Research article

Economic valuation of ecosystem services: application of a choice experiment approach on mount Guna services, North West of Ethiopia

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ARTICLE INFO

Keywords:
Choice experiment
Ecosystem
Willingness to pay
Mount Guna

ABSTRACT

Guna Mountain is the highest point with an elevation of 4,113 m above sea level and located in South Gondar Zone. It is surrounded by Este, Lay Gayint, Begemidir Guna, and Farta Woredas and served as a source of livelihood for the nearby communities. However, the area of Mount Guna has been still unprotected because of a lack of suitable conservation measures and weak control of inappropriate practices. Moreover, empirical investigations on the value of the mountain in terms of its ecosystem service are scanty available. This study aims at valuing ecosystem services of Guna Mountain using the choice experiment method and hence identifying farmer’s choices of ecosystem service attributes. By considering farmers’ preferences, watershed protection service, harvesting of medicinal plants, and water supply together with the cost of management attribute were identified as ecosystem service attributes. Primary data were collected from randomly selected respondents and the Random Parameter Logit model (RPL) was employed for estimation. Results of this model revealed that the signs of attribute levels are positive except for watershed protection service level 25%, and harvesting of medicinal plant 20%. In addition to this, socioeconomic variables were significant such as family size and farm distance with a negative sign, education, and land size with a positive sign. The estimated MWTP from the basic model of RPL for non-monetary attribute levels were Ethiopian Birr (ETB) 1 8.575 and 175.526 per household per year for watershed protection service level 25% and watershed protection service level 50%. It was ETB 1.190 and 00.487 per household per year for the harvesting of a medicinal plant at 10% and harvesting of a medicinal plant at 20%. The contribution was ETB 116.868, 112.642, and 77.767 for water supply at two seasons of the year, water supply at three seasons of the year, and water supply for all seasons of the year attribute levels respectively. Valuing watershed protection was more than water supply followed by harvesting of medicinal plants attribute. To improve the quality and quantity of protection and water supply service, the government and farmers should work together.

1. Introduction

Ecosystem services’ demand has been increasing rapidly as populations and environmental dwindling, and awareness of the community increase. Then, valuation is a precondition in managing these services (Millennium Ecosystem Assessment, 2006). Ecosystem provides crucial role of provision, regulation, cultural and other for numerous stakeholders involved in the surroundings. A wide range of stakeholders are overplaying on many of the ecosystem services which may leads to conflicting interests and, the over-exploitation of some services (forest, water system, biodiversity and so on) at the cost of others. This in turn leads to the total degradation of ecosystem services which may affect the wellbeing of the upcoming generation, and other services. Ecosystem can be categorized as an environmental asset like any other assets of capital. It provides a flow of services overtime in which the consumer may reap a benefits. In this way, attaching monetary valuing for the service obtained plays a paramount significant roles in policy and decision making process, (Ibid).

Mount Guna afro alpine ecosystem is known to be the home of nationally and globally important biodiversity’s and the source of many rivers that drain to the three basins, namely Abay, Tekeze, and Lake Tana basin. Besides, Mount Guna is the origin of the Rib, Gumara and many
other rivers which flow down to the Lake Tana catchment area. A total of 4,615 ha around Mount Guna is currently administered under formal protection with the full mandate of the Regional Council and Local Communities. Species such as Fiestuka, Erica and Thyme which were disappearing have now started regenerating and lives a variety of bird and some wild animals have been reported by the locals. Millions of the nearby residents directly depend on the catchment and its resources for their livelihoods (Ibid).

Conservation of Mount Guna provides raw materials, regulation services, recreational opportunities for human wellbeing with its outstanding beauty, diverse attractions and great tourism potentials and, development or promotion of cultural, historical and natural heritages. It is better to sacrifice our wellbeing to preserve the environment as it is natural capital, one of economy's vital assets that give various purposes. Hence, ecosystem services are the benefits the society gets from ecosystems. These consist of different services like food and water; regulating services including regulation of floods, drought, and disease; supporting services including soil formation and nutrient cycling; and cultural services such as recreational and other important benefits (Costanza and d’Arge, 1997).

