increasing demand for frankincense in the world and domestic markets, there is an ecological concern that the species is in a danger of extinction unless certain conservation measures are taken. TRAFFIC (the wildlife trade monitoring program of WWF ad IUCN) has listed *Boswellia papyrifera* as endangered species that need priority in conservation (Marshal, 1998). Therefore, this study assesses whether rural households are willingness to contribute cash or labor for BPF conservation, and identifies the factors that affect their willingness to make a contribution.

2. Methodology

2.1. Value to be estimated and the CV method

A review of environmental economics' literature suggests that the total economic value of a resource is the sum of its use, option, existence, and bequest values (Campbell and Luckert, 2002). Preservation value includes option, existence, and bequest values (Walsh et al., 1984). Frankincense from *Boswellia papyrifera* is used as input in pharmaceuticals, chemical, food and cosmetic industries. The leaves of the tree have nutritive value as livestock feed (Melaku et al., 2010). These direct uses can be valued using market-based methods. However, the resource has also non-market benefits. With uncertainty about future demand, there may be interest to keep the resource as an option for future use. Given the current trend of degradation, people are concerned of the danger of its extinction and one would get utility form contributing for its conservation and improving the welfare of future generations.

CV methods have received increasing attention as a means to estimate option and existence values and it is the only approach to elicit the existence value of environmental amenity from both users and nonusers (Carson and Mitchell, 1993). Money is the only unit of account of value used in conventional CV question and studies show positive correlation between income and WTP. Beder (1996) questioned whether this should be interpreted as evidence that the rich care more for their local environment than the poor? In poor countries, household incomes are often inadequate to meet the basic needs and asking only WTP from their income may not fully capture their valuation of environmental amenities. Alam (2006) applied an extended CV method in which respondents in Dhaka City of Bangladesh were asked to contribute time along with WTP in cash for a CV scenario to capture the non-market benefits of the Buriganga River Cleanup Program. The study calculated the median WTP and willingness to contribute time. However, the impact of socioeconomic characteristics was not analysed. Understanding the effect of these factors on WTP is very important to use CV models for forecasting, simulation, benefit transfer, and ascertaining the marginal value of changes in amenity levels associated with particular resource (Cameron and Quiggin, 1994). This study applies CV to quantify rural households' WTP and WTCL towards BPF conservation and analyze factors influencing WTP and WTCL.

Many CV studies rely on single bound dichotomous choice (SBDC) approach in which respondents are asked whether they would accept a randomly assigned predetermined single bid amount. However, this method can be highly statistically inefficient (Cameron and Quiggin, 1994). A double bounded dichotomous choice (DBDC) approach in which the respondent is asked a follow-up question if s/he would pay a higher or lower bid depending on the response to the initial bid (Hanemann et al., 1991) is often used to improve the efficiency. Thus, we opted to design a DBDC questionnaire for eliciting respondents' WTP and WTCL for the conservation of BPF.

2.2.Survey design

2.2.1. Survey structure

According to CV experts, it is important to provide respondents with adequate and accurate information and make them fully aware of the contingent market situation in order to arrive at correct WTP measures. Therefore, a survey with four major parts is designed. The first part describes the uses of the resource, its state of degradation, the need for conservation and its three goals. The verbal description is accompanied by three photographs of *Boswellia* stands taken from the same study area.

Figure 1: *Boswellia papyrifera* stands in different state of degradation in Western and Central Tigray

The second part deals with the method of provision, payment mechanism, decision rule and time frame of the payment. Respondents were informed about the requirement of their financial and labor contributions for achieving the goals. The cash contributions will be in the form of an annual tax to the local government whereas the annual labor contribution is as a guard for patrolling the conservation site for controlling free grazing, cutting of trees, shifting cultivation practices, and tapping of frankincense. They were informed that enough volunteers would have to participate for achieving the goals. The third part deals about the valuation questions before which respondents were reminded of their household income and expenditure, the amount of household labor capable of contributing labor for the planned conservation, and the total labor time they require for farming and other household activities as well as community works. The questions were followed by debriefing questions. The last part inquires about the household's attitude and socioeconomic variables.

