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Research article

Economic valuation of attributes of Lake Tana: random parameter model

Asmamaw Getnet [a], Tefera Berihun Taw [b,*]

[a] Department of Economics, Debre Tabor University, Ethiopia
[b] School of Economics, University of Gondar, Ethiopia

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ABSTRACT

The general objective of the study is estimating economic value of Lake Tana attributes using stated preference method of valuation in general and choice experiment method in particular. The target population was households who live around Lake Tana. The study has identified four attributes of Lake Tana (Water quality, fishery, irrigation, and recreation). The study has formulated three alternatives in which two of them were improved whereas the one is the status quo. Each attribute has three levels. The study has surveyed 238 households which were selected using multistage sampling method. Each respondent was presented with eight choice sets. Each choice set has three alternatives including opt option. The study has employed random parameter logit model for data analysis. In line with this model the study has conducted the extended random parameter logit model. The status quo (ASC0) is negative and significant both in random parameter logit model but positive and insignificant in extended random parameter logit model. This means that households have preferred the improved situation of the Lake Tana. This indicates that households are willing to pay to improve the current situation of the lake. Random parameter logit model shows that all improved attributes have positive sign and significant at 1% significance level. This means that improved situation of attributes that are identified by this study improve utility of households. Government should protect Lake Tana from any problem by raising funds from households since households are willing to pay to improve Lake Tana's attributes.

1. Introduction

Lakes are very important element of earth's hydrological process and it provides various services for human beings and ecosystem functioning (Mekete & Jan, 2015). Ethiopia has more than 24 natural lakes and several manmade reservoir, with a total of surface area of about 7500km square (Gebremedhin et al., 2018). Among the natural lakes, Lake Tana is the largest lake in Ethiopia which accounts for 50% of the fresh water resource of the country. According to Dessalegn et al. (2011), Lake Tana is well known for its biodiversity. It is source of fish resource for both local communities particularly and elsewhere in Ethiopia in general. The lake is an important source of natural resources including water for domestic supply, irrigation and hydropower production, fisheries, grazing and water for livestock, and reeds for boat construction. It is also important for water transport and as a tourist destination. Vijverberg et al. (2017), Lake Tana and its adjacent wetlands provide directly and indirectly a livelihood for more than 500000 people. Wetlands are very important for breeding and enhancing the biodiversity. Wetlands in Lake Tana are important section of the lake and have significant role in sediment retention, flood protection, purification of water 'Kidney' of the landscape, important breeding grounds for birds and some fish species like Oreochromis Nilotic us (Goraw and Shimelis, 2017).

Environmental resources are one of scarce resources which provide wide range of goods and services that are valuable for society. The set of needs and wants satisfied by environmental services range from breathing pure air to much more complex one like recreation. Economics deal with allocating of limited productive resources depends on valuation to convey society with information about the relative resource scarcity. The value of ecosystem services and biodiversity is reflection of what societies are given up to conserve these natural and environmental resources (Pascual et al., 2010). Natural resources, such as forest and commercially and exploitable fisheries, and environmental attributes like air quality are valuable assets in which it provides series of services to people. Public policies and actions of agents can lead to changes in the flow of services of environmental resources, thereby creating benefits and costs. The public good nature of most environmental resources hinder the market system to convey information about the valueof those resources, and the market system is inefficient to signal directions about the allocation of such resource (Freeman

* Corresponding author.
E-mail address: tefera1974ec@gmail.com (T.B. Taw).

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III, 2003). This means market fail to capture the value of environmental services due to non-excludability and externality. However, it does not mean that environmental resources have not value. People derive real value from natural resources and environment for many reasons.

Scholars have developed different techniques to estimate economic value of non-marketed environmental goods and resources. Broadly, valuation techniques can be categorized into stated preference and revealed preference. Stated preference valuation method attempt to estimate the economic value of non-marketed goods by providing imaginary market to individuals who are concerned to the resource being valued. However, revealed preference method of environmental valuation uses the support of the actual market to derive the economic value of non-marketable resources (Gunatilake, 2003). Stated preference valuation method has used two main questions to derive the economic value of environmental resource. These questions are willingness to pay (WTP) and willingness to accept (WTP). The choice between them lies from the property rights regarding resource being valued. If an individual has the right to sell the resource, WTA question is more appropriate whereas if the individual buy the resource, WTP question is recommended. Stated preference method of environmental valuation has two main methods that are contingent valuation method and choice experiment method.