However, Mount Guna had been still unprotected area. This is because of population growth, poverty, traditional cultivation, decreasing productivity, low awareness and sense of ownership on values of wildlife and their habitats, lack of suitable conservation measure. Unless restoration, enhancement, conservation and management mechanisms to these ecosystems are implemented, multiple benefits are being lost as a result (Mekonnen, 2013).

Valuation of ecosystem services is the process of estimating the effects of changes in ecosystem services against other stuff that enhance human wellbeing. It offers a tool which improves decision makers’ ability to evaluate tradeoffs among different ecosystem management systems (Millennium Ecosystem Assessment, 2006). There are various valuation methods that are currently used to measuring the respondent's willingness to pay for certain environmental changes improvement or deterioration. Out of the valuation methods, choice experiment is the yet growing method used in environmental economics. This is due to the advantage of choice experiment over contingent valuation technique in detecting potential source of biases and providing a broad base data from respondents (Hanley et al., 2001). I spite of this, comprehensive studies on valuation of the multi-functions and services of Afro-alpine ecosystem have not undertaken. As per the knowledge of the researchers, empirical findings on the economic valuation of ecosystem attributes in Mount Guna, North West Ethiopia are scanty available. Comprehensive studies on valuation of multi-functions and services of Afro-alpine ecosystem have not received much attention in general and Guna mountain range in particular. Thus, the general objective of this study was to evaluate economic value of mount Guna ecosystem services attributes using the exploited approach, choice experiment.

2. Description of study area

Guna mountain community conservation area is located in South Gondar Zone of Amhara region, Ethiopia. It is surrounded by four Woredas including Estie, Lay Gayint, Begemidir Guna and Farta. It is the highest point in the South Gondar Zone, with an elevation of 4,113 m above sea level. Guna is found between 38°10’19.59"- 38°16’34.63"N and 11°39’48.09"- 11°45’31.61”E. The Guna mountain ecosystem area would safeguard habitats for 30 higher and small mammals, for 139 Birds and greater than 96 plant species. The Guna massif is also serving as a home for 6 and 13 endemic mammals and birds respectively (Abebaw, 2016) (see Figure 1).

3. Data and methods

3.1. Sampling and data collection method

The target population and data source of this research was heads of rural farm households whose livelihoods depend directly or indirectly on the resource of mount Guna. This is due to the fact that they are the victims and agents of ecosystem services preservation. Residence proximity to afro-alpine Mount Guna was the main rationality to randomly choose the representative Woredas and Kebeles (The lowest administrative units in Ethiopia). The range of Mount Guna afro-alpine ecosystem was the major factor to select the sample Woreda. Lay Gayint Woreda takes the lion share of Mount Guna. Due to this reason, Lay Gayint Woreda was selected as the target Woreda purposively. This Woreda has a total of 32 Kebeles and of these Kebeles, Mount Guna ecosystem was found only in four kebeles namely: Dera-Kefoye, Guna

Figure 1. Map of mount Guna. Source: Bureau of culture and tourism and parks development.
3.2. Design of choice experiment approach

The foundation of stated preference experiment is a survey design. The manipulation of the levels of the variables demands a particular form of a statistics to decide what manipulation to make and when to make them (David et al., 2005). The following steps were involved in the design of choice experiment.

3.2.1. Description of attributes and attribute levels

To identify attributes and attribute levels the researchers used formal and informal contact with local communities to understand the perception of the locals towards the conservation area, the cause, and potential solutions of conflicts between the governments and communities. Furthermore, attributes were selected after conducting a Focus Group Discussion (FGD) with afro-alpine residents, related literature and key informants. The potential attributes that were proposed for FGD discussants were, provisioning services including food and water; regulating services consisting regulation of floods, drought, and disease; supporting services such as soil formation and nutrient cycling; and cultural services including recreational and other important benefits by assuming that other attributes of the Mount Guna ecosystem services were held constant. A thorough consultation with experts and review on a valuation of ecosystems, three non-monetary attributes, and one cost attribute were identified with their respective levels for choice experiment designation. These are watershed protection, harvesting of medicinal plants, water supply, and management cost along with the yearly charge.

