Land Use Policy 105 (2021) 105382

Contents lists available at ScienceDirect

Land Use Policy

journal homepage: www.elsevier.com/locate/landusepol

Willingness to accept compensation for afromontane forest ecosystems conservation

Tewodros Tadesse [a,*], Tsegay Berhane [b], Dawit W. Mulatu [c,d], Meley Mekonen Rannestad [e]

[a] Department of Agricultural and Resource Economics, Mekelle University, Endayesus campus, P.O. Box 231, Mekelle, Ethiopia
[b] Tigray Bureau of Water Resources, P.O. Box 520, Mekelle, Ethiopia
[c] Environment and Climate Research Center (ECRC), Policy Studies Institute (PSI), P.O. Box 2479, Addis Ababa, Ethiopia
[d] Environment, Natural Resources and the Blue Economy Global Practice, World Bank: Africa Region, Addis Ababa, Ethiopia
[e] Department of Ecology and Natural Resource Management, Norwegian University of Life Sciences (NMBU), Ås, Norway

ARTICLE INFO

Keywords:
Forest conservation
Willingness to accept
Desa'a forest
Choice experiment
Mixed logit

ABSTRACT

This study explored local communities' willingness to accept compensation for the conservation of Desa'a state forest, which is located in northern Ethiopia. For this purpose, a sample of two hundred forty rural households living around the forest was randomly selected. A choice experiment approach encompassing three forest-related choice attributes namely, biodiversity, soil and water conservation and agro-forestry, was used to elicit willingness to accept compensation for conservation of the forest. Mixed logit model that helps account for differences in household preferences was then used to estimate marginal willingness to accept compensation for forest conservation. Results show that households would be willing to accept an average compensation of 7.7 USD to work for 5–10 additional days of public work on soil and water conservation as part of contributing to Desa'a forest conservation. On the other hand, households' preferences to work on biodiversity conservation and agroforestry expansion were found to be negligible as the respective marginal willingness to accept estimates show. Given costs that the government of Ethiopia incurs for environmental rehabilitation programs through soil and water conservation, strengthening such investments in and around forestlands could prove useful in creating incentives for households to sustainably conserve and use forests.

1. Introduction

Dry land afromontane forests such as the Desa'a state forest located in northern Ethiopia constitute among the natural resources that the rural poor depend on for their livelihoods. Degradation of the forest and the resources within the forest could mean loss of livelihood for many rural households. In fact, Gebreegziabher (1999) and Giday (2013) documented the presence of severe deforestation and forest deterioration in Desa'a. This forest degradation and deterioration has continued unabated though Desa'a forest is designated as a National Forest Priority Area (NFPA). Ethiopian government attempts to protect the forest have not largely materialized due to limited role of local communities in forest management plans, lack of appropriate incentive mechanisms for farmers and lower-level management bodies, weak enforcement and follow up and poor management intervention by responsible government bodies (Aynekulu, 2011; Amare et al., 2016).

Property right of the Desa'a forest is clearly defined; and it belongs to the state. This would imply that without the state's (apparatus) permission, no one is allowed to infringe into the forest. Especially, cutting down trees and hunting is prohibited. However, the state's weak enforcement and poor management interventions resulted in an almost open access to the forest where cutting, pollarding, grazing and seasonal settlement are common (Giday, 2013). Continual deforestation for expanding agricultural and pasture lands and settlement has led to significant reduction in forest resources and indirect benefits to local communities (Mebrat and Gashaw, 2013). Such over-exploitation of the forest and its resources takes place despite the state putting regulatory mechanisms in place (such as mobilization of paid and armed patrol guards, checkpoints at different exit points, penalties, etc.), which may not be as effectively enforced as they need to be to prevent desperate members of local communities from breaking the rules. With permission from the state, the rural communities inhabiting adjacent to the forest use charcoal and fuel wood trading, lumber for construction, timber and non-timber forest products for their livelihood, all of which come from

* Corresponding author.
E-mail address: tewodros.tadesse@mu.edu.et (T. Tadesse).

https://doi.org/10.1016/j.landusepol.2021.105382
Received 10 September 2019; Received in revised form 23 September 2020; Accepted 24 February 2021
Available online 30 March 2021

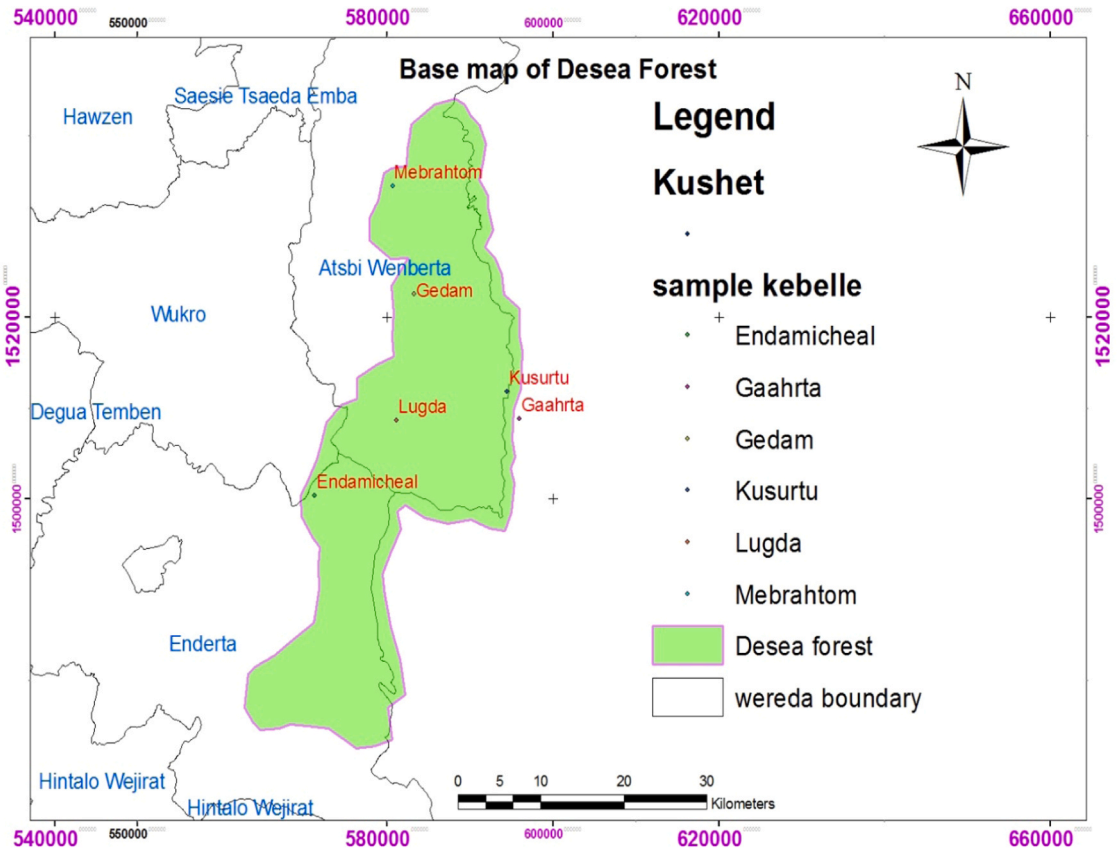

Figure 1: Location map of Desa'a forest and study villages

Fig. 1. Location map of Desa'a forest and study villages.

the forest. Despite the importance of these forest resources for the range of economic, environmental, social and cultural benefits they provide, there is a continuous and inefficient utilization of forest resources of Desa'a, resulting in deforestation, soil erosion (i.e., land degradation) and changes in the micro-climate of the area (Fig. 1).