Contingent valuation method (CVM) is valuation method where respondents are asked their maximum willingness to pay (or minimum willingness to accept in compensation) for a predetermined improvement or loss in environmental quality (Mogas et al., 2002). Choice experiment is the second popular type of stated preference method of valuation. Choice experiment method (CEM) is state of art method which has been applied to economic valuation of environment recently. Choice experiment provides the respondents with the choice of attributes regarding with the resource being valued (Henrik et al., 2014). The base of choice experiment method (CEM) is Lancaster's characteristics theory of value (1966) which states that any goods can be explained in terms of its attributes of the good, and consumers purchase the attributes of the good rather than the good itself. The dominant valuation method that was employed by economists for the past three decades is contingent valuation method. However, choice experiment has become an alternative and best valuation method over contingent valuation method. Choice experiment has its own strengths over contingent valuation. Contingent valuation method has focused on describing changes in a given good or service via different information instruments. This means respondentsare presented with power points of the good or service being valued without detail of the good or service. However, the result of contingent valuation rely on accuracy and completeness of information provided to respondents about the resource being valued. However, choice experiment is not rely on information about specific resource rather it describes that resource through its attributes. The other strength of choice experiment over contingent valuation is that choice experiment allows for respondents to make tradeoff between attributes of the good or service being valued (Boxall, 1996).

Lake Tana is one of the ecosystems and environmental resource in which its value could not be determined by standard market institution. The lake has multidimensional advantage forlocal community. According to Melesse & Chebud (2010), the lake provides transport, electric power generation, fishing, ecological preservation, recreational activity, and irrigation supply in dry season for the local community. However, the economic value ofthese and other services of the lake is not estimated bystandard market institution. Failing to determine the value of the Lake Tana's services leads to undesirable outcome of the lake. Estimating the value of the lake by any means is mandatory to decide whether the public value the lake's attribute or not. Economic valuation is the best alternative to estimate the value the lake. Economic valuation of Lake Tana will demonstrate whether the lake is source of utility or not to the surrounding people. Not only this but also economic valuation give direction about the effectiveness of the policies whether to conserve the lake.

Carlsson et al. (2003) used choice experiment to value wetland attributes. Their study had attempted to identify the attributes of wetland that improve or deteriorate societies' welfare. They identified six attributes those are surrounding vegetation, fish, cray fish, biodiversity, walking facilities and fence. They employed random parameter model to analyze the data. Their result shows that fence and cray fish have negative effect on welfare but biodiversity and walking facilities have positive effect on welfare. Goibov et al. (2012) used choice experiment to estimate farmers' preference for different land use option in Northern Tajikistan. Their objectives were to confirm the applicability of choice experiment in the study area, and to estimate the non-market values of agri-environmental attributes based on farmers' preference. They have identified seven attributes including cost attribute, and each attribute has four levels. Attributes are agricultural land use pattern prioritization, water quality, number of trees per hectare, number of workers in agriculture, loss in biodiversity and cost attribute. They presented eight choice set per respondent, and three choice options in each choice set. They surveyed 117 farmers. They employed both conditional logit and random parameter logit model. However, except cost attribute they got different result between those models. By using log likelihood test, they recommended the result of random parameter logit model to their analysis.

There are a few valuation studies regarding Lake Tana. Among these "*economic analysis of household preferences for wetland attributes: Application of Choice Experiment to the Case of Lake Tana Wetlands*" by Yimenu and Nandeeswara (2015). The main objective of the study conducted by Yimenu and Nandeeswara (2015)was economic analysis of household preferences for wetland attributes: Application of Choice Experiment to the Case of Lake Tana Wetlands was estimating the economic value of Yiganda wetland attached by households. Their study has not given due attention to the economic value of other Lake Tana's attributes. Their study identified four attributes that are fish stock, preserved ecology function, surface area and monetary cost. They have applied conditional logit model and their finding shows that the improved attributes of wetland are positive and significant. The other study was "*estimating willingness to pay for Labeobarbus fish species conservation in Lake Tana, Ethiopia: a contingent valuation study*" by Asmamaw et al. (2016). The major objective of their study was estimating willingness of the households to pay for continuous existence of Labeobarbus fish conservation. Their study has methodological gap since they were applied contingent valuation method (CVM) to estimate willingness of the households to pay. However, contingent valuation could value the whole thing without considering different characteristics of the good being valued. The above both studies have emphasized on the single attributes of Lake Tana. In other word, they could not address the different attributes of the lake since Lake Tana has several characteristics. However, this study has attempted to address this gap by examining the economic value of the Lake Tana attributes with application of choice experiment method.

Grand objective.

➢ The grand objective of this study is estimating economic value of Lake Tana attributes using choice experiment method.

Specific objective.

➢ Estimating the maximumwillingness to pay to each attribute that is included in the model.
➢ To identify socioeconomic factors which determine the marginal willingness to pay forLake Tana attributes.