A watershed protection service was leveled in three choices. That is improving watershed protection service by 25%, improving watershed protection service by 50%, and the status quo level. The harvesting of medicinal plants attribute was leveled in three levels. That is the current coverage of medicinal plants, expanding the coverage by 10% and expanding the coverage by 20%. The water supply attribute was leveled in four choices. These were one season, two seasons, three seasons, and for all seasons of the year. Last but not least, monetary attribute considers yearly payment on each household and had four levels. Its levels were 0, 100, 200, 300 and 400 each in Ethiopian Birr.

After the policy relevant attributes and their levels were identified, choice sets were construction using experimental design. The combination of different levels of the aforementioned attributes results different policy option scenario and construction of choice cards. This study deployed orthogonal fractional factorial design procedure by using Ngene 1.1.2 choice metrics statistical software. The experimental design through this software results the creation of 36 optimal choice sets. The choice set was divided in to 6 blocks, so that each respondent received 6 choice sets/cards only.

3.3. Method of analysis of choice experiment approach

Random utility theory formulated by Luce (1959) and Lancaster consumer choice model (Lancaster, 1966) are foundation for stated preference choice experiment approach. According to these scholars, the total utility derived from a consumption of a good is a function of the observable or random component whose values directly depend on the attributes and the other unobservable error component which is assumed to be the error terms of the resulting utility function independently and identically distributed (Louviere et al., 2000).

For an individual, the utility of choosing alternative \( n \) is a function of the attributes of the option \( n \). The utility function \( V_{nt} \) composed of random or observable part, \( V_t \) which is in turn composed of environmental attributes of ecosystem \( (Z_t) \) and the socio-economic characteristics of the respondent \( (S_t) \), and the error component portion often that stands for unobservable random variables.

The random utility function is shown as follows

\[
U_{nt} = V(Z_{nt}, S_t) + \epsilon_{nt}
\]

\[
U_{nt} = Z_{nt} + \epsilon_{nt}
\]

where \( U_{nt} \) stands for the utility of individual \( t \) for choosing the \( n \) option, \( Z \) indicates attributes of Guna mountain, \( S_t \) indicates the socio-economic characteristics of an individual \( t \), \( V_t \) the vector of deterministic component of the latent utility that is the function of the attributes of the alternative and the socio-economic characteristics of the individual that individual \( t \) has from choosing alternative, \( \epsilon_{nt} \) is the vector of random component of the latent utility associated with option \( i \) and consumer \( t \) (Adamowicz and Boxall, 2001) which is not correlated with the deterministic part by assumption of Identically and Independently Distributed (IID).

However, it is unable to forecast respondent preferences because of the error term. Therefore, by expressing preference in terms of probabilities can be predict individual preferences. Thus, the likelihood of every respondent prefers option \( n \) in the choice set to any alternative option \( h \), can be articulated as the probability that the utility linked with option \( n \) surpass those linked with all other alternative.

\[
P(\frac{1}{C_n}) = \text{Prob} \{U_{nt} > U_{ht}\} \text{ for all n, h elements of C, n} \neq h
\]

\[
P(\frac{1}{C_n}) = \text{Prob} \{V_{nt} + \epsilon_{nt} > V_{ht} + \epsilon_{ht}\} \text{ for all n, h elements of C, n} \neq h
\]

where, \( C_n \) is the set of all possible alternative scenarios. To estimate Eq. (4), assumptions need be made over the distribution of the error terms. The most widely applicable assumption made is that the errors are Gumble-distributed (Type I Extreme value distribution) and independently and identically distributed. Depending on the assumption we put on the error term, we may come up with different models.

3.3.1. The multinomial logit model (MLM)

Multinomial model is easiest and straight forward in estimating choice modeling. Under this model, the probability of selecting option is formulated as a function of attributes and socio-economic variables of the respondents (Greene and Hensher, 2003).

In order to estimate choice probabilities using MLM it is assumed that

i. The random components are independently and identically distributed (IID)

ii. The choice probability of the alternative depends only on the difference in the systematic utilities of different alternatives rather than actual values.