What is more pronounced for the unsustainable use and management of Desa'a forest resources is the failure of the policy-making institutions to integrate and maintain various interests, especially the benefits of local communities from the forestland. When Desa'a forest was designated as National Forest Priority Area (NFPA), the economic value or livelihood importance of the forest to the local communities was not duly considered (Gebreegziabher, 1999). Yet, creating sense of ownership and active participation of local communities have been documented as key instruments for sustainable use and management of forests (Mannigel, 2008; Reed, 2008; Chirenje et al., 2013; Martini et al., 2017). For sustainable use and management of forest ecosystems however, policy makers need viable information not only on the economic value and livelihood importance of forests but also on their contribution to ecosystem sustainability. This is especially true for forest lands up on which surrounding local communities heavily depend for livelihood.

Previous studies (such as Brey et al., 2007; Christie et al., 2007; Wang et al., 2007; Lindhjem and Mitani, 2012; Cacho et al., 2014; Ninan and Kontoleon, 2016) provide useful insight into how forest conservation may be promoted under varying preferences of individuals or households. The situation around Desa'a forest is however different in that a large number of local communities depend on the forest for their livelihoods. Melesa (2017) for example estimated between 29% and 36% of the households around Desa'a forest obtain farm tools and construction materials from the forest. Moreover, between 28% and 54% of the households around Desa'a forest collect wild fruits (for human consumption) and livestock fodder, directly from the forest (Melesa, 2017). Still, 62% of the households collect fire wood from the forest for sale in urban areas, which is one main income source for rural communities around Desa'a forest. Unlike contexts from previous studies where people did not significantly depend on forestlands, Desa'a forestland makes significant livelihood contribution to local communities (Gebreegziabher, 1999; Melesa, 2017). In this regard, farmers would be motivated to engage in different activities to ensure forest sustainability and hence the sustainable supply of provisioning services that define livelihoods of local communities. Desa'a state forest, being a designated state forest, represents a public good. Forest policy makers need to consider such market imperfections emanating from lack of clearly defined property rights and offer incentives to farmers to ensure sustainable use of forest resources. Given the high stakes local communities have in the forest, this study, based on literature review, discussion with experts and focus groups considered demand-driven attributes that reflect the direct (livelihood) dependence that local communities have on the forest and tried to entwine this to the extent to which farmers would be willing to accept compensation for the sustainable management of the forest. Given the ecosystem and socio-economic importance of the Desa'a forestland, households would want to conserve the forest and its resources despite the expected variation in preferences. In this regard, studying differences in preferences among rural households for forest conservation and what this would mean to the forest's conservation can provide useful policy implications for the sustainable use and management of the forest (both for promoting socio-economic wellbeing and ecosystem sustainability). To this end, this paper attempted to estimate the willingness of local communities to accept compensation for

sustainable conservation of Desa'a forest. In doing so, a sample of rural households that depend on the forest for their livelihood was selected where choice experiment was used to elicit mean willingness to accept compensation for sustainable forest conservation.

The rest of this paper is organized as follows. Section 2 describes the design of the choice experiment and the experimental process. In Section 3, a description of the theoretical framework and the analytical method used for estimating marginal willingness to accept is presented. In Section 4, description of the study area is presented. In addition, the data used for analysis are described in this section. Section 5 reports results and provides relevant discussion. In Section 6, concluding remarks are presented.

2. The choice experiment design

In environmental valuation studies, the choice respondents face can be framed either in willingness to accept (WTA) or willingness to pay (WTP) formats (Rolfe et al., 2006). In the literature related to such choices, there are challenges to the standard theory of willingness to pay or willingness to accept framework, non-compensatory preferences and preferences construction (Vatn, 2004). As well, values people place on environmental goods and services, through stated preferences techniques are susceptible to a range of inconsistencies and biases, although these methods still have a legitimate role (MacMillan et al., 2006; Fisher et al., 2009). In environmental valuation studies, the choices respondents face can be framed either in willingness to accept or willingness to pay formats (Rolfe et al., 2006). The National Oceanic and Atmospheric Administration (NOAA) panel recommended the use of the willingness to pay format over the willingness to accept. However, since that recommendation there has been emerging evidence that choice experiment is able to elicit willingness to accept values successfully. Moreover, there are concerns that the focus on willingness to pay formats will underestimate values for willingness to accept situations (Adamowicz et al., 1998a; Hanley et al., 2001; Mulatu et al., 2014). To ensure the valuation exercise is conceivable and not exceedingly complex, issues related to complexity and incentive compatibility in choice experiment and stated preference survey designs should balance the information required to enhance decision making and preference elicitation (Johnston et al., 2017). Indeed, well-known empirical and practical challenges linked to willingness to accept estimation lead most studies to estimate willingness to pay. We do acknowledge the limitations of willingness to accept estimation that may result in biased estimates due to difficulty in framing incentive-compatible questions and higher rates of scenario rejection. Therefore, information provision, incentive compatibility, suitable valuation design, presence of differences in preferences as well as the recommended considerations for environmental valuation studies in NOAA (Arrow et al., 1993) are considered in our survey and choice experiment design.

Given the multi-faceted role that forests play and varying nature of forest ecosystem attributes, this paper used choice experiment to elicit willingness to accept compensation for forest conservation. The first and most important aspect of the experimental process was the selection of attributes. Both demand and supply-side issues were considered when selecting attributes. In doing so, extensive review of the literature in forest use and dependence, forest ecosystem services and forest conservation-related WTA (and/or WTP) was made (such as Colombo et al., 2005; Birol et al., 2006; Horne, 2006; Babulo, 2007; Brey et al., 2007; Wang et al., 2007; Gadaud and Rambonilaza, 2010; Giday, 2013; Haltia, 2015; Ninan and Kontoleon, 2016). From this review, a number of core parameters (indicators) for forest dependence and forest ecosystems conservation were identified. Following this, focus group discussion with forest experts and scholars was organized to discuss and identify indicators and further refine the list. However, what forest experts or scholars think of forest dependence or forest ecosystems conservation may not match well with what local farmers think of these important forest issues. In order to align the identified general attributes with farmers' needs and priorities, one focus group involving only farmers and another focus group involving farmers' administration and associations were formed where participants (including women) discussed the general attributes in some detail. Using the feedback that highlighted farmers' own priorities and current protracted forest management activities, the final set of attributes were selected.

Table 1
Description of attributes and levels.

Attributes	Description of attributes	Description of levels
Bio-diversity conservation	The numbers of common and endemic fauna and flora species in the forest reserve	Option 1: Planting 4 (four) afromontane plant species Option 2: Allow residence of 8 endangered animal species Status quo: No change, neither planting of any afromontane plant species nor allowing residence of any endangered animal species
Soil and water conservation	Construction of physical soil and water conservation (SWC) structures to for forest rehabilitation and conservation	Option 1: Participate in the construction of soil and water conservation structures for 25 days annually Option 2: Participate in the construction of soil and water conservation structures for 30 days annually Status quo: Participate in the construction of soil and water conservation structures for 20 days annually
Agro-forestry expansion	Agro-forestry seedling planting for conservation and generating additional income	Option 1: Planting of 3 agro-forestry tree seedlings Option 2: Planting of 6 agro-forestry tree seedlings Status quo: No planting of agro-forestry tree species
Compensation in Ethiopian Birr per year	Payment for farm households willing to accept compensation to improve the conservation of the forest reserve	Option 1: Receive Birr 750 Option 2: Receive Birr 1500 Status quo: Zero compensation

Note: At the time of data collection for this study in 2017, 1 USD was equivalent to 22.87 Ethiopian Birr.
Farm labor on average costs Birr 150 per day around the study area. The compensation values are computed accordingly: Birr 750 (5 days of labor work times 150 birr per day) and Birr 1500 (10 days of labor work multiplied by 150 Birr per day).