2. Materials and methods

2.1. Description of the study area

Lake Tana is the largest lake among Lakes in Ethiopia with an area of about 3200 km^2 and it is located in the northwestern highland part of the country. Lake Tana's highest altitude is 1800m. It is shallow lake and its depth range between eight meter and 14m. It is the tropical lake with surface area of 3111Km^2, 284Km^3 volume and has maximum length of 90km and 65km. The lake is fed by four major rivers those are Gumara,

Megech, Rib and Abay. The drainage basin receives an average annual rain fall of 1200 mm which helps to replenish the lake seasonally. Lake Tana is surrounded by four districts; Dembia in north, Alefa in west, Fogera in east and Bahirdar in south (see Figure 1).

2.2. Nature of data and sampling

The data that employed in this studyis primary cross sectional. The data is collected from the local residents who live around the Lake Tana. The total projected households who live permanently in the study area are 383,703 (CSA, 2013). Even if population of the study havesame socioeconomic characteristics, the population has stratified into different strata in terms of geographical location; Alefa Taqusa, Semen Achefer, Dembia, Fogera, Bahirdar Town, Gondar Zuria and Bahirdar zuria. After such stratification, samples were drawn randomly in each strata given each strata respective proportion.

There are many sampling size determinations; however, rule of thumb sample size determination is common practice in choice experiment studies. According to Orme (2010), the following rule of thumb formula is used to determine sample size in choice experiment:

$$n = 500 * LLOAA / NA * CSPR$$

where, n minimum sample size, $LLOAA$ = largest level of any attribute, NA = number of alternative and $CSPR$ = choice set per respondent. Hence, in this study there are five attributes including the monetary cost and each attribute has three levels but the monetary cost has six levels. Total number of choice sets per respondent is 16 but it is too much to present 16 choice set for a single respondent. For this reason, the study has applied two blocking choice set design. As a result, each respondent should present with eight choice set. Therefore, based on the above formula, the study has employed 250 respondents that is twice of 125 since the design is two blocking. After this, the study has applied purposive sampling in each cluster to select kebeles based on nearness to the Lake Tana.

$$n = 500 * 6 / 3 * 8 = 125$$

The study area has stratified into seven strata based on geography. To draw the representative sample in each strata, proportional sampling has applied. Therefore, the study has randomly selected representative samples in each strata given each strata's proportion.

$$S_i = \frac{n_i}{N} * n$$

where, (i = 1, 2, 3, 4, 5, 6, 7)

$$s_1 = \frac{58780.444}{383,703} * 250 = 38 (\text{Fogera})$$

$$s_2 = \frac{69199}{383,703} * 250 = 45, (\text{Dembia})$$

$$s_3 = \frac{43281}{383,703} * 278 = 28.19 = 28 (\text{kunzla})$$

$$s_4 = \frac{48383}{383,703} * 278 = 31.52 = 32 (\text{Alefa})$$

$$s_5 = \frac{45392}{383,703} * 278 = 29.57 = 30, (\text{Bahirdar zuria})$$

$$s_6 = \frac{69647}{383,703} * 250 = 45.37 = 46, (\text{Bahirdar})$$

$$s_7 = \frac{49018}{383,703} * 278 = 31.94 = 32, (\text{Gondar zuria})$$

The study has collected the relevant data with structured questionnaire from statistically determined samples. The questionnairewas composed with two types of questions that are socioeconomic characteristics of the households and choice set questions. The socioeconomic part of the questionnaire has contained households' demographic and economic characters whereas the second type has contained choice set questions which are designed by the experiment. From the choice set part of the questionnaire, respondents are invited to choose among alternatives which are composition of attributes of Lake Tana with different levels.

2.3. Method of data analysis and model specification

The study has applied econometric model to analyze the data that is collected with choice elicitation method. The econometric analysis of the