Based on the above assumption the probability of choosing alternative scenario multinomial model has the following expression

\[
P_i = \frac{\exp\gamma \theta_{i}}{\sum \exp \gamma \theta_{j}}
\]

where, \( \gamma \) is the scale parameter, it is impossible to identify this parameter from the data. In addition, to this the model can be estimated by maximum likelihood estimation taking the log likelihood function.
Log \( L = \sum_{n=1}^{N} \sum_{i=1}^{n} Y_{in} \log \frac{\exp \beta_{in}}{\sum_{j=1}^{n} \exp \beta_{jn}} \)  \hspace{1cm} (6)

\( Y_{ij} \) is an indicator variable that takes available of one if individual or respondent choose alternative \( n \) and 0 otherwise. To estimate the multinomial logit model, modeling constant known as Alternative Specific Constant (ASC) are included in the multinomial logit model.

\( V_{nt} = A S C_i + \sum_{M} B_{in} H_{im} + \sum_{t} Y_{it} (ASC_i \ast St) \)  \hspace{1cm} (8)

where \( ASC_i \) is an alternative specific constant which represents the role of the unobserved source of utility for option \( n \), \( Him \) is the \( M^th \) attribute value of alternative \( n \). the effect of attribute on the choice set are captured by \( Z \) variables. By interacting \( ASC \) with socioeconomic variable is one of the possible mechanisms of considering individuals or respondents Heterogeneity or detect “Hessian” singularities.

The model can be specified in the following form.

Table 1. Example of choice set.

| Attributes                          | Plan 1                                                                 | Plan 2                                                                 | Plan 3 (status quo)                           |
|-------------------------------------|------------------------------------------------------------------------|------------------------------------------------------------------------|---------------------------------------------|
| Watershed protection                | Improve watershed protection service by 50%                           | Current level of watershed protection (status quo)                      | Current level of watershed protection (status quo) |
| Harvesting of medicinal plants      | Current level of medicinal plants (status quo)                         | Expanding the coverage of medicinal plants by 20%                       | Current level of medicinal plants (status quo) |
| Water supply                        | Improve the supply of water for all seasons of the year                | Improve the supply of water for 2 seasons of the year                   | Current level of water supply (status quo)    |
| Monetary payment (ETB)              | 400                                                                    | 300                                                                    | No payment                                  |

Source: Researchers Compilation

Table 2. Results of socio-economic variables.

| Variable Categories | Frequency | Percentage | Mean |
|---------------------|-----------|------------|------|
| Sex                 | Male      | 176        | 88%  |
|                     | Female    | 24         | 12%  |
| Age                 | '24       | 0          | 0    | 53   |
|                     | 25–29     | 7          | 3.5% |
|                     | 30–49     | 72         | 36%  |
|                     | '65       | 121        | 60.5%|
| Family size         | 1–3       | 36         | 18%  | 5.5  |
|                     | 4–6       | 112        | 46%  |
|                     | 6–9       | 49         | 24.5%|
|                     | '9        | 3          | 1.5% |
| Education           | Illiterate| 144        | 72%  |
|                     | Read and write | 41  | 20.5%|
|                     | 1–6       | 11         | 5.5% |
|                     | '9        | 4          | 2%   |
| Income              | '10000    | 1          | 5%   | 24,345|
|                     | 10001–20000| 63       | 31.5 |
|                     | 20001–30000| 89      | 44.5%|
|                     | 30001–40000| 43      | 21.5%|
|                     | '40000    | 4          | 2.0% |
| Farm distance       | '1        | 88         | 44   |
|                     | 1–3       | 99         | 49.5%|
|                     | '3        | 13         | 6.5  |
| Farm size           | '1        | 43         | 21.5%|
|                     | 1–2       | 78         | 39   |
|                     | '2        | 79         | 39.5 |