2.2.2.Survey pre-test , bid design and sampling

We conducted a pretest survey on 50 random sample households in the study area to design bid levels for the final survey and test the questionnaire. In discrete choice CV, welfare estimates could be sensitive to specification and size of bid amounts (Cooper and Loomis, 1992) and a number of methods are proposed by different authors (Boyle et al., 1988; Cooper, 1993; Alberini, 1995) for designing bids. The Boyle et al.'s method uses WTP data from pretest survey of open ended questions. We used this method for it is not complex and requires less computational effort and selected five initial bid levels (Alberini, 1995) (Table 1). The follow-up bids were determined by doubling and halving the initial bids respectively.

Table1: Bid design and number of sample households randomly assigned to each bid level

Bid (Birr year $^{-1}$) *[Initial, upper, lower]*	**Bid (labor day year^{-1})** *[Initial, upper, lower]*	**Initial bid probabilities**	**Number of Respondents**
[19, 38, 10]	[2, 4, 1]	0.15	103
[47, 94, 24]	[5, 10, 3]	0.35	104
[68, 136, 34]	[7, 14, 4]	0.50	106
[84, 168, 42]	[9, 18, 5]	0.65	104
[113, 226, 57]	[12, 24, 6]	0.85	103

The study was conducted in frankincense producing districts of central and western Tigray of northern Ethiopia. We selected five rural communities on the basis of availability of rural cooperative firms engaged in frankincense extraction and trading. A total of 520 stratified random sample households were selected from lists of household heads obtained from the local administration. After incorporating the findings of the pretest survey, determining the bid levels, and random assignment of bids to sample households, we trained interviewers and conducted the final face to face survey in March 2009.

2.3.Model specification for measuring WTP and WTCL

The dichotomous choice elicitation model relies on the assumption that respondents maximize their utility function and that they will accept the initial bid (which is a randomly assigned tax and/or labor contribution for the preservation of BPF) only under the following condition (Hanemann, 1984):

$$v_{1i}(m_i - t_i; s_i) + \varepsilon_{1i} \geq v_{0i}(m_i; s_i) + \varepsilon_{0i} \quad \textbf{(1)}$$

where, v_{1i} is the indirect utility in a state of BPF conservation, v_{0i} is the indirect utility in the status quo, and v_i depends on m_i, which is income if the bid t_i is in terms of cash, and m_i is leisure if the bid t_i is in terms of labor contribution; s_i is the other socio-economic variables and leisure if the bid is in terms of cash and, s_i represents other socio-economic variables and income if the bid is in terms of labor; $\varepsilon_1 \, and \, \varepsilon_0$ are the identically, independently distributed random variables with zero means. Let X is a vector of socioeconomic variables that include m and s of the above specification and $\varepsilon_i \sim N(0,\sigma^2)$. Then, following the censored econometric model (Cameron and James, 1987), the rural household's WTP or WTCL function Y, can be specified as:

$$Y_i = \beta X_i + \varepsilon_i \tag{2}$$

In discrete choice CV studies Y_i is a latent continuous censored variable. The observed variable is the answers 'YES' or 'NO', which can be given by a dummy variable I = 1 if YES and zero otherwise, to the question regarding whether or not the respondent would be willing to pay or willing to contribute a given bid amount t_i. The i[th] respondent will say yes if $Y_i > t_i$ and this will be true if the condition in equation 1 is satisfied. Therefore, the probability of a yes response can be written as:

$$\begin{aligned}\Pr(I=1) = \Pr(v_{1i}(m_i - t_i; s_i) + \varepsilon_{1i} \geq v_{0i}(m_i; s_i) + \varepsilon_{0i}) &= \Pr(\beta X_i + \varepsilon_i > t_i) \\ &= \Pr[\varepsilon_i / \sigma > (t_i - \beta X_i)/\sigma] \\ &= 1 - \Phi[(t_i - \beta X_i)/\sigma] \\ &= 1 - \Phi(z_i) \end{aligned} \tag{3}$$

where $\Phi(.)$ is the standard normal cumulative distribution. Then, the log-likelihood function for i=1 ...N sample observations will be:

$$LogL = \sum_{i=1}^{N} \{ I_i \log[1 - \Phi([t_i - \beta X_i]/\sigma)] + (1 - I_i)\log[\Phi([t_i - \beta X_i]/\sigma)] \} \tag{4}$$

Maximum likelihood (ML) estimates of the parameters $(-1/\sigma, \beta/\sigma)$ can be obtained by maximizing equation 4. The value of $-1/\sigma$ is derived from the estimated parameter for t. Using the invariance property of ML estimator the point estimates of the valuation function parameter vector $\theta = (\beta)$ can be retrieved (Cameron and James, 1987).