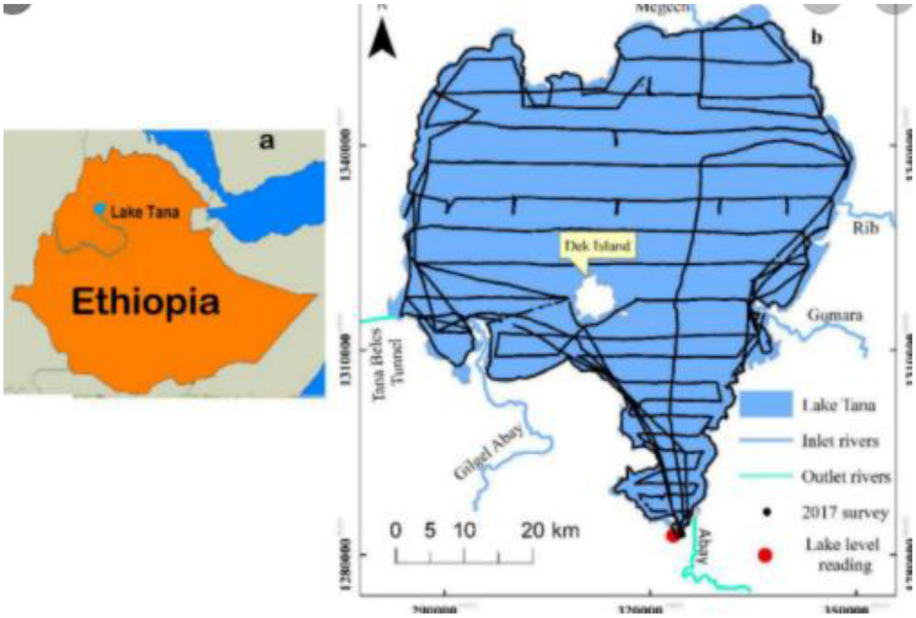

Figure 1. Location of the study area.

study used one of the class of standard logit model that is conditional logit. Choice experiment has utilized the theory of consumer behavior to specify its model of analysis by borrowing from Lancastrian microeconomics approach that states consumers derive utility from the characteristics of the good rather than directly from the good itself. A change in price of the good will cause discrete change from one bundle to the other that will provide the most cost-effective combination of attributes. The choice experiment provides respondents with attributes of the resource being valued and then they will choose the attribute that offer highest utility. This study also identified the basic attributes of Lake Tana. For such process, Random utility model is appropriate. Random utility model states that respondents have consistently selected among alternatives that offers the highest utility. Assume two alternatives (i & j) provided to the respondents. Rational respondents will choose alternative j if its utility higher than utility of state i.

$$u_{nj} = v_j\left[A_j,\ X_n\right] \tag{1}$$

$$u_{ni} = v_i[A_i, X_n] \tag{2}$$

where A_j = attribute j, Ai = attribute i, Xn = socioeconomic characteristics of individual n, U_{ni}&U_{nj} = total utility derived from attribute i or j by individual n respectively.

According to Lancaster (1966), utility derived from the consumption of a good is the sum of two components. The first one is deterministic but the second one is stochastic. Hence the above two equations show the deterministic one. However, the study must incorporate the stochastic term of utility from the consumption of the good.

$$U_{nj} = v_j\left[A_j,\ X_n, \varepsilon_{nj}\right] = v_j\left[A_j,\ X_n\right] + \varepsilon_{nj} \tag{3}$$

where, X_n is the vector of socioeconomic variables of individual n.

$$U_{ni} = v_i[A_i,\ X_n, \varepsilon_{ni} = v_i[A_i, X_n] + \varepsilon_{ni} \tag{4}$$

Thus, an individual n will choose attribute j if:

$$U_{nj} - U_{ni} \geq 0 \tag{5}$$

There is probabilistic nature regarding with the choice since the researcher could not know individuals' utility:

$$p(j / A_c) = p\left\{v_j\left[A_{nj},\ X_n\right] + \varepsilon_{nj} > p\{v_i[A_{ni},\ X_n] + \varepsilon_{ni}\right. \tag{6}$$

$$p(j / A_c) = p\left\{v_j\left[A_j,\ X_n\right] - v_i[A_i,\ X_i] > \varepsilon_{ni} - \varepsilon_{nj}\right\} \tag{7}$$

The correct econometric model specification of a given study depends up on the distribution of error term and how the error term enter in indirect utility function (Alpízar et al., 2001). Based on Eq. (7) we have to make some assumption about the error term to make important analysis. From Eq. (7) we have the difference of two error terms. The difference of two gamble errors is logistically distributed with Type I gamble distribution. Hence, it is possible to express the probability to choose alternative j over alternative i by individual n with conditional logit model (Meginnis, 2018). Greene (2003), if the disturbance term of choice j is independent and identically distributed with type I Extreme Value, the probability to choose alternative j will be given by:

$$\boldsymbol{p(j)} = \frac{\boldsymbol{e^{\omega v_j}}}{\sum_{i=1}^{\boldsymbol{N}} \boldsymbol{e^{\omega v_i}}} \tag{8}$$

ω = scaling parameter.

Eq. (8) can be calculated by using multinomial logit model since choice experiment provides individuals with multiple alternatives that are set of attributes levels. This model has one great assumption that is independence of irrelevant alternatives (IIA). The IIA assumption states that the probability that an individual selecting alternative j is independent of absence or presence of the other alternatives. Again, the equation 8implies that the same parameter for all individuals for all attributes since the model is conditional logit model. This means homogeneous taste and preference. However, this is not the case under non market valuation due to many observed or unobserved factors make heterogeneity. Discrete choice experts have developed different models that can consider the heterogeneity. Even if they could develop many models, they did not specify which model is the superior among those models. The well known models are Random Parameter logit and Latent class model. Both random parameter logit and latent class logit models allow heterogeneity and relax the assumption of independence of irrelevant alternatives (Zhang and Sohngen, 2018).