Source: Authors Computation from Survey data, 2019

| Degree | Causes of degradation | Responses |
|--------|-----------------------|-----------|
|        | Frequency             | Percentage |
| 1\(^{st}\) | Agricultural expansion | 236       | 25.6  |
| 2\(^{nd}\) | Resettlement         | 190       | 20.6  |
| 3\(^{rd}\) | Climate change       | 182       | 19.8  |
| 4\(^{th}\) | Deforestation        | 177       | 19.2  |
| 5\(^{th}\) | Other factor         | 136       | 14.8  |

Source: Authors Computation from Survey data, 2019

Table 3. Farmers perception about mount Guna ecosystem degradation (multiple responses).

| Degree | Causes of degradation | Responses |
|--------|-----------------------|-----------|
|        | Frequency             | Percentage |
| 1\(^{st}\) | Agricultural expansion | 236       | 25.6  |
| 2\(^{nd}\) | Resettlement         | 190       | 20.6  |
| 3\(^{rd}\) | Climate change       | 182       | 19.8  |
| 4\(^{th}\) | Deforestation        | 177       | 19.2  |
| 5\(^{th}\) | Other factor         | 136       | 14.8  |

Source: Authors Computation from Survey data, 2019
3.3.2. Random parameter logit model (RPL)

To avoid the problem related to the MNL model, Greene and Hensher (2003) have recommended the use of the RPL model due to the following advantages of the RPL over the MNL model. First, RPL is not subject to the IIA assumptions. Second, it accommodates correlation among panel observations. Third, the process unambiguously incorporates heterogeneity in taste variation across observations by permitting the model parameters to vary randomly over respondents (Adamowicz and Boxall, 2001).

The random utility function for the random parameter logit model takes the following form:

\[ U_{nt} = V_{nt} + \epsilon_{nt} = Z_i(B + nt) + E_{it} \]  

(9)

where: \( U_{nt} \) is the total utility for respondent \( t \) from choosing alternative \( n \) in the choice set. It is assumed that the utility function consists of both systematic component \( V_{nt} \) and stochastic component \( \epsilon_{nt} \). The indirect utility is assumed to be a function of the choice attribute \( Z_i \) with socio economic \& environmental attribute variables, if included in the model, which due to preference heterogeneity may vary across respondents by a random component \( \epsilon_{nt} \).

The probability that an individual \( t \) chooses alternative \( i \) from each choice set is presented as

\[ P_{it} = \frac{\exp(V_{it} + \beta_i)}{\sum \exp(V_{jt} + \beta_j)} \]  

(10)

As mentioned by Birol et al. (2005), the RPL model does not require the IIA assumption, the stochastic part of utility may be correlated among alternatives and across the sequence of choices via the common influence of \( nt \). Moreover, RPL model is superior to multinomial logit model in terms of overall fit \& welfare estimates.

3.3.3. Marginal willingness to pay (part worth)

Implicit prices for ecosystem attributes are the estimations of the WTP of individuals for an improvement in the attribute of interest, given everything else is constant. Implicit prices are determined with the following formula:

\[ \text{Implicit price (Part worth)} = - \left( \frac{\text{inon} - \text{market attribute of ecosystem}}{\beta \text{ monetary attribute}} \right) \]  

(11)

where, \( \beta \) are the estimated coefficients of the attributes.

3.4. Econometric specification of ecosystem choice experiment approach

In both MNL and RPL Models, the three utility functions were estimated for three alternatives: The status quo, Mount Guna Ecosystem services improvements, plan (Alternative) one and two. The basic and extended MNL models are described in the following general forms.

\[ U_i = b_{wsheld}wshelp + b_{harmed}harmed + b_{watsup}watsup + b_{cost}cost + \theta_1ASCi^{\text{AGE}} + \theta_2ASCi^{\text{FAMSZ}} + \theta_3ASCi^{\text{EDUS}} + \theta_4ASCi^{\text{INC}} + \theta_5ASCi^{\text{GNDR}} + \theta_6ASCi^{\text{FARDIST}} + \theta_7ASCi^{\text{LANDSIZE}} \]  

(12)
b-represents the coefficients associated with each of the four attributes, i.e. improvement in, watershed protection (wshedp), harvesting medicinal plants (harmed) water supply (watsup), and monetary payment (cost) respectively. ASCI = Alternative specific constant and takes the value 0 for status quo option and 1 for choose alternative one and two. Whereas, AGE stands for age, FAMS (family size), EDUS (education), INC (income), GNDR (gender), DSKM (distance from the mountain), and LANDSIZE is size of land as socioeconomic variables, \( \theta \) is the coefficient of socioeconomic variables.