Most empirical works that used SBDC data assumed a logistic error distribution and use logit model for its simplicity to compute. For this study however, we assumed normality of the error terms with homoschedastic variance σ^2 since we want to model each respondent's two discrete responses jointly using bivariate normal probability density function. This function allows for a non-zero correlation between initial and follow up responses, whereas the standard logistic distribution does not (Cameron and Quiggin, 1994). We argue that the estimated valuation function ought to have the same parameters for responses underlying the same set of well-behaved preferences. The bivariate probit model can be specified as if the two discrete responses are from the same valuation function, allowing for two correlated error terms $(\varepsilon_1, \varepsilon_2) = (\sigma_1 z_1, \sigma_2 z_2)$, with correlation coefficient $\rho(z_1, z_2) = Cor(z_1, z_2)$. A restricted version of the bivariate probit model (i.e., if initial and follow-up responses are assumed to be motivated by same latent WTP value, observed differences are due to randomness in the WTP distribution, and the correlation coefficient $\rho = 1$) leads to a DB interval data probit model (Hanemann et al., 1991).

Based on the above model, the following specification problems need to be tested. The first is on the choice of independent variables. The socio-economic characteristics of the respondents which are expected to affect WTP and WTCL responses are given in Table 2 below. We include dummies for each of the village to capture village fixed effects like differences in off farm employment opportunities. Except for the variables age and number of dependent household members which we expected negative sing, all the remaining independent variables are anticipated to have a positive effect on WTP and WTCL responses. For the village dummies, we expected positive sign for the villages in the Kafta Humera site which is relatively more endowed with off-farm employment opportunities in private commercial farms, mainly during crop harvesting season. The second is related to whether the initial and follow-up responses are independent. The hypotheses corresponding to this test are: $H_0^I: \rho = 0,\ \ H_a^I: \rho \neq 0$. The last is related to whether or not the two stochastic valuation functions of the bivariate probit model have identical distributions of error terms so that they are agreeable to the DB probit analysis. The other form of this restriction is: $H_0^\varepsilon: \rho = 1,\ \ H_a^\varepsilon: \rho \neq 1$. We used the likelihood ratio test to test the above hypotheses.

3. Results

3.1.Respondents' knowledge and attitude

After informing respondents about the different uses of BPF, a question was posed to elicit what they knew before they were informed and their level of understanding of the uses. The survey showed that majority of the respondents (68.65%) had previous knowledge about all or most of the uses. A little more than a quarter (28.46%) reported that they had previous knowledge about few of the uses but were able to learn more from the interview and understood all uses very well. After informing respondents on the state of degradation of the resource, a number of questions were posed to elicit their attitudes towards conserving it. Almost all (99.23%) reported that they would prefer to transfer the BPF areas in their village to their grand children in good state. All respondents reported that they are concerned about the deforestation and risk of extinction of which the majority (66.35%) are very much concerned. To elicit respondents' attitudes on the conservation goals, they were asked to state their interest on a scale of 1 to 10, with 10 as 'Very interested' and 1 as 'Not at all interested'. Nearly one third (65%) had an option value for the resource as they were very interested in keeping it as an option of meeting future demands. Almost same proportion (65.96%) had an existence value for the resource as they were very interested in realizing its existence and curbing the possibility of its extinction. The majority (72.69%) had bequest value for the resource as they were very interested in conserving it for improving the welfare of future generations. No respondent selected scale 1, in each questions implying that all respondents had option, existence and bequest values for BPF with different degrees of interest and majority (72.12%) were very much interested in the overall conservation policy.