Under random parameter logit model coefficients of attributes are random to account taste of respondents. The odds of probabilities of two alternatives could not beaffected by adding or removal of other alternative. Random part of utility in this model can be categorized into two; the first one is independent and identically distributed that is gamble and the second one is preference of individuals can take any distribution (Zeng, 2011). Given two alternatives presented to respondents that are j & i, the probability to choose alternative j:

$$p_{jn} = e^{\beta \acute{x}_{jn}} \Big/ \sum_{j=1}^{J} e^{\beta x_{in}} f(\beta) d\beta$$

Therefore, the utility of alternative j is given by:

$$V_{jn} = \beta_0 + \beta_1 A_1 + \ldots + \beta_h A_h + \gamma_1 X_1 + \gamma_2 X_2 + \ldots + \gamma_s X_s$$

where, $A_1 \ldots A_n$ attributes in option j, $X_1 \ldots X_s$ are socioeconomic characters tics of individual n.

β_0 represent alternative specific constant. Alternative specific constant (ASC) account the mean effect of unobserved factors in the error term for each alternative (Blamey et al., 1999).

2.4. Attribute identification

The attribute identification of this study has used the help of experts and focus group discussion of households. Therefore, the study has identified five major attributes of Lake Tana including monetary cost. These are water quality of Lake Tana, irrigation service of Lake Tana, fishery, recreation and price. Except price (monetary cost) all attributes have three levels including status quo. The level of each attributes has been determined with the help of experts and focus group discussion. However, Price (monetary cost) has six levels. The level of price seems many; however, it has its own advantage. Providing respondents with many prices will expand the choice of respondents among different attributes of the resource being valued (see Table 1).

2.5. Identification of socioeconomic variable

Socioeconomic factors would have their own effect on household's willingness to pay to the resource being valued. Hence, the following socioeconomic variables are included in this study.

i. Expenditure other than Lake Tana: it is the amount of expenditure spent by households for their consumption, and other activities. It is measured in terms of birr. The study expects that expenditure would have positive effect on status quo but negative for improved situation. The result proven the study's expectation that is expenditure of household's on other commodity has negative effect on the improved situations of attributes of Lake Tana but positive on status quo.
ii. Level of education: it is the schooling year of individuals. The study used education as categorical variable. Education in this study is categorized in to four (Illiterate (Edui), Basic Education (EduB), Primary and secondary Education (Edusp) and TVT and above Education (EduTA)); the reference category is illiterate (Edui). The study had expected that as household's schooling

Table 1. Attribute identification.

Attribute	Description	Level
Water quality	it is measured by amount of turbidity and Sewage of the lake	1. Status quo 2. Medium quality 3. High quality
Irrigation	the lake has its own role of irrigation. The role Of irrigation measured by the cover of irrigation land	1. Status quo 2. Increase by 5% 3. Increase by 10%
Fishing	Fishery is the main economic activity of Lake Tana. Harvesting of fish by using tone is the measure of fishery economic activity.	1. Status quo 2. Increase by 10% 3. Increaseby 20%
Recreation	Recreation is the other attributes of Lake Tana is recreation	Recreation facilities 1. Status quo are main factors to derive some sort 2. Increase by 5% pleasure.Beaches are used to measure 3. Increase by 10% availability of recreation facilities. Since there is no beach around the lake, number of lodge is used to measure availability of facilities.
Monetary cost	it is the price that is paid by households to preserve Lake Tana's attributes.	1. Birr75 2. Birr140 3.birr200 4.birr300 5.birr410 6.birr600

increases, they will prefer the improved attributes of Lake Tana attributes. The result also supports this expectation in which households who attend technical and vocational training (TVT) and above have preferred the improved attributes of the lake relative to illiterate individuals.

iii. Sex: it is the sex of respondents. It is discrete variable which sex takes value 1 if individual is male, 0 otherwise. The study expects that being female or male would not have an effect. The result shows that sex has not significant effect.

iv. Age: it is the years of age for individuals. It is continuous variable that is measured in terms of year. The study expects that it would have positive effect for improved situation but negative for status quo. The result shows that younger households have preferred the improved attributes of Lake Tana, however households who are aged have preferred the status quo attributes of Lake Tana.

v. Land ownership around Lake Tana (lav). This variable is categorical variable in which land ownership takes value 1, ifa respondenthave land around the lake0 otherwise. The study had expected that households who haveland around the lake will prefer the improved attributes of the lake relative to the status quo. The result supports this expectation that is households who land around the Lake Tana have preferred the improved attributes of the lake relative to households who have not land around.