### 4. Results and discussion

#### 4.1. Descriptive statistics

Ahead of conducting the full survey, pretesting has been conducted on a small number of respondents, 12 households who were not included in the main survey. From this we got a paramount significance for the appropriate modifications of any shortcoming of the designed questionnaire and as training for enumerators. The pretest result revealed that the questionnaire was very long, time demanding 65 and not written in simple word. Thus, these factors were considered before the main survey. Concerning about the response rate, it was 100 %, the sampled respondents were willing and committed to take part the full field survey implying that they are concerned about the improvement in ecosystem services in their vicinity.

Further, about 88% of respondents were male and the remaining were female-headed rural households. The mean family size of the farmers or household heads was about 5.5 which are greater than the National Central Statistical Agency standard of family size 4.5. The mean age of respondents was about 45 of which 58% are male and 42% are female.

### Table 5. Results of extended random parameter logit model.

| Variables                                | Coefficient | St.Error | z   | Prob.|z| >*Z* |
|------------------------------------------|-------------|----------|-----|-----|-----|------|
| Random parameters in utility functions   |             |          |     |     |     |      |
| Watershed protection service level 25%   | -.00963     | .15549   | -.06| .9506 |
| Watershed protection service level 50%   | .37255**    | .15171   | 2.46| .0141 |
| Harvesting of medicinal plant attribute level 10% | -.05488 | .14520   | -.38| .7055 |
| Harvesting of medicinal plant attribute level 20% | .04971    | .13966   | .36 | .7219 |
| Water supply at two seasons of the year  | .42619*     | .24116   | 1.77| .0772 |
| Water supply at three seasons of the year| .16598      | .24878   | .67 | .5047 |
| Water supply all seasons of the          | .01586      | .18298   | .09 | .9309 |
| Nonrandom parameters in utility functions|             |          |     |     |     |      |
| PLAN3                                    | -3.03486*** | .94397   | -3.21| .0013 |
| Mgt cost                                 | -.00204***  | .00051   | -3.96| .0001 |
| ONE, SEX1                                | .57486      | .45793   | 1.26| .2094 |
| ONE, INCOME1                             | -.12187D-04 | .1849D-04| -.66| .5098 |
| ONE, AGE1                                | .00249      | .01352   | .18 | .8539 |
| ONE, FAMILY SIZE1                        | -.12444     | .08655   | -1.44| .1505 |
| ONE, LAND SIZE1                          | -.23289     | .40205   | -.58| .5624 |
| ONE, FARM DISTANCE1                     | .23396**    | .11372   | 0.06| .0396 |
| ONE, EDUCATION1                          | .66373***   | .196213  | .38 | .0007 |
| TWO, SEX2                                | -.38390     | .31057   | -1.24| .2164 |
| TWO, INCOME2                             | -.10186D-04| .1436D-04| -.71 | .4781 |
| TWO, AGE2                                | .00854      | .00824   | .04 | .3000 |
| TWO, FAMILY SIZE2                        | .09977      | .06091   | .64 | .1014 |
| TWO, LAND SIZE2                          | -.10809***  | .30137   | -3.64| .0003 |
| TWO, FARM DISTANCE2                     | .11695      | .08091   | 1.45 | .1484 |
| TWO, EDUCATION2                          | .28380**    | .13091   | 2.17| .0302 |

Log-likelihood function: -1112.91910
McFadden Pseudo R-squared: .1558145
Number of observations: 3600
Number of respondents: 200

Note: nnnnn.D-xx or D + xx = > multiply by 10 to -xx or + xx.
Note: ***, **, * = >> Significance at 1%, 5%, 10% level.
Source: Authors Computation from Survey data, 2019