3.2.Data calibration

Before using the data for statistical analysis, we calibrated it by dropping protest responses and adjusting WTP and WTCL responses with certainty given by the respondents' answers to debriefing questions. In the CV literature reasons other than financial constraint and the good having no value to the respondent are considered as protest responses (Labao et al., 2008). In the WTP bidding, 35 respondents (6.73%) answered no/no. Among these, 16 respondents (3.08%) replied that they have some interest in the conservation but would not pay anything to join the program. These could be considered as free riders and classified as protest responses. In case of WTCL bidding, we found 51 'no/no' (9.81%) of which 38 (7.31%) were protest responses. From the total protest responses of both biddings, 7 respondents answered 'no/no' to both biddings, 9 respondents to only the WTP bidding, and 31 respondents to only the WTCL bidding. Therefore, there are a total of 47 respondents who respond 'no/no' at least to one of the biddings. Therefore, in order to see the effect of each covariate on WTP and WTCL using same sample, we considered them as protest responses. After the protest screening, 473 respondents were retained for statistical analysis. The data was further subjected to certainty calibration using asymmetric uncertainty model (Champ et al., 1997). Respondents who replied yes/yes, yes/no and no/yes to initial and follow-up bids were asked how certain they were in making the payment. A ten point scale was used with 1 as 'Very uncertain' and 10 as 'Very certain'. All yes/yes, yes/no and no/yes responses were classified as no/no responses if the respondent chooses certainty scores 1 to 9. Accordingly, responses of 181 in the WTP and 158 in the WTCL were classified as 'no/no' responses. Table 2 shows definitions and summary statistics for the independent variables.

Table 2: Description and summary statistics of variables used for WTP and WTCL models

Variable	Description	Mean (S.D)
RESP	Dependent variable, equals 1 if Yes for the proposed bid; 0 otherwise:WTP	0.55 (0.49)
	: WTCL	0.61 (0.49)
BID	The randomly assigned amount to each respondent : Birr $year^{-1}$	65.89(32.03)
	: Days $year^{-1}$	6.97 (3.41)
GENDER	1=Male; 0=Female	0.91 (0.29)
RESID	1= The household head has been living in the area since before the resettlement year (2002); 0 = otherwise	0.72 (0.45)
SHARHOLD	1=If the household is shareholder in the local frankincense producing and trading cooperative firm; 0 =otherwise	0.23 (0.42)
HSINCOME	Household annual income in Birr	20828.34 (38830.04)
RADIO	1= If the household owns radio; 0=otherwise	0.39 (0.49)
LABOR	Number of household members 15-64 years old	2.70 (1.30)
DEPEND	Number of household members <15 and > 64 years old	2.59 (1.60)
AGE	Age of the household head	40.50(12.46)
EDU	Education of the household head: 1=illiterate, 2=Read and write but no formal schooling, 3= Elementary, 4= Jounior Highschool, 5= Highschool	2.12 (1.11)
LAND	Land size of the household in hectares	2.32 (1.71)
VIL1 …VIL5	Village dummies: for each of the five rural communities in the site.	

3.3.Parameter estimates of WTP and WTCL

To undertake the statistical tests in section 2.3, we first run two probit regressions models for each of the WTP and WTCL responses (Table 3). In the first regression, household income is included and other household characteristics that affect income are excluded (models of category A). In the second regression household income is excluded (models of category B). With the anticipation of multicollinearity, we checked for pair wise correlation between the covariates and dropped insignificant or relatively less significant variables. As a result, 8 SBDC models (Table 4), 4 bivariate probit and 4 interval data probit models (Table 5) were estimated. These reduced models are: Models IA & IB (SBDC for initial question of WTP); Models IIA & IIB (SBDC for initial question of WTCL); Models IIIA & IIIB (SBDC for the follow-up questions of WTP); Models IVA & IVB (SBDC for the follow-up questions of WTCL); Models VA & VB (Bivariate probit model of WTP); Models VI &VIB (Bivariate probit model of WTCL); Models VIIA & VIIB(Interval data probit (DB) model of WTP) ; and Models VIIIA & VIIIB (DB models of WTCL).

In all of the models, the variable BID is statistically significant at 1% (Tables 4 and 5) and the coefficients have the expected negative sign consistent to the theory of demand. This indicates that, in the case of WTP, the higher the BID price for the BPF conservation, the less likely respondents would be willing to pay. Similarly for the WTCL, the higher the BID in terms of labor contribution for the BPF conservation, the less likely respondents would be willing to contribute. GENDER is positive for all of the models of WTP and WTCL in category A and significant at 5% for model IA, IIA, VA, and VIA (Table3 4 and 5). This implies male household heads have a higher probability of accepting higher bid levels both in cash and labor than female household heads. Although GENDER is positive, but insignificant in Model B of WTCL (Table 3), it was not included in reduced models of category B for it has a significant positive correlation (r=0.148; p< 0.01), with the variable LABOR.