vi. Distance from the Lake Tana (Dist): It is continuous variable and measured in terms of kilometer about Lake Tana. The study had expected that distance from the lake will have negative effect on the improved attributes of the lake. However, distance from Lake Tana has not significant effect on the choice of households.

vii. Family size (famsiz): This is one of the socioeconomic variables that many studies consider as factor to conserve natural resource. Family size means the number of people in a given household. The study had expected that family size will have negative effect on willingness to pay to improved attributes of Lake Tana. However, the result shows that family size has positive effect on the improved situation of attributes of Lake Tana. This means as family size increases households have preferred the improved attributes of the lake relative to status quo. The justification is provided in the discussion part of the article.

2.6. Choice experimental design

After the identification of attributes and levels of the resources being valued, the next task of choice experiment is experimental design (Birol et al., 2006). Experimental design is used to nominate attribute levels to the alternatives that form basis for choices and it is also important to construct set of choices that will be provided to respondents. Alternatives that will be presented to respondents must have sufficient variation over attribute levels to estimate parameters of preference. Providing all combinations of attributes is difficult and impossible (Holmes et al., 2017). Providing all combinations of the good attributes is not feasible because the number of combinations of the good attributes is many and result in very large number of choice sets. Many choice sets discourage respondents to make rational choice among alternatives. Hence, the challenges of choice experiment are designing choice sets with simple and efficient manner. Different experimental designs are available including orthogonal main effect design, D-optimal design, fractional factorial design and cycled design (Zhifeng Gao, 2009). Therefore, by considering the element of efficient experimental design, this study has applied fractional design and R lab was used to design the choice set of this study.

2.7. Nature of survey

The survey was administered for two months between March and April 2018. The survey was conducted through face to face interview with structured questionnaire. The survey has two parts. The first part deal with socioeconomic character of respondents, the second part deal with choice of respondents regarding with valuation. The study was proposed to survey 250 respondents. The respondents were household head. However, the actual survey used to analysis of the study was 238 individuals. Twelve questionnaire were defective due to careless response of respondents. This means the response rate was 95.2%. Among 238 respondents, 45 were females. The survey reveals that the number of female respondents was smaller compared to the male respondents.

3. Result and discussion

3.1. Descriptive statistics

The study describe the nature of quantitative variables by using central location and dispersion measurements. This study has four socioeconomic continues variables, age, expenditure other than Lake Tana (Expend), family size (famsiz) and distance (Dist). The following Table 2 shows the summary statistics of those variables:

The mean age, family size (famsiz), expenditure other than Lake Tana (expend) and distance from Lake Tana (Dist) is 42.76, 5, 50904.79 and 2.10 respectively. The standard deviation of age, family size, expenditure other than Lake Tana and distance from Lake Tana is 12.23, 2.21,

Table 2. Summary statistics of continuous variables.

Variable	Obs	mean	Std.Dev	Min	Max
age	238	42.7605	12.22815	24	76
famsiz	238	5.394958	2.212529	1	11
Expend	238	50904.79	46594.14	1240	234780
Dist	238	2.101227	2.114708	0.02	14

Source own computation based on survey

46594.14 and 2.11 respectively. The range of age of households is wide that is 52 (76–24). This means age of households is more variable. The minimum and maximum expenditure other than Lake Tana is 1240 and 234780 respectively. This indicates there is extreme difference between households' expenditure other than Lake Tana.

The study has described socioeconomic variables over sex of respondents. The mean age, expenditure other than Lake Tana, distance from the lake and family size of female headed household is 39.6, 47085, 1.81 and 5.15 respectively. The mean age, expenditure other than Lake Tana, distance from the lake and family size of male headed respondents is 43.5, 51795, 5.45 and 2.16 respectively. Except expenditure other than Lake Tana, it is possible to say that the mean of all variables approximately equal both in female headed and male headed respondents. The following Table 3 illustrates the description of socioeconomic variables over sex of respondents.

The study finds that there is extreme difference between households' expenditure other than Lake Tana. The mean income of female headed and male headed respondent is somewhat different. The study has conducted t-test to test whether mean of expenditure other than Lake Tana between female headed and male headed is statistically different. The t-test indicates that the mean difference between female and male is significant at 1% significance level. This means that the expenditure of male respondents is higher than female respondents (see Table 4).

The other socioeconomic variable that the survey examined is level of education of respondents. The study categorized education into five groups. These are illiterate (Edui), basic education (EduB), primary education (EduP), secondary education (Edus) and technical and vocational training and above education (EduTA). The survey found that most of respondents were illiterate. In percentage form 48.32% of respondents were illiterate, 13.45% of respondents were attend basic education, 12.61% attend primary education, 8.40% were attend secondary education and 17.23% had attend TVT and above education. The following Table 5 shows that the summary statistics of households' education over socioeconomic variables.