### Table 6. Mean marginal WTP of improved Guna mountain ecosystem services.

| Attribute levels                          | MWTP   | 95% confidence interval |
|------------------------------------------|--------|-------------------------|
| Watershed protection at 25%              | 8.575  | -109.903                |
| Watershed protection at 50%              | 175.526| 34.783                  |
| Harvesting medicinal plant at 10%        | 1.190  | -117.907                |
| Harvesting medicinal plant at 20%        | 24.487 | -90.665                 |
| Water supply 2 season of the year        | 116.868| -48.108                 |
| Water supply 3 season of the year        | 112.042| -39.782                 |
| Water supply all seasons of the          | 26.766 | -105.375                |

Source: Authors Computation from Survey data, 2019
the respondents was found to be 53. Concerning the level of education, 72% of respondents affirmed that they can't read and write.

The mean yearly income of the farmers was about 24,345 ETB which is equivalent to about 869.46428 USD (1$ = 27ETB). The average farm distance from Mount Guna was 2 km and the average size of farm land-holding sizes was one hectare per household.

Farmers were also asked about the major factors that affect the degradation of Mount Guna afro-alpine ecosystem area. They ranked that the first factor was agricultural expansion (25.6%), resettlement (20.6%), climate change (19.8%), deforestation (19.2%), and other factors (14.8%).

### 4.2. Econometric results of choice experiment

The package, LIMDEP10.0 NLOGIT 5.0 was used to estimate the basic and hybrid RPL model. In the basic model, Mount Guna services attributes which explain individuals' choice for different services interventions were considered, whereas, socio-economic and environmental variables were considered in the extended models.

Limdep 10 Nlogit 5.0 Econometrics software was used to analyze the quantitative data of the study. The estimates of random parameter logit model were used to identify important attributes: watershed protection, water supply, and harvesting of medicinal plants. The parameter logit model has an advantage in introducing respondents' preference heterogeneity as independent variables in explaining the probability of choice (Greene and Hensher, 2003). In this study the researcher specified attributes and its levels such as WSHEDP 25%, WSHEDP 50%, HARMED 10%, HARMED 20%, WATSUP 2, Season WATSUP 3 seasons, and WATSUP all seasons to be randomly distributed.

The pseudo R-square is implying better explanatory power of random parameter logit model than the standard logit models. The result of the estimation revealed that the level of 2 seasons of water supply attribute level and watershed protection attribute level at 50% retain the expected sign and significant at 10% and 5% respectively. This result indicated respondents had been willing to share the cost of improving Mount Guna's level of attributes. The coefficients monetary attribute indicate that the inverse relationship between respondent utility and cost of improvement. The implication is that as cost of improvement increased, the respondent participation for the improvement of environmental plan would decrease.

Further, the finding of the study revealed significant negative value for the Alternative Specific Constant (ASC) for environmental plan one. This shows the utility of respondent decreases as they shift from the status quo to the alternative environmental improvement plans 1. According to Samuelsson and Zeckhouser, such kind of result might be due to status quo bias. It's a common phenomenon and supported by a lot of evidence from literature (Adamowicz et al., 1998). In this particular case, there were 46 respondents choosing the status quo, valuing the current situation more than the improved one. This could be low awareness and sense of ownership on values of wildlife and their habitat, look for additional than the improved one. This could be low awareness and sense of ownership on values of wildlife and their habitat, look for additional benefit of services using a choice experiment approach. The choice experiment was employed. Results from both models showed that the extended random parameter logit model result from Table 4.4 revealed that farm distance and education could positively affect the probability of choosing environmental plans 1 at 5% and 1% level of significant respectively. The implication is that educated household had a better understanding of the benefits of ecosystem improvements. Moreover, land size with negative coefficient significantly affected the probability of choosing environmental plan 2 at 5% level of significant which suggested that as the size of the farmers owned cultivated land increases ecosystem improvement will decreases.

The socio-economic variables age, sex and income implied that the involvement of these variables were not a significant factor in affecting the probability of choosing the improved plans. But the coefficient of interaction of ASC with years of education was positive and significant. This indicates that as years of education increases, the probability of choosing improve environmental plan increases, ceteris paribus. In addition to this, the coefficient of interaction of ASC with sex is positive which implies that the probability of choosing the improvement option was higher for male as compared to female other things being constant.