Table 3: Parameter estimates full regression of the SBDC for WTP and WTCL

	WTP		WTCL	
	A	**B**	**A**	**B**
Constant	-0.730(0.762)	-0.421 (0.733)	0.832 (0.678)	1.068 (0.682)
BID	-0.022[a] (0.002)	-0.020[a](0.002)	-0.174[a] (0.020)	-0.181[a] (0.021)
GENDER	0.626[b] (0.250)	0.659[a] (0.245)	0.360 (0.227)	0.276 (0.231)
AGE	0.014 (0.015)	0.007 (0.015)	-0.008 (0.013)	-0.023 (0.014)
EDU	0.240[c] (0.137)	0.329[b] (0.128)	0.090 (0.111)	0.090 (0.111)
RESID	1.312[c] (0.782)	1.289[c] (0.753)	-0.544 (0.700)	-0.763 (0.701)
DEPEND	-0.008 (0.046)	0.018 (0.044)	0.057 (0.043)	0.050 (0.043)
SHARHOLD	0.224 (0.187)	0.269 (0.179)	-0.057 (0.169)	-0.062 (0.172)
RADIO	0.343[b] (0.152)	0.465[a] (0.145)	0.337[b] (0.137)	0.308[b] (0.138)
HSINCOME	(4.4E-05)[a] (7.3E-06)		1.2E-06 (1.9E-06)	
LABOR		0.046 (0.060)		0.193[a] (0.060)
LAND		0.091[c] (0.047)		0.010 (0.042)
VIL1	0.062 (0.257)	0.117 (0.241)	-0.168 (0.231)	-0.207 (0.235)
VIL2	0.241 (0.232)	0.208 (0.219)	0.019 (0.205)	-0.009 (0.206)
VIL4	-0.206 (0.280)	-0.521[b](0.265)	0.040 (0.259)	-0.009 (0.262)
VIL5	-0.418 (0.291)	-0.808[a] 0.274)	-0.141 (0.267)	-0.107 (0.271)
AgeRESID	-0.022 (0.017)	-0.020 (0.016)	0.021 (0.015)	0.027[c] (0.015)
EduRESID	-0.295[c] (0.159)	-0.382[b](0.149)	0.016 (0.134)	0.007 (0.133)
Log *L*	-214.634	-238.316	-261.968	-256.725
Pseudo R^2	0.340	0.267	0.174	0.190
% Correct prediction	79.92	74.63	72.73	72.73

Values in parentheses are standard errors. [a] Significant at p<1%, [b] significant at p< 5%, [c] significant at p< 10%. VIL3 is dropped because of collinearity.

The parameter for RESID is negative and significant at the 1% for models IA, IB, IIIB and VB, at 5% for VA and VIIA of the WTP models. This indicates that respondents who have been living in the study area since before the resettlement program have a lower probability of accepting higher bid levels compared to the settlers for whom severe environmental degradation is the main push factor for their migration. Therefore, the result is in line with our expectation that the settlers would be more willing to contribute for the conservation. In the case of WTCL, however, the coefficient of the variable RESID is positive but significant only at 10% for models IIA and VIIIB. As anticipated, the coefficient of SHAREHOLD is positive and significant at 1% for models IB, IIIB, VB and VIIB, at 5% for models IA, IIIA and VA, and at 10% for model VIIA. This indicates that a respondent with a share in the local frankincense cooperative firm has a higher probability of accepting a given bid level than a respondent without a share. This may be explained by the fact that shareholder respondents are benefiting from the resource and they might feel more responsible for conserving it. However, in case of WTCL, the coefficient of this covariate was found negative for models II and VI but it was statistically insignificant. The coefficient of RADIO is significant at 1% for model IB, IIIB and VB, at 10% for models IA, VA and VIIB in the case of WTP and significant at 1% for models IIA,IIB, VIA and VIB, and at 5% for model IVA, IVB and

VIIIA in the case of WTCL. It has the expected positive sign in all the models indicating that respondents who own radio have a higher probability of accepting a higher bid level. This may be explained by the fact that radio owning respondents have better access to information on environmental and forest degradation and related issues from the media. The variable HSINCOME has the expected positive sign in all the models of category A and significant at 1% for models IA, IIIA, VA and VIIA. This implies that conservation is like a normal good to the rural households for which demand increase with increase in income. In case of WTCL, HSINCOME is positive but insignificant.