Three attributes– biodiversity conservation, soil and water conservation, agro-forestry expansion– along with the compensation attribute were finally identified and used to design the choice experiment. The attributes and their levels were designed based on the results of the literature review and discussion with experts in alignment with what is plausible and realistic about local farmers' needs and conditions (not least the analytical capability of the farmers, many of whom did not have formal education), both under the status quo, and with varying actions to foster forest conservation (Table 1).

The full factorial design (computed through $2^4 \times (2^4 - 1)/2$) resulted in 120 combinations of choices. However, it was realistically difficult for local farmers to properly comprehend and manage this large set of choices. Following Louviere et al.,2008 therefore, experimental design techniques that yield orthogonal fraction (that lead to fractional factorial design) were used to have optimal number of choice sets. During this process, maximum statistical efficiency by extracting maximum information (hence, minimizing multicollinearity) was obtained via D-efficient designs. Following the fractional factorial design, 16 choices were identified. To allow realistic tradeoffs among the choices, these choice

Table 2
A sample of choice set.

Attributes	Visual indicator of attribute	Option 1	Option 2	Option 3 (SQ)
Bio-diversity conservation		Protecting diversity of 4 animal species	Planting 8 afromontane tree seedlings	No change
Soil and water conservation		25 days	30 days	20 days
Agro-forestry expansion		Planting 3 agro-forestry tree seedlings	Planting 6 agro-forestry tree seedlings	No agro-forestry
Compensation in Ethiopian Birr		750	1500	0
I prefer (tick)		Option 1 ☐	Option 2 ☐	Status quo ☐

sets were further divided into 4 blocks, in which each block contained four orthogonal choice sets (refer to Appendix 1A to see a sample of choice sets distribution across blocks). In the end, these blocks and choice sets were randomly assigned to the 240 sample farm households, each block containing 60 households, the commonly applied block assignment for obtaining sufficient degrees of freedom (Louviere et al., 2008; Kjaer, 2005). Farmers were free to choose any of the three options. As part of this, farmers were informed that choosing the status quo (SQ) option would involve no compensation. They were also informed that the SQ Option would mean the usual mismanagement of the forest that would most probably lead to forest degradation and resources depletion (including soil and water, flora and fauna biodiversity), which the households, to a large extent, depend on for their livelihoods. A sample choice set is presented in Table 2.

3. Theoretical framework and estimation strategy

Choice experiment's econometric basis is the Random Utility Model (RUM); and its theoretical grounding comes from in Lancaster's model of consumer choice (Lancaster, 1966). This theory rests on the assumption that households' preference for alternative services or goods hinges on the expected utility derived from the characteristics of the service or good (Rolfe et al.,2000). In this general framework, households' preferences for different alternatives would probabilistically vary based on respective random utilities (Hanley et al., 1998; Birol et al., 2006). In this set up, the generic individual utility function (U) for household i and alternative j is presented as

$$U_{ij} = V(F_j, S_i) + \varepsilon(F_j, S_i) \quad (1)$$

where$V(F_j, S_i)$ denotes the observable component of the utility function represented by the attributes of Desa'a forest–F_j, and the socioeconomic characteristics of the household–S_i;and the unobservable random component–ε, which is also a function of the same components.

In the framework of random utility, choices made among alternatives would be a function of the probability that utility associated with a particular alternative is higher than that of other alternatives. In this case, if household i chooses alternative j over some alternative n, it would mean that $U_{ij} > U_{in}$ for all $n \neq j$, which will lead to the expression given by:

$$P_{ij} = P(V_{ij} + \varepsilon_{ij} > V_{in} + \varepsilon_{in}) \forall n \in C \quad (2)$$

where n denotes alternative forest services or goods, which would be chosen from the choice set C, and Pis the probability of the outcome. Given this preference based on expected random utility, an estimator that properly models the data generating process of choices from alternatives characterized by varying attributes is needed. In this case, Adamowicz et al. (1998b) and Hoyos (2010) emphasize that the choice of a relevant model in choice experiment is determined by the distribution of the random component of the utility function indicated in Eq. (1), which may vary due to omitted variables or measurement error, etc. Before explicitly describing the competing models, let us simplify a part of Eq. (2) to:

$$U_{ij} = V_{ij} + \varepsilon_{ij} = \theta + \boldsymbol{\alpha}_a' \mathbf{w}_{aj} + \boldsymbol{\beta}_k' \mathbf{X}_{ijk} + \varepsilon_{ij} \quad (3)$$

where **w**represents the vector of a attributes (with corresponding vector of $\boldsymbol{\alpha}$ coefficients, which are assumed to be normally distributed, see Train, 2003), **X** is the vector of k covariates (corresponding to vector of $\boldsymbol{\beta}$coefficients) and θ is Alternative Specific Constant (ASC) which captures the effects on utility of any attribute of forest conservation not included in choice specific attributes (see for example Hanley et al.,

Table 3
Distribution of sample farm households across study villages.

Region	District	Name of village	Population	Total number of households			Number of sample households		
				Male-headed	Female-headed	Total	Male-headed	Female-headed	Total sample
Tigray	Atsbi	Gedam	987	257	133	390	26	13	39
		Luguda	2283	331	211	542	31	24	55
		Mebrahtom	2717	263	209	472	26	22	48
	Enderta	Endamichael	1144	261	119	380	27	11	38
Afar	Berahle	Kusurtu	1286	256	64	320	24	8	32
		Gaharta	1152	223	57	280	21	7	28
Total			9569	1591	793	2384	155	85	240

1998). Train (2003) adds that the use of ASCs[1] is supported as they help minimize the problem of multicollinearity.

Eq. (3) can be estimated using either conditional logit or mixed logit models, depending up on the distribution of the random component. The conditional logit is the starting place for mixed logit model itself, and let us present the probability that household i chooses alternative j from each choice set based on the condition logit model given by:

$$P_{ij} = \frac{\exp\{V(F_j(\boldsymbol{\alpha}'\mathbf{w}), S_i)\}}{\sum_{n\in C}\exp\{V(F_n(\boldsymbol{\alpha}'\mathbf{w}), S_i)\}} \quad (4)$$

Eq. (3) can be estimated using the conditional logit model given in Eq. (4). However, doing so may lead to biased estimates unless some distributional requirements are met. The conditional logit model is restrictive because it provides unbiased estimates only when the assumption of independence of irrelevant alternatives (IIA) for the random component holds true. In many cases however, the IIA assumption is not realistic. Mixed logit model on the other hand accounts for the IIA assumption and accounts for preference heterogeneity (Hanley et al., 2001; Hoyos, 2010). In the framework of the mixed logit model, the probability that household i chooses alternative j from each choice set takes the following form:

$$P_{ij} = \frac{\exp\{V(F_j(\boldsymbol{\alpha} + \gamma_i), S_i)\}}{\sum_{n\in C}\exp\{V(F_n(\boldsymbol{\alpha} + \gamma_i), S_i)\}} \quad (5)$$

Hensher and Greene (2003) emphasize that commonly observed heterogeneous preferences means that accounting for this heterogeneity helps capture correlation of the random component in Eq. (1) among alternatives and across the set of choices through γ. This estimation process helps obtain unbiased marginal estimates of individual preferences and enhances accuracy and reliability of estimates.

As it is often case in choice experiments, one of the attributes is a monetary measure of the willingness to accept (or, pay). This enables us to compute the implicit price that helps monetize non-monetary forest attributes (Bennett and Adamowicz, 2001). Assuming the indirect utility function is linearly specified, the marginal willingness to accept (MWTA) compensation for a particular choice set is computed as follows:

$$\text{MWTA} = -\frac{\alpha_F}{\alpha_p} \quad (6)$$

where MWTA is the marginal willingness to accept compensation for a change in any of the attributes to improve forest conservation, α_F is the coefficient of the forest conservation attributes (for each attribute) and α_p is the coefficient of the monetary compensation attribute.