3.2. Relative choice of the alternative

The study has developed and presented two improved scenario and status quo of Lake Tana to respondents. As mentioned on the design part of the study eight choice sets were presented to each respondent. This indicates that 1904 (238*24) choices are made by respondents. Among choices the opt out (status quo) is chosen 81 times. In other words, 4.25% of the whole choices are status quo. The second option is chosen 978 times among the whole choices. The third scenario is selected 845 times among the total choices. This means 44.38% of 1904 choices are the third scenario. Therefore, it is possible to say that households have more likelihood to prefer the improved scenario. This implies that households will be better off for the improved scenario of Lake Tana relative to the scenario. Table 6 summarizes the relative choice of the scenario (see Tables 7, 8, 9).

3.3. Econometric result

3.3.1. Test of independence of Irrelevant Alternatives(IIA)

Economic valuation using choice experiment can be analyzed by conditional logit or random parameter logit model. The choice between conditional logit and random parameter logit models depends on IIA assumption. The IIA assumption states that the probability that an individual selecting alternative j is independent of absence or presence of the other alternatives. Independence of irrelevant of alternatives in conditional logit model can be tested by the method developed by Hausman so called Hausman specification test. If the subset of the choice set really irrelevant, removing a given alternative in the set will not change parameter estimates systematically. Excluding a given alternative will inefficient but still consistent (Greene, 2003).

Table 3. Mean of continuous variables over sex.

Sex	Freq	Mean (age)	Mean (expend)	Mean (Dist)	Mean (Dist)
Female	45	39.6	47085	1.81	5.15
Male	193	43.5	51795	2.16	5.45

Source own computation based on survey

Table 4. Households' expenditure difference over sex.

Group	Freq	Mean	Std. Err	Std. Dev	95% CI
Female	45	47085	1916.35	62977.59	(43324.92,50845.3)
Male	193	51795	614	41821	(50590.69,53000.07)
Diff			-4710.272		Pr (|T| >|t|) = 0.0028 T = -2.9938

Table 5. Households' education over continuous variables.

Group of Education	Freq	Mean (age)	Mean (Expend)	Mean (famsiz)	Mean (Dist)
Edui	115	47	45776	6	2.3
EduB	32	42	48374	5.46	1.7
EduP	30	39	45583	5.1	1.773
Edus	20	36.15	49274	4.2	2.065
EduTA	41	36	71953	3.75	2.05

Source; own Computation based on the survey

Table 6. Relative choice of scenario.

Alternative	choice of Freq	percentage
Scenario1 (status quo)	81	4.25
Scenario2	978	51.36
Scenario3	845	44.38

Source, own computation based on the survey

Table 7. Result of RPL model.

Dependent Variable	Attributes	Parameters	Standard error	P - value
Choice	ASC0	-0.76	0.29	0.0082731 **
	WQ_medium	1.66	0.25	5.216e-11 ***
	WQ_high	2.71	0.28	2.2e-16 ***
	IR_10	1.17	0.17	1.240e-11 ***
	IR_15	2.40	0.53	7.232e-06 ***
	Fish_10	0.91	0.19	2.918e-06 ***
	Fish_20	0.71	0.16	1.217e-05 ***
	Rec_5	1.35	0.28	1.911e-06 ***
	Rec_10	0.96	0.18	1.186e-07 ***
	Price	-0.001	0.001	0.0001880 ***
	Sd. WQ_medium	0.76	0.39	0.0544362
	Sd. WQ_high	2.04	0.25	1.776e-15 ***
	Sd.IR_10	1.56	0.24	2.604e-10 ***
	Sd.IR_15	2.56	0.68	0.0001942 ***
	Sd. Fish_10	0.67	0.38	0.0844018
	Sd. Fish_20	0.69	0.34	0.0482395 *
	Sd. Rec_5	1.91	0.37	2.902e-07 ***
	Sd. Rec_10	1.64	0.26	5.290e-10 ***

$X^2 = 845.5173$; Pchisq = 3.172895e-177; AIC = 2377.966; McFadden Pseudo R^2 = 0.27; Number of obs = 5712.
Note: *p < 0.1; **p < 0.05; ***p < 0.01.
Source own computation based on the survey

Table 8. Extended random parameter logit model.