Table 4: Parameter estimates of SBDC models for WTP and WTCL responses

Variable	Reduced form SBDC1 Models				Reduced form SBDC2 Models			
	WTP		WTCL		WTP		WTCL	
	IA	IB	IIA	IIB	IIIA	IIIB	IVA	IVB
Constant	0.379	1.442[a]	0.719	0.743[a]	-0.045	0.694[a]	0.162	0.335[c]
	(0.313)	(0.230)	(0.272)	(0.223)	(0.273)	(0.202)	(0.249)	(0.200)
BID	-0.021[a]	-0.018[a]	-0.169[a]	-0.172[a]	-0.006[a]	-0.005[a]	-0.067[a]	-0.066[a]
	(0.002)	(0.002)	(0.020)	(0.020)	(0.001)	(0.001)	(0.009)	(0.009)
GENDER	0.573[b]		0.485[b]		0.309		0.587[a]	
	(0.240)		(0.217)		(0.220)		(0.214)	
RESID	-0.419a	-0.733[a]	0.245[c]	0.169	-0.277[c]	-0.539[a]	0.128	0.033
	(0.160)	(0.146)	(0.141)	(0.140)	(0.146)	(0.136)	(0.138)	(0.137)
SHARHOLD	0.377[b]	0.595a	-0.024	-0.032	0.392[b]	0.560[a]	0.148	0.154
	(0.172)	(0.156)	(0.152)	(0.153)	(0.157)	(0.147)	(0.147)	(0.147)
RADIO	0.261[c]	0.439[a]	0.370[a]	0.372[a]	0.184	0.342[a]	0.302[b]	0.314[b]
	(0.145)	(0.133)	(0.132)	(0.132)	(0.133)	(0.125)	(0.127)	(0.126)
HSINCOME	5.0E-05[a]		1.1E-06		3.5E-05[a]		2.4E-06	
	(6.8E-06)		(1.8E-06)		(5.7E-06)		(1.8E-06)	
LABOR		0.047		0.193[a]		0.035		0.169[a]
		(0.049)		(0.051)		(0.047)		(0.048)
Log *L*	-221.36	-264.91	-266.66	-262.07	-265.95	-296.76	-290.74	-289.40
Pseudo R^2	0.319	0.186	0.159	0.173	0.188	0.094	0.108	0.113
% Correct prediction	77.80	71.46	71.04	73.15	72.52	66.60	67.65	66.81

Values in parentheses are standard errors. [a] Significant at $p<1\%$, [b] significant at $p< 5\%$, [c] significant at $p< 10\%$.

The coefficient of LABOR is positive as expected and significant at 1% for models IIB, IVB, VIB and VIIIB of WTCL models. This indicates that the larger the number of family members in the productive age group, the higher the probability of accepting the bid. Soil and water conservation works have been common practices in Tigray for which rural households make free labor contributions every year. Therefore, we expected that households with more family labor would be willing to contribute more labor for BPF conservation. However, in the case of WTP models IB, IIIB, VB and VIIB, the variable LABOR has the expected positive sign but insignificant. The remaining variables in the full regression models were dropped because they are correlated with one or more of the other variables. For example the variable AGE has significant correlation with eight of the other variables in the full models. The variable EDU has significant correlation with RESID ($r =0.1972$) and with RADIO ($r= 0.1922$). In effect we also dropped the interaction term variables. The dummies for village fixed effect were also significantly correlated with each other and with the variables SHARHOLD and RESID. The variables DEPEND and LAND were significantly correlated with the variable LABOR.

Results suggest that the SBDC models IA, IB, IIA, IIB and IIIA have high predictive power and statistical reliability. The percentage of correct prediction in each model is reasonably high. The values of Pseudo R^2 for model IA is reasonably higher than the 0.2 level suggested by Louviere et al., (2000) indicating a very good fit. The likelihood ratio test result ($\chi2$ = 89.18; p= 3.61E-21 for model IIIA Vs IA; $\chi2$ = 48.15; p = 3.95E-12 for model IIIB Vs IB) for the WTP models showed that the restriction that the follow-up response (model III) is independent of the initial response (model I) was not valid and hence is rejected. Similar result was found for the WTCL models ($\chi2$ = 63.70; p= 1.82E-15 for model IIIB Vs IB; $\chi2$ = 54.66; p = 1.43E-13 for model IVB Vs IIB). The statistical significance of the correlation coefficients for models V and VI also signify these outcomes. The hypothesis $H_0^{\varepsilon}:\rho=1$ cannot be rejected both in the case of WTP models ($\chi2$ = -142.72; p = 1 for models VIIA Vs VA; $\chi2$ = -157.32; p = 1 for models VIIB Vs VB) and WTCL models ($\chi2$ = -240.30; p = 1 for models VIIIA Vs VIA; $\chi2$= -243.29; p = 1 for models VIIIB Vs VIB) suggesting the DB models would lead to more efficient estimates of WTP and WTCL than the bivariate models.