[1] In the mixed logit models, ASCs for option 1 (Option 1_ASC) and option 2 (Option 2_ASC) are included as dummy variables while leaving out (as a reference category) the ASC for the status quo option.

Table 4
summary statistics of socio-economic variables.

Variables	Full sample (N = 240)		Tigray (N = 180)		Afar (N = 60)	
	Mean	SD	Mean	SD	Mean	SD
Age of household head (years)	45.9	14.6	48.4	14.9	38.6	10.7
Gender of household head (male = 1)	0.65	0.48	0.61	0.49	0.75	0.43
Education of household head (years of schooling)	0.44	1.69	0.56	1.9	0.08	0.64
Family size of household (number)	4.5	2.1	4.58	2.2	4.45	1.79
Marital status of household head (married = 1)	0.64	0.48	0.62	0.49	0.72	0.45
Land size (hectares)	0.33	0.29	0.43	0.26	0	0
Livestock ownership (TLU)	2.4	2.5	2.99	2.65	0.69	0.81
Access to natural resource management extension service (1 = yes)	0.55	0.5	0.733	0.44	0.02	0.13
Crop income (Birr)	3468	5468	4623	5876	0	0
Livestock income (Birr)	1155	2770	1215	3103	975	1328
Off-farm income (Birr)	817	2625	443	4155	0	0
Remittance income (Birr)	332	3603	353	1805	2210	3902
Transfer and aid income (Birr)	2953	1741	2655	1732	3846	1437
Forest-related income (Birr)	4725	2188	5066	2239	3700	1644

4. Desa'a forest, study villages and choice experiment data

Desa'a forest is one of the remaining patches of forestlands located mainly in Tigray Regional State, northern Ethiopia. The forest lies between $13^0 20'$ and $14^0 10'$ North latitudes and between $39^0 32'$ and $39^0 55'$ East longitudes having an area of 120,026 ha (Gebreegziabher, 1999). The forest land stretches for about 91 km long. The terrain is rugged and the land feature varies from 0% to 50% with an elevation ranging from 1500 to 3000 m.a.s.l (SFDPD, 1997). Though the largest area of Desa'a forest falls in Tigray Regional State, some part of it also falls in Afar Regional State. In Tigray, it extends across three districts namely, Saesie Tsaeda Emba, Atsbi Wonberta and Enderta. Administratively, the first two districts are found in the eastern zone of Tigray and the third district in the south-eastern zone of Tigray. The part of the protected state forest falling in Afar region extends across three districts namely, Shiket, Berahle and Dalol.

The area around Desa'a forest is characterized by plain to steep slopes with an elevation range between 1000 and 2760 m above sea level. About 45% of the area has a slope class greater than 30%. Based on the classification of forests ecosystems (IBC, 2005), the vegetation of Desa'a forest is broadly categorized as dry Afromontane forest, which is characterized by dry climate (annual precipitation less than 1000 mm) with *Juniperus procera* in the canopy and *Olea europaea* subsp. *cuspidata* as dominant tree species. The diversity of the forest is dominantly covered by shrubs/herbs and trees which cover about 70% and 30% of the area, respectively (Aynekulu, 2011). Desa'a forest is located in semi-arid agro-climatic zone and rainfall occurs in the months of July

Table 5
Hausman–McFadden test for IIA in conditional logit model.

Choice dropped	Chi-square statistic	Degree of freedom	P-value
Option 1	12.6	4	0.013**
Option 2	9.1	4	0.060*
Status quo	78.5	4	0.000***

Note: Values presented in parentheses are p- values.
Statistical significances are denoted by *** for 1%, ** for 5% and * for 10% significance levels.
Source: Own estimates (2017)

Table 6
Estimates of willingness to accept for forest conservation.

Variables	Full sample (Model 1) Coefficients (p-value)	Tigray (Model 2) Coefficients (p-value)	Afar (Model 3) Coefficients (p-value)
Mean estimates			
Option 1_ASC	-0.37 (0.028)**	-0.62 (0.013)**	-0.18 (0.433)
Option 2_ASC	-0.11 (0.865)	1.5 (0.151)	-1.63 (0.094)*
Soil & water conservation	0.67 (0.000)***	0.85 (0.000)***	0.24 (0.027)**
Biodiversity conservation	0.001 (0.980)	0.025 (0.727)	-0.004 (0.955)
Agro-forestry	0.015 (0.810)	0.01 (0.927)	0.005 (0.959)
Compensation	0.004 (0.000)***	0.005 (0.000)***	0.002 (0.000)***
Standard deviation of estimates			
Soil & water conservation	1.02 (0.000)***	1.21 (0.000)***	0.60 (0.000)***
Biodiversity conservation	0.0002 (0.998)	0.002 (0.981)	-0.017 (0.937)
Agro-forestry	-0.19 (0.052)*	-0.27 (0.008)***	0.19 (0.324)
Number of respondents	240	180	60
Number of observations	2880	2160	720
Log likelihood	-501.1	-324.9	-154.4

Note: Values presented in parentheses are p-values.
Statistical significances are denoted by *** for 1%, ** for 5% and * for 10% significance levels.
Source: Own estimates (2017)

and August, which ranges from 116.3 to 230 mm (Gebreegziabher, 1999) (Table 3).

The majority of the Tigray communities inhabiting the surroundings of Desa'a forest make a living mainly on rain-fed mixed crop-livestock farming (Table 4). Yet, many engage in salt trading as the area is a key corridor for salt production and marketing. Still, many farm households, especially, the poor are granted special rights to collect forest products to support their subsistence. Remittance and transfer aid are also other main income sources which support the livelihood of the people around Desa'a forest. On the other hand, the Afar communities are mainly pastoralists, who make a living on livestock husbandry (Table 4).

There are 14 Kebelles[2] (12 in Tigray region and 2 in Afar region) surrounding Desa'a forest, each of them consisting of 3–5 villages. To select representative sample from these Kebelles, this study used multistage sampling. In the first stage, Tigray and Afar regions were purposively selected as the Desa'a forest lies across these two regional states, affecting the livelihoods and biophysical characteristics of the local communities in these regions. In the second stage, four villages from Tigray and two villages from Afar were randomly selected. In the third stage, farm households were selected randomly from the six selected villages based on probability to proportional to size (PPS). Farmers' rosters were obtained from respective Kebelle administrations and these were used to select sample farm households using systematic random sampling method. Based on this process, a sample of two hundred forty farm households was selected.

Structured questionnaire was prepared which included choice cards for the choice experiment. The questionnaire was pretested on fifteen sample households before the main survey was conducted. The main survey for the choice experiment was conducted in January and February 2017. The questionnaires were completed by hired enumerators through face-to-face interview with farmers at their homesteads. Apart from the willingness to accept compensation for forest conservation, data related to forest services, use and management, socio-demographic, economic, farm-specific and community-specific characteristics were collected.

5. Results and discussion

When the assumption of Independence of Irrelevant Alternatives (IIA) holds, the conditional logit is the best unbiased estimator. In many applications however, the IIA assumption is restrictive. In light of this, we start from the presentation of the Hausman and McFadden (1984) test to explore whether the IIA assumption holds or not (Table 5). This was made for all the three models, the results of which are reported in Table 6. For the all these three models, the Hausman and McFadden (1984) test indicates that the hypothesis of no systematic variation in the coefficients of the conditional logit model is strongly rejected (at 5% for Option 1 and SQ) and rejected for Option 2 (at 10%). The rejection of the assumption implies that the ratio of choice probabilities of any two options depends on the inclusion or omission of other options in the choice set. It means that the IIA assumption is violated in the conditional logit models. Hence, mixed logit model that accounts for preference heterogeneity and is not affected by the IIA assumption is used for estimating marginal willingness to accept compensation for forest conservation (Table 7).