The coefficient of family size was not expected to be negative for plan 1. The negative coefficient of land size was not expected for the two environmental plans but significant for plan 2 implying that as land size increases, the probability of choosing environmental plan decreases. The coefficient of the watershed attribute was greater than that of water supply attribute and harvesting of medicinal plant which implies that farmers give more value to level of watershed protection attribute.

### 4.2.1. Estimation of marginal willingness to pay (MWTP)

Implicit prices (MWTP) for ecosystem attributes are the estimations of the WTP of respondents for an improved in the attribute of interest, given everything else is constant. Implicit prices are determined at the ratio of the coefficients of the attributes of Guan mountain afro-alpine ecosystem in random parameter logit model to the estimated coefficients of the monetary attribute. Accordingly, respondents’ marginal WTP for an environmental improvement plan for watershed protection service 25% and watershed protection service 50% is 8.575 and 175.526 ETB respectively.

Harvesting medicinal plant attribute plan 10% and 20% WTP for the improvements of harvesting of medicinal plant attribute is ETB 1.190 and birr 24.487 respectively. For the water supply attribute of Guna Mountain respondents marginal WTP for environmental improvement plan for two seasons of the year, three seasons of the year and all seasons of the year is ETB 116.868, 112.042, and 26.766 respectively. The MWTP of water supply across all seasons of the year level result is low as compared to two seasons of the year and three seasons of the year. The result was not surprising because this might be choosing among option might be complex to respondents and they might be uncertain whether they are willing to make trade-off or not. In closing, respondents give priority to watershed protection attribute environmental plan 50% followed by water supply for two seasons of the year.

### 5. Conclusions

The main objective of this study was to investigate the preferences and WTP of households for enhanced Mount Guna Range Ecosystem Services using a choice experiment approach. The choice experiment data was collected from 200 rural farm households residing in North West of Ethiopia. In addition to the basic random parameter logit and the hybrid model was employed. Results from both models showed that sampled households were willing to share the cost of improving Mount Guna ecosystem services attributes.

Further, some socioeconomic variables were found to be a significant determinant in influencing respondents’ choice of improved interventions. Higher yearly marginal willingness to pay of respondents for the environmental improvement plans of the specified attributes and its levels suggested as a remedy to solve the degradation of the Mount Guna.
ecosystem attributes and its levels by creating other options to the farmers whose livelihood is directly depend on the Mount Guna.

6. Policy implications and directions to future researchers

Based on the finding of the study, the following policy implications are recommended. Large preference heterogeneity is found within respondents in the study area. Therefore, decision makers who are interested to get efficient ecosystem services conservation and improvements should consider this preference heterogeneity before developing suitable plan in Mount Guna. The implication of the community contribution for levels of Mount Guna quality improvement and options were that the service provider can create income from the society to promote ecosystem services conservation and cuts the cost of handling its improvement, and then the divergence between the demand and the supply of the Mount Guna ecosystem service can be settled.

Lastly, the issue related to the methodology used by the study indicated that CEA can be fruitfully used in the context of ecosystem services valuation. Through vigilant identification of relevant attributes, appropriate construction of the efficient choice sets, specification of models, the method can effectively be used in identifying individuals preferences for proposed policy interventions and then forward policy relevant information about enhanced environmental services. The methodology is anomalous yet and study need envisage this method to examine individual's preferences for non-marketed environmental goods and services using Latent Class Logit Econometric Model too.

Declarations

Author contribution statement

Yirga Wondifraw: Conceived and designed the experiments; Performed the experiments; Analyzed and interpreted the data.

Tefera Berihun Taw & Esthetie Woretaw Meried: Analyzed and interpreted the data; Contributed reagents, materials, analysis tools or data; Wrote the paper.

Funding statement

This research did not receive any specific grant from funding agencies in the public, commercial, or not-for-profit sectors.

Data availability statement

Data will be made available on request.

Declaration of interests statement

The authors declare no conflict of interest.

Additional information

No additional information is available for this paper.

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