Table 5: Parameter estimates of bivariate and interval data probit WTP and WTCL models

Variable	Bivariate probit Models				Interval data probit Models			
	WTP		WTCL		WTP		WTCL	
	VA	VB	VIA	VIB	VIIA	VIIB	VIIIA	VIIIB
Constant	0.424	1.411[a]	0.693[a]	0.723[a]	4.978[c]	13.141[a]	9.815a	8.579[a]
	(0.300)	(0.227)	(0.264)	(0.218)	(2.818)	(3.872)	(3.530)	(2.938)
BID	-0.021[a]	-0.018[a]	-0.165[a]	-0.166[a]	-0.213[a]	-0.258[a]	-2.189[a]	-2.176[a]
	(0.002)	(0.002)	(0.019)	(0.019)	(0.063)	(0.075)	(0.644)	(0.634)
GENDER	0.463[b]		0.496[b]		1.479		2.971	
	(0.223)		(0.208)		(1.973)		(2.270)	
RESID	-0.375[b]	-0.684[a]	0.219	0.139	-2.739[c]	-6.086[b]	1.793	1.149[c]
	(0.153)	(0.141)	(0.140)	(0.139)	(1.501)	(2.084)	(1.440)	(1.370)
SHARHOLD	0.408[b]	0.585[a]	-0.010	-0.013	2.753[c]	5.406[a]	0.029	-0.007
	(0.170)	(0.156)	(0.152)	(0.153)	(1.599)	(2.054)	(1.481)	(1.465)
RADIO	0.245[c]	0.441[a]	0.397[a]	0.387[a]	0.694	2.627[c]	3.272[b]	3.179
	(0.143)	(0.132)	(0.132)	(0.132)	(1.245)	(1.481)	(1.529)	(1.498)
HSINCOME	4.7E-05[a]		8.0E-07		3.9E-04[a]		1.3E-05	
	(6.3E-06)		(1.7E-06)		(1.1E-04)		(1.6E-05)	
LABOR		0.040		0.187[a]		0.267		1.724[a]
		(0.049)		(0.050)		(0.496)		(0.654)
ρ	0.941[a]	0.950[a]	0.917a	0.912a	-	-	-	-
	(0.019)	(0.015)	(0.022)	(0.137)				
Log *L*	-365.96	-409.99	-438.93	-435.43	-294.60	-331.33	-318.78	-313.75

Values in parentheses are standard errors. [a] Significant at $p<1\%$, [b] significant at $p< 5\%$, [c] significant at $p< 10\%$.

3.4. Estimation of WTP and WTCL

We did a likelihood ratio test and compared models of category A with B. In the case of WTP models, the test result rejects the models of category B in favor A. In the case of WTCL, the test statistics reject models of category A in favor of B except for model IV. Therefore, for estimating mean and median WTP we used Models IA, VA and VIIA whereas the estimations for WTCL were based on models IIB, VIB, and VIIIB. Based on the parameter estimates of these models, the following equation is used to estimate WTP and WTCL. Therefore, the WTP of each individual respondent can be calculated as:

$$WTP_i = \sum_{j=0}^{m} [(\beta_j/\sigma)/(-1/\sigma)] X_{ij} \qquad (5)$$

where the coefficient of the bid term is the ML estimate of $-1/\sigma$ and the coefficients of the j variables in the models (Table 4 and 5) represent ML estimates of β_j/σ where j =0 represent the constant term and j=1, 2,..m represent X_{ij} variables other than the bid term.

The average WTP using the SB model I is higher by 37.07% than the result for the DB Model VII and their 95% confidence intervals (CI) do not overlap implying significant difference (Table 6). The standard error of the mean is smaller for the DB than the SB model indicating the estimate of the DB model is more efficient and the result is consistent with the findings of Hanemann et al. (1991). For both WTP and WTCL, the difference of mean values of the SB and the bivariate probit models is insignificant as indicated by the overlap of their 95% CIs.