To avoid multicollinearity, as recommended by Train (2003), we included two alternative specific constants (Option1_ASC and Option 2_ASC) that are allowed to vary with the choice sets, since we wanted to test whether any factor other than the attributes themselves affected the choices (Morrison et al., 2002). As a result, the mixed logit models were estimated by considering ASCs, corresponding to the two options (Option 1 and Option 2). About 36% of the sample farm households selected the status quo option, indicating that they would not be committed to forest conservation activities or at least would need better incentives to do so. However, it was identified during the survey that about 99% of the farm households would opt for higher compensations to participate in forest conservation programs. Mixed logit estimation results for the full sample are reported in Table 6. Table 6 also reports results separately for Tigray and Afar, which will help see if there is regional heterogeneity in preferences for forest conservation.

Only the soil and water conservation attribute was estimated to be statistically significant. The other two attributes– agroforestry and biodiversity conservation– that carry positive coefficients which is consistent with utility theory were found to be statistically insignificant. The positive coefficient for soil and water conservation implies that, keeping other factors constant, households would be inclined to accept compensation in return for participating in soil and water conservation as part of Desa'a forest conservation. Rural households in the surroundings of Desa'a forest would enjoy additional utility from the compensation even if that means working for 5–10 additional days in soil and water conservation. Soil and water conservation is intensively practiced in Tigray as part of rehabilitating degrading lands, where the results confirm the strong commitment that rural households in the Tigray part of the Desa'a forest have in contributing to forest conservation through soil and water conservation engagements. Not less important however, households in Afar were also found to draw utility

[2] *Kebelle* is the lowest administrative unit in Ethiopia.

Table 7
Marginal willingness to accept for forest conservation.

Forest conservation attributes	Full sample		Tigray		Afar	
	Birr	USD equivalent	Birr	USD equivalent	Birr	USD equivalent
Soil and water conservation	175.7 (0.000)***	7.68	168.7 (0.000)***	7.37	97.2 (0.034)**	4.25
Biodiversity conservation	-0.33 (0.980)	-0.014	-4.97 (0.728)	-0.22	1.65 (0.955)	0.07
Agro-forestry	-3.97 (0.810)	-0.17	-1.65 (0.927)	-0.07	-1.92 (0.959)	0.08

Note: Values presented in parentheses are p-values.
At the time of data collection for this study, 1 USD was equivalent to 22.87 Ethiopian Birr.
Statistical significances are denoted by *** for 1% and ** for 5% significance levels.
Source: Own estimates (2017)

from the subsequent compensation for participation in soil and water conservation.

The compensation attribute, as expected, carries a positive and statistically significant coefficient. This indicates that the higher the compensation, the higher the probability of households to participate in soil and water conservation for the purpose of contributing to Desa'a forest conservation. This is the result of the higher compensation that is leading to increased utility from participating in soil and water conservation as part of the sustainable use and management of the Desa'a forest. The alternative specific constant associated with Option 1was found to be negative and statistically significant. The indication is that the alternative specific constant captured the average effects of external factors other than the forest conservation attributes. However, the negative sign of the alternative specific constant associated with Option 1 implied that any perceived improvement to Desa'a forest conservation, relative to the status quo, had a negative impact on utility. This in turn meant that any change in the management of the forest that drastically reduces utility would strengthen households' reluctance to accept payment that is not big enough to refuse (keeping other things constant). This might be because rural households around the Desa'a forest fear that their access to forest resources would be restricted, which would mean drastic reduction in overall utility from the forest.

The estimated standard deviations for the three attributes differ. Soil and water conservation has highly significant standard error at less than 1% in all the three models. The standard deviation for agro-forestry attribute is significant at less than 10% and less than 1% for model 1 and model 2, respectively. These indicate the data support for unconditional and unobserved heterogeneity in respondents' preference for attributes (Birol et al., 2006). All parameters except the compensation attribute were specified to be normally distributed (Carlsson et al., 2003). The coefficient of compensation is specified to be fixed because keeping at least one parameter fixed facilitates estimation. Note that a fixed compensation/reward coefficient does not imply that response to compensation is assumed to be the same for all respondents (Hensher et al., 2005). The estimated standard deviations are significant and sizeable except for biodiversity conservation attribute, indicating that the data support choice-specific unconditional unobserved heterogeneity for these attributes (Birol et al., 2006). This result also implies that there is heterogeneity in preferences for these attributes and the relative magnitude of the standard deviations implies that there is a probability that respondents might have the reverse preference for a particular attribute (Carlsson et al., 2003).

The marginal willingness to accept or 'the implicit price', which represents the marginal rate of substitution between forest conservation attributes and the monetary attribute (Bennett and Blamey, 2001), was estimated using Eq. (6) for the three models: full sample (model one), Tigray (model two) and Afar (model three) for all forest conservation attributes. The implicit prices are useful to demonstrate the trade-off between attributes. A comparison of the implicit prices of attributes affords some understanding of the relative importance that respondents hold for them. On the basis of such comparisons, policy makers are better placed to propose alternative interventions in forest conservation and to understand the effect of policy changes. These prices stand for the minimum amount of money that households are willing to accept as compensation corresponding to the specified forest conservation attributes.

The three models were considered to explore if there were any disparities between the regions (Tigray and Afar) in terms of willingness to accept. Only the attribute for soil and water conservation was estimated to have highly significant marginal willingness to accept compensation for the three models. The marginal willingness to accept compensation in all the three models carried a positive sign, as expected a priori. This indicates soil and water conservation improvement is highly supported and preferred attribute by farm households. On the other hand however, the "reservation prices" farmers would be willing to accept (as compensation) for agroforestry expansion and biodiversity conservation were found to be not high enough. The opportunity costs emanating from agroforestry expansion (potential reduction in income from crops, specifically by agro-silvicultural practices as reported by Birhane (2014))[3] and biodiversity conservation (potential reduction of income from livestock) may outweigh the expected utility (combined income) from these attributes.

The marginal willingness to accept (MWTA) compensations estimated for the full sample, Tigray and Afar are 175.7 Birr (USD 7.7), 168.7 Birr (USD 7.4) and 97.2 Birr (USD 4.3) per person per day, respectively. The marginal willingness to accept compensation for soil and water conservation is roughly closer to the market value of labor man-day (around the Desa'a forest) of Birr 150 (USD 6.6), which was used to estimate the levels for the payment attribute. In aggregate, as part of forest conservation activities, if every economically active labor were to work on soil and water conservation, it would cost roughly Birr 1.3 million $(= 0.686 \times 4.5 \times 2384 \times 175.5)$.[4] On the other hand, estimates show clear regional disparity in willingness to accept compensation for participation in soil and water conservation for Desa'a forest conservation. In Tigray, soil and water conservation is conducted regularly through intensive mobilization of the community. As part of this, rural farm labor investment in soil and water conservation is huge. Given this investment, the higher compensation is expected.

One point of interest is the effect that household-specific characteristics have on preferences. Useful insight can be obtained by incorporating socioeconomic variables in the mixed logit model and see how they influence preferences for forest conservation. One problem in this regard is that there is no point in including such variables in the model directly since they do not change over choice occasions. As a way around this problem, Birol et al. (2006) suggested the use of interaction terms of

[3] In parkland agroforestry practices (agro-silvicultural practices where farmers selectively plant trees on crop farmlands), large canopy trees may create large shades that prevent crop seedling from having sufficient access to sunlight for photosynthesis, which may affect growth and crop yield. Farmers understand this and they are often reluctant to introduce such trees in their crop farmlands.

[4] CSA (2007) estimated that the economically active labor force in Tigray is 68.6%. The rest of the values in this computation include: average family size (5.4), total household size (2384) in the study villages and estimated marginal willingness to accept compensation (175.5).

Table 8
Estimates of willingness to accept for forest conservation with interaction terms.

Variables	Full sample (Model 1) Coefficients (p-value)	Tigray (Model 2) Coefficients (p-value)	Afar (Model 3) Coefficients (p-value)
Mean estimates			
Option 1_ASC	-0.35 (0.036)**	-0.58 (0.022)**	-0.225 (0.354)
Option 2_ASC	-0.16 (0.081)*	1.42 (0.087)*	-1.701 (0.094)*
Soil & water conservation	0.60 (0.049)**	0.96 (0.052)*	0.19 (0.601)
Biodiversity conservation	0.26 (0.194)	0.04 (0.908)	0.57 (0.062)*
Agro-forestry	-0.08 (0.723)	0.07 (0.844)	-0.37 (0.292)
Compensation	0.004 (0.000) ***	0.005 (0.000) ***	0.003 (0.000) ***
Soil-water conservation: age	-0.031 (0.000) ***	-0.043 (0.000) ***	-0.011 (0.217)
Soil-water conservation: gender	0.085 (0.791)	0.177 (0.719)	-0.063 (0.899)
Soil-water conservation: education	0.021 (0.574)	0.008 (0.834)	1.12 (1.00)
Soil-water conservation: marital	0.215 (0.517)	0.164 (0.751)	0.220 (0.655)
Soil-water conservation: family size	0.097 (0.032)**	0.101 (0.132)	0.097 (0.100)
Soil-water conservation: land	0.929 (0.010)**	1.19 (0.018)**	
Soil-water conservation: resource extension	0.37 (0.026)**	0.481 (0.051)*	4.05 (1.00)
Soil-water conservation: TLU	-0.037 (0.307)	-0.045 (0.315)	0.044 (0.710)
Soil-water conservation: income	-0.00003 (0.028)**	-0.00002 (0.184)	-0.00005 (0.019)**
Biodiversity conservation: age	-0.0114 (0.014) **	-0.0106 (0.122)	-0.009 (0.197)
Biodiversity conservation: gender	0.029 (0.902)	-0.0405 (0.903)	0.064 (0.937)
Biodiversity conservation: education	0.0143 (0.642)	0.0125 (0.740)	1.42 (1.000)
Biodiversity conservation: marital	0.0708 (0.769)	0.2875 (0.384)	-0.203 (0.803)
Biodiversity conservation: family size	0.0319 (0.285)	0.032 (0.476)	0.017 (0.734)
Biodiversity conservation: land	0.4231 (0.087) *	0.338 (0.339)	
Biodiversity conservation: resource extension	0.0062 (0.955)	0.1054 (0.472)	-10.035 (1.000)
Biodiversity conservation: TLU	-0.0287 (0.236)	-0.034 (0.28)	-0.092 (0.369)
Biodiversity conservation: income	-4.62 (0.555)	1.33 (0.915)	-0.000015 (0.33)
Agro-forestry: age	-0.0008 (0.877)	0.0012 (0.883)	-0.0072 (0.414)
Agro-forestry: gender	-0.106 (0.688)	-0.046 (0.901)	-0.613 (0.587)
Agro-forestry: education	0.0106 (0.705)	0.0196 (0.571)	-1.919 (1.000)
Agro-forestry: marital	0.0398 (0.883)	-0.065 (0.862)	0.551 (0.624)
Agro-forestry: family size	0.0671 (0.054) *	0.0882 (0.109)	0.0898 (0.107)
Agro-forestry: land	-0.5706 (0.047) **	-0.4546 (0.298)	
Agro-forestry: resource extension	-0.1396 (0.263)	-0.139 (0.424)	-7.663 (1.000)
Agro-forestry: TLU	0.0262 (0.355)	0.0440 (0.245)	0.017 (0.872)
Agro-forestry: income	2.12 (0.835)	-0.00002 (0.282)	0.00003 (0.150)
Standard deviation estimates			
Soil & water conservation	0.782 (0.000) ***	0.932 (0.000) ***	0.467 (0.000) ***
Biodiversity conservation	-0.004 (0.995)	0.0035 (0.967)	0.092 (0.612)
Agro-forestry	0.088 (0.654)	-0.189 (0.231)	-0.135 (0.538)
Number of respondents	240	180	60
Number of observations	2880	2160	720
Log likelihood	-435.8	-132.7	-132.8

Note: Statistical significances are denoted by *** for 1%, ** for 5% and * for 10% significance levels.
Source: Own estimates (2017)

the household-specific control variables and forest conservation attributes to account for the sources of unobserved heterogeneity in the mixed logit model. Table 8 reports results related to this.

Households with lager family members and land were found to be more likely to be committed to soil and water conservation activities as part of Desa'a forest conservation. Soil and water conservation activities in Ethiopia are labor demanding. If the incentives for labor in soil and water conservation are higher (than other labor markets), rural households would be inclined to supply labor for work in soil and water conservation activities. Households with access to natural resource use extension service were more likely to invest additional days for soil and water conservation. But participation in soil and water conservation was found to decline with income, keeping other things constant. On the other hand, older heads were less likely to prefer biodiversity conservation while preference for biodiversity conservation was found to increase with land size. Agroforestry expansion on the other hand is positively correlated with family size. The unexpected result in this case is the negative effect of land on agroforestry expansion. More land was expected to allow for integrated crop and livestock agroforestry practices but it appears that the rural households prefer otherwise. Birhane (2014) noted that farm households who have flat farmlands were reluctant to grow large trees on their farm land as it forgoes space for annual crops. Moreover, farmlands of different farmers are situated very close to one another; and one farmer's decision to plant large canopy trees on his/her own farm land may bring disagreements as such agroforestry practices infringe on other farmers' plots (the canopy from large trees create shades on a given area, preventing effective crop growth).

6. Concluding remarks

This paper attempted to value how much forest-dependent rural communities would forgo direct and indirect forest benefits in return for monetary compensation to participate in forest conservation activities. For this purpose, three forest conservation attributes– soil and water conservation, plant and wildlife management (biodiversity conservation) and agroforestry expansion– together with compensation attribute were considered to elicit willingness to accept. Following a choice experiment and household survey, a mixed logit model that accounts for correlations among attributes and captures heterogeneity in preferences was used to estimate mean willingness to pay.

We find that rural communities are more supportive to engagements in soil and water conservation. The indication is that farmers have higher preferences for soil and water conservation activities, which they would be willing to work for as many as 10 additional days in return for compensation, thereby contributing to Desa'a forest conservation. The willingness to participate in soil and water conservation is partly due to the significant emphasis put on by policy makers in such conservation activities for rehabilitating not only degrading forest lands and wood lands and but also agricultural lands over several years. The policy of mobilizing farmers in soil and water conservation has multifaceted purposes. Among the goals is not only to rehabilitate degraded land around forests but also prevent further incursion into forests and woodlands. In this regard, soil and water conservation is implemented not only around the forest but also within the forestland where there are relatively dwindling forest patches, which helps rehabilitate both the flora and fauna population of the forest. Still, soil and water conservation in the wider watershed in which the Desa'a forest is located helps balance soil and water availability and allow the forest population's (both flora and fauna) access to water and regenerated habitat for wildlife. This is especially vital given the Desa'a forestland is located in the dryland escarpment of north-east Ethiopia where surrounding communities suffer from moisture stress. Given this, paying farmers for soil and water conservation within and around the forest (and in the wider watershed) will not only contribute to allowing woodland (on the edge of the forest) and forestland regeneration but consequently allow wildlife repopulation via the improved habitat of increased forest shelter

and availability water.