Table 6: Mean and median WTP and WTCL houseold^{-1} year $^{-1}$ for BPF conservation

Model	**WTP in Birr [US$] (S.E)**			**WTCL in Days (S.E)**		
	Mean	**95% CI**	**Median**	**Mean**	**95% CI**	**Median**
SB	85.85[6.42] (4.35)	77.31 to 94.39 [5.78 to 7.06]	66.92[5.00]	8.84 (0.09)	8.67 to 9.02	8.65
Bivariate probit	83.53[6.24] (4.12)	75.43 to 91.63 [5.64 to 6.85]	64.95[4.86]	8.92 (0.09)	8.74 to 9.10	8.67
DB	62.63[4.68] (3.32)	56.09 to 69.16 [4.19 to 5.17]	46.47[3.47]	7.03 (0.06)	7.15 to 7.15	6.85

3.5.Aggregate preservation value

To compute a conservative estimate of the preservation value for the site, we make the following assumptions: a) observations with protest and uncertain responses have a zero WTP; b) we used the estimate from the SB model as the upper bound estimate and the estimate from the DB model as the lower bound estimate; c) mean and median WTP estimates were used to compare the total welfare with distributional implications (Becker and Freeman 2009). Based on these assumptions and following Jin et al., (2008) we recalculated estimates of WTP to be used for the aggregation. The recalculated estimates of mean WTP are Birr 58.37 (US$ 4.36) for the SB model IA and Birr 42.67(US$ 3.19) for the DB model VIA houseold^{-1} year $^{-1}$. The corresponding median values are Birr 40.72 (US$ 3.04) for model IA and Birr 30.25 (US$ 2.26) for model IVA. According to data from the Ethiopian population census of 2007, there are 6830 households in the five rural communities of our site. Accordingly, the aggregate preservation value of the resource to rural households was Birr 398.69 thousand (US$ 29.89 thousand) as upper bound and Birr 291.43 thousand (US$ 21.78 thousand) as lower bound estimates. The median value gives very conservative estimates (Birr 278.15 thousand (US$ 20.79 as upper bound and Birr 206.60 thousand (US$ 15.44 thousand) as lower bound estimate.

4. Conclusions and policy implications

The aim of this research was to assess the factors determining rural households' WTP and WTCL for conservation of BPF and estimate their WTP and WTCL. For this, a contingent market situation was designed in which the benefits include option, existence and bequest values of the resource. Our study indicated that in addition to the conventional measure of value, i.e. money, labor time contributions to natural resource conservation programs can be used as a pragmatic measure of value in CV studies in developing countries context. All the probit regression analyses revealed that the probability of a 'Yes' response to the WTP and WTCL biddings vary with a number of covariates in a reasonable and expected manner, thereby offering some support for the construct validity of our CV applications. We found that the variables HSINCOME is the most important factor affecting WTP whereas LABOR is the most important factor affecting WTCL responses. The upper and lower bound mean WTP were Birr 85.85(US$ 6.42) and Birr 62.63(US$ 4.68) houseold^{-1} year $^{-1}$. These estimates are smaller than the monetary value of the estimated WTCL converted at the market wage rate. The WTCL were 8.84 and 7.03 days houseold^{-1} year $^{-1}$, which are equivalent to Birr 333.10(US$ 24.90) and Birr 263.63(US$ 19.71) at the market wage rate for daily labor in the study area. This indicates the considerable importance of conservation of BPF to the rural households in the study area. In designing programs and policies for mobilizing resources for BPF conservation, it could be very important for decision makers to take into account the choice of rural communities to make either cash or labor contributions.

The relatively high predictive power and statistical reliability of the SB models IA, IB, IIA, IIB, and IIIA and the consistent findings of the statistical tests (for independence of initial and follow-up responses as well as on the correlation of error terms of the bivariate probit models) with literature on DBDC CV studies suggests that a carefully designed CV study is possible in developing countries to measure the non-market benefits of forests using labor and cash contributions. This study is the first of its kind in Ethiopia and possibly in Africa where this specific resource is reported to be found. From the point of conservation and sustainable management of BPF, the study indicated that despite Ethiopia is a low income country, people are interested to contribute for the conservation of the resource. Though our sample doesn't allow for extrapolation of results to regional, country, or world level, taking the fact that BPF has been the source of frankincense that has cultural, medicinal and other economic values to the country and importing countries, this study identifies a research gap.

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