On the other hand, we find that farm households did not commit (at least in terms of statistical significance) to implement agroforestry practices, plantation activities and re-population of wild life as forest conservation activities. One explanation could be the higher opportunity costs that farm households place on (expect from) wild life repopulation and agroforestry expansion that may lead to reduction in livestock assets and crop production, respectively. In this regard, earlier studies documented the dampening effect that wildlife have on livestock, and also that of large canopy trees (through expanding agroforestry) on crop production. Another explanation however could also be that preferences of farm households for these forest conservation attributes (biodiversity conservation and agroforestry) are so heterogeneous that the compensations presented on average were not high enough to entice them to participate in these forest conservation activities. As a designated state forest, it is widely documented that Desa'a forest's biodiversity resources (both flora and fauna) did not get the attention and promotion they needed (Birhane et al., 2018). Not enough awareness has been created among farming communities to conserve biodiversity resources; and as a result farm households did not consider biodiversity resources could provide sufficient enough benefits (as compared to direct provisioning services from forests) and to receive compensation for their conservation. With sufficient emphasis and promotion to biodiversity development, Gebreegziabher (1999) and Birhane et al. (2018) for instance argued that tourism development around (in) the forest can bring farmers high stakes, which would encourage them to receive compensation for their conservation efforts. Given the potential for tourism development around Desa'a forest, if the government promotes the role of biodiversity conservation for tourism purposes and help farmers understand the stakes, the indication is there may be compensation rates that are high enough to entice farmers to work for their conservation (through receiving compensation for sustainable management of flora and fauna resources of the forest).

In conclusion, preference for agroforestry expansion, tree plantation and wild life re-population is lower compared to soil and water conservation. Strengthening the practice of soil and water conservation does not only allow trees to regenerate but also produce positive spillover by maintaining and creating the required landscape for wild life re-population in Desa'a forest. The case specific nature of this study may make it difficult to generalize the findings to other areas of the country; however, the estimated willingness to accept appears to be within the government's ability to pay amidst high stakes from dwindling forest lands in Desa'a and other forests across Ethiopia. Indeed, future studies of these aspects should consider conducting detailed cost-benefit analysis to know the full range of costs and benefits in forest conservation interventions. As a final note, Desa'a forest is a communal forest resource; thus, forest policy makers need to consider clearly defined property rights and offer incentives to farmers to ensure sustainable use of forest resources. Local communities have higher preferences for forest conservation efforts that contribute to their economic and resource needs (such as soil and water conservation). Therefore, streamlining their interests and needs into forest management policies can help ensure improved management of forest resources while meeting the needs of local communities.

CRediT authorship contribution statement

Tewodros Tadesse: Conceptualization, Methodology, Formal analysis, Writing - review & editing, Software; **Tsegay Berhane**: Conceptualization, Data curation, Formal analysis, Writing - original draft, Writing - review & editing; **Dawit W. Mulatu**: Methodology, Writing - review & editing, Software; **Meley Mekonen Rannestad**: Conceptualization, Methodology, Writing - review & editing.

Declarations of interest

None.

Acknowledgement

The authors would like to thank enumerators who worked hard to collect the choice experiment data. Authors would also like to thank farmers who sat for a long period of time to provide data. This work was supported by the "Steps toward Sustainable Forest Management with Local Communities in Tigray, northern Ethiopia (with grant reference number: ETH-13-0018)" project financed by the Norwegian Support for Higher Education and Development (NORHED/NORAD), Norway. The authors would like to thank for the funding. Any remaining errors are that of the authors.

Appendix 1A

Table A.1

Table A.1
One sample block nesting choice sets.

	CS	Attributes	Option 1	Option 2	Option 3	Choice
Block-1	CS1	Biodiversity conservation	8	4	0	
		Soil and water conservation	30	25	20	
		Agro-forestry	3	6	0	
		Compensation	1500	750	0	
	CS2	Biodiversity conservation	4	8	0	
		Soil and water conservation	25	30	20	
		Agro-forestry	3	6	0	
		Compensation	750	1500	0	
	CS3	Biodiversity conservation	4	8	0	
		Soil and water conservation	25	30	20	
		Agro-forestry	3	6	0	
		Compensation	1500	750	0	
	CS4	Biodiversity conservation	8	4	0	
		Soil and water conservation	30	25	20	
		Agro-forestry	6	3	0	
		Compensation	1500	750	0	

Note: CS stands for 'choice set'.

References

Adamowicz, W., Louviere, J., Swait J., 1998a. Introduction to attribute-based stated choice methods, Report to NOAA resource valuation branch, Damage Assessment Centre, National Oceanic and Atmospheric Administration, US.

Adamowicz, W., Boxall, P., Williams, M., Louviere, J., 1998b. Stated preference approaches for measuring passive use values: Choice experiments and contingent. Am. J. Agric. Econ. 80 (1), 64–75. https://doi.org/10.2307/3180269.

Amare, D., Mekuria, W., Teklewold, T., Beyene, B., Teshome, A., Yitaferu, B., Tessema, T., Tegegn, B., 2016. Perception of local community and the willingness to pay to restore church forests: the case of Dera district, northwestern Ethiopia. For. Trees Livelihoods 25 (3), 173–186. https://doi.org/10.1080/14728028.2015.1133330.

Arrow, K., Solow, R., Portney, P., Leamer, E., Radner, R., Schuman, H., 1993. Report of the NOAA Panel on Contingent Valuation, 58. Federal Register, pp. 4602–4614.

Aynekulu, E., 2011. Forest Diversity in Fragmented Landscapes of Northern Ethiopia and Implications for Conservation (Ph.D. Thesis). University of Bonn, Bonn, Germany.

Babulo, B., 2007. Economic Valuation and Management of Common-pool Resources: The Case of Enclosures in the Highlands of Tigray, Northern Ethiopia. Catholic University of Leuven, Leuven, Belgium.

Bennett, J.W., Adamowicz, W., 2001. Some Fundamentals of Environmental Choice Modelling, The choice modelling approach to environmental evaluation, 37–69, Cheltenham, UK.

Bennet, J., Blamey, R., 2001. The Choice Modelling Approach to Environmental Valuation. Edward Elgar Publishing Limited, Massachusetts.

Birhane, E., 2014. Agroforestry governance in Ethiopia, Unpublished consultancy report. Mekelle, Ethiopia.

Birhane, E., Tadesse, T., Kidu, G., Aregay, M., Muruts, H., Gebrewahid, H., 2018. Ecotourism potential of forests and contribution to regional economy: the case of Desa'a and Hugumburda forests, Northern Ethiopia. Technical report, Mekelle University, Ethiopia.

Birol, E., Karousakis, K., Koundouri, P., 2006. Using a choice experiment to account for preference heterogeneity in wetland attributes: the case of Cheimaditida wetland in Greece. Ecol. Econ. 60, 145–156. https://doi.org/10.1016/j.ecolecon.2006.06.002.

Brey, R., Riera, P., Mogas, J., 2007. Estimation of forest values using choice modeling: an application to Spanish forests. Ecol. Econ. 64, 305–312. https://doi.org/10.1016/j.ecolecon.2007.07.006.

Cacho, O.J., Milne, S., Gonzalez, R., Tacconi, L., 2014. Benefits and costs of deforestation by smallholders: Implications for forest conservation and climate policy. Ecol. Econ. 107, 321–332. https://doi.org/10.1016/j.ecolecon.2014.09.012.

Carlsson, F., Frykblom, P., Liljenstolpe, C., 2003. Valuing wetland attributes: an application of choice experiments. Ecol. Econ. 47, 95–103. https://doi.org/10.1016/j.ecolecon.2002.09.003.

Chirenje, L.I., Giliba, R.A., Musamba, E.B., 2013. Local communities' participation in decision-making processes through planning and budgeting in African countries. Chin. J. Popul. Resour. Environ. 11 (1), 10–16. https://doi.org/10.1080/10042857.2013.777198.

Christie, M., Nick Hanley, N., Hynes, S., 2007. Valuing enhancements to forest recreation using choice experiment and contingent behaviour methods. J. For. Econ. 13, 75–102.

Colombo, S., Nick Hanley, N., Calatrava-Requena, J., 2005. Designing policy for reducing the off-farm effects of soil erosion using choice experiments. J. Agric. Econ. 56 (1), 81–95. https://doi.org/10.1111/j.1477-9552.2005.tb00123.x.

, 2005CSA (2007), Ethiopia-Population and Housing Census report, Central Statistics Agency (CSA).

Fisher, B., Turner, R.K., Morling, P., 2009. Defining and classifying ecosystem services for decision making. Ecol. Econ. 68, 643–653. https://doi.org/10.1016/j.ecolecon.2008.09.014.

Gadaud, J., Rambonilaza, M., 2010. Amenity values and payment for free recreation services from non-industrial private forest properties: a French case study. J. For. Econ. 16 (4), 297–311. https://doi.org/10.1016/j.jfe.2010.05.001.

Gebreegziabher, Z., 1999. Desa'a Protected Area: An Assessment of Human Impact, Evolutionary Pattern and Options for Sustainable Management. Tigray Region Bureau of Agriculture and Natural Resources, Mekelle, Ethiopia.

Giday, K., 2013. Management Interventions to Assist Restoration of Degraded Dry Afromontane Forest in Northern Ethiopia (Ph.D. Thesis). Leuven University, Leuven, Belgium.

Haltia, E., 2015. Contingent Valuation and Choice Experiment of Citizens' Willing to Pay for Forest Conservation in Southern Finland. Department of Forest Sciences Faculty of Agriculture and Forestry University of Helsinki, Helsinki, Finland.

Hanley, N., Wright, R., Adamowicz, W., 1998. Using choice experiments to value the environment: design issues, current experience and future prospects. Environ. Resour. Econ. 11 (3), 413–428.

Hanley, N., Mourato, S., Wright, R.E., 2001. Choice modeling approaches: a superior alternative for environmental valuation? J. Econ. Surv. 15 (3), 435–462. https://doi.org/10.1111/1467-6419.00145.

Hausman, J., McFadden, D., 1984. Specification tests for the multinomial logit model. Econometrica 52, 1219–1240. https://doi.org/10.2307/1910997.

Hensher, D., Shore, N., Train, K., 2005. Households' willingness to pay for water service attributes. Environ. Resour. Econ. 32, 509–531. https://doi.org/10.1007/s10640-005-7686-7.

Hensher, D.A., Greene, W.H., 2003. The mixed logit model: the state of practice. Transportation 30, 133–176. https://doi.org/10.1023/A:102255871.

Horne, P., 2006. Forest owners' acceptance of incentive based policy instruments in forest biodiversity conservation – a choice experiment based approach. Silva Fenn. 40 (1), 169–178. https://doi.org/10.14214/sf.359.

Hoyos, D., 2010. The state of the art of environmental valuation with discrete choice experiments. Ecol. Econ. 69, 1595–1603. https://doi.org/10.1016/j.ecolecon.2010.04.011.

IBC (Institute of Bio-diversity Conservation), 2005. National bio-diversity strategy and action plan. Institute of Bio-diversity Conservation, Addis Ababa, Ethiopia.

Johnston, R.J., Boyle, K.J., Adamowicz, W., Bennett, J., Brouwer, R., Cameron, T.A., Hanemann, W.M., Hanley, N., Ryan, M., Scarpa, R., Tourangeau, R., Vossler, C.A., 2017. Contemporary guidance for stated preference studies. J. Assoc. Environ. Resour. Econ. 4, 319–405. https://doi.org/10.1086/691697.

Lancaster, K.J., 1966. A new approach to consumer theory. J. Political Econ. 74 (2), 132–157. ⟨www.jstor.org/stable/1828835⟩.

Lindhjem, H., Mitani, Y., 2012. Forest owners' willingness to accept compensation for voluntary conservation: a contingent valuation approach. J. For. Econ. 18 (4), 290–302. https://doi.org/10.1016/j.jfe.2012.06.004.

Louviere, J.J., Islam, T., Wasi, N., Street, D., Burgess, L., 2008. Designing discretechoice experiments: do optimal designs come at a price? J. Consum. Res. 35, 360–375.

MacMillan, D., Hanley, N., Lienhoop, N., 2006. Contingent valuation: environmental polling or preference engine? Ecol. Econ. 60, 299–307. https://doi.org/10.1016/j.ecolecon.2005.11.031.

Mannigel, E., 2008. Integrating parks and people: how does participation work in protected area management? Soc. Nat. Resour. 21 (6), 498–511. https://doi.org/10.1080/08941920701618039.

Martini, U., Buffa, F., Notaro, S., 2017. Community participation, natural resource management and the creation of innovative tourism products: evidence from Italian networks of reserves in the Alps. Sustainability 9, 1–16. https://doi.org/10.3390/su9122314.

Mebrat, W., Gashaw, T., 2013. Threats to Woody Plant Species Diversity and Their Conservation Techniques in Ethiopia. Department of Biology and Department of Natural Resources Management, Adigrat University, Adigrat, Ethiopia (Unpublished document).

Melesa, G.T., 2017. Valuation of Selected Forest Ecosystem Services: The Case of Desa'a Forest, Eastern Tigray, Northern Ethiopia (M.Sc. Thesis). Mekelle University, Mekelle, Ethiopia.

Morrison, M., Bennett, J., Blamey, R., Louviere, J., 2002. Choice modeling and tests of benefit transfer. Am. J. Agric. Econ. 84, 161–170. https://doi.org/10.1111/1467-8276.00250.

Mulatu, D.W., van der Veen, A., van Oel, P.R., 2014. Farm households' preferences for collective and individual actions to improve water-related ecosystem services: the Lake Naivasha basin, Kenya. Ecosyst. Serv. 7, 22–33. https://doi.org/10.1016/j.ecoser.2013.12.001.

Ninan, K.N., Kontoleon, A., 2016. Valuing forest ecosystem services and disservices – case study of a protected area in India. Ecosyst. Serv. 20, 1–14. https://doi.org/10.1016/j.ecoser.2016.05.001.

Reed, M.S., 2008. Stakeholder participation for environmental management: a literature review. Biol. Conserv. 141 (10), 2417–2431. https://doi.org/10.1016/j.biocon.2008.07.014.

Rolfe, J., Windle, J., Reeson, A., Whitten, S., 2006. Assessing the incentives needed to improve riparian management in grazing systems: comparing experimental auctions and choice modelling approaches, paper presented at the 50th Annual Conference of the Australian Agricultural and Resource Economics Society, February 8–10, 2006, Sydney, Australia.

Rolfe, J., Bennett, J., Louviere, J., 2000. Choice modelling and its potential application to tropical rainforest preservation. Ecol. Econ 35, 289–302.

SFDPD, 1997. Management plan for Desa'a state forest. Addis Ababa.

Train, K.E., 2003. Discrete Choice Methods with Simulation. Cambridge University Press, Cambridge, UK.

Kjaer, Trine (2005), A review of the discrete choice experiment — with emphasis on its application in health care, Health Economics Papers 1.

Vatn, A., 2004. Environmental valuation and rationality. Land Econ. 80, 1–18. https://doi.org/10.2307/3147141.

Wang, X., Bennett, J., Xie, C., Zhang, Z., Liang, D., 2007. Estimating non-market environmental benefits of the conversion of cropland to forest and grassland program: a choice modeling approach. Ecol. Econ. 63, 114–125. https://doi.org/10.1016/j.ecolecon.2006.10.001.