Dependent Variable	Attributes & interacted Vars	Coefficients	Standard errors	P- Value
Choice	ASC0	2.94	3.1	0.3394601
	WQ_medium	1.54	2.3996e-01	1.526e-10 ***
	WQ_high	2.46	2.6134e-01	2.2e-16 ***
	IR_10	1.1	1.6831e-01	3.340e-10 ***
	IR_15	2.41	5.7178e-01	2.483e-05 ***
	Fish_10	8.51	1.8680e-01	5.189e-06 ***
	Fish_20	5.9012e-01	1.5383e-01	0.0001250 ***
	Rec_5	1.25	2.6478e-01	2.285e-06 ***
	Rec_10	9.2953e-01	1.7628e-01	1.342e-07 ***
	Price	-1.8556e-03	5.2053e-04	0.0003640 ***
	ASC0:sex	-1.1604e-01	8.0331e-01	0.8851399
	ASC0:Expen	1.1305e-05	3.2333e-06	0.0004716 ***
	ASC0:famsiz	-2.3835e-01	1.5109e-01	0.1146685
	ASC0:Dist	-9.5888e-02	2.1326e-01	0.6529804
	ASC0:lav	-4.23	8.7084e-01	1.211e-06 ***
	ASC0:age	-1.9742e-01	1.3343e-01	0.1389910
	ASC0:age2	2.8864e-03	1.4114e-03	0.0408425 *
	ASC0:Edui	5.3518e-01	1.04	0.6077946
	ASC0:EduB	1.5224e-01	1.06	0.8867251
	ASC0:Edups	1.6681	8.7321e-01	0.0560857
	ASC0:EduTA	4.0126e-01	7.5894e-01	0.5970126

Log-Likelihood: -1118.8; Pchisq: 2.654706e-189; AIC = 2295.628: pseudo R^2 = 0.29; X^2 = 949.8556.
Note: *p < 0.1; **p < 0.05; ***p < 0.01.

$$X_k^2 = \left(\widehat{\beta}_s - \widehat{\beta}_f\right)' \left[\widehat{\nu}_s - \widehat{\nu}_f\right]^- \left(\widehat{\beta}_s - \widehat{\beta}_f\right)$$

where k = $\widehat{\beta}_s$ = parameter estimates when a given alternative is excluded, $\widehat{\beta}_f$ = parameter estimates when full alternative is considered, $\widehat{\nu}_s$ = covariance of parameters when a given alternative is removed, $\widehat{\nu}_f$ = covariance of parameters when all alternatives are available, and k = number of rows in removed alternative estimation.

H0 : IIA holds

H1 : IIA is rejected

This study also conducted Hausman-McFadden test. The result shows that X^2 = 25.956 and the probability value is 0.003799. This result indicates that the alternative hypothesis is accepted. This means alternatives of this study are not independent. Hence, it is better to conduct the random parameter logit model (RPL).

3.3.2. Random parameter logit model

Econometric model of this study has applied random parameter logit model since this model can account forpreference heterogeneity. The study has also conducted conditional logit model but it failed to satisfy independence of irrelevant alternatives (IIA). The study used the status quo as bench mark to see the preference of respondents for improved situation of Lake Tana. The random parameter logit model result shows that all improved levels of Lake Tana's attributes have the expected sign that is positive and significant at 1% significance level. This implies that respondents preferred the improved level of attributes relative to the status quo. An alternative specific constant (ASC0) for status quo option indicates the expected sign is negative at 5% significance level, and it is very nice to find negative ASC0. This implies that respondents have preferred the improved alternatives (option2 and option3) relative to the status quo option.

The usual model fitness measurements are AIC and BIC. Both AIC and BIC specified as $-2ll + k\gamma$, where ll is log likelihood value of the unrestricted model, k is number of parameters estimates of corresponding to variables in the model, and γ is the penalty constant that is 2 in AIC and natural log of the sample size in BIC. AIC and BIC have attempted to evaluate the model fitness by targeting on reducing information loss. The lower AIC and BIC values are more preferred over models those have higher AIC and BIC (Hauber, 2016). This study also estimates value of AIC both in conditional logit model as well as in random parameter logit. The AIC of random parameter logit model is lower than AIC of conditional logit model. In figure, AIC of random parameter logit model is 2377.966 but the AIC of conditional logit model is 2647.036. This indicates that information loss is lower in random parameter logit model than conditional logit model.

Table 9. Extended random parameter logit model (Interaction between socio-economic variables and attributes).

Attributes & interacted	Vars coefficient	Std. Error	z-value	Pr (>|z|)
ASC0	-0.87323464	0.31494825	-2.7726	0.0055605 **
WQ_medium	1.74477636	0.27126080	6.4321	1.259e-10 ***
WQ_high	-0.73418427	1.76359264v	-0.4163	0.6771902
IR_10	-1.50856918	1.98016281	-0.7618	0.4461549
IR_15	2.27566450	4.01628173	0.5666	0.5709793
fish_10	0.94958146	0.20729633	4.5808	4.632e-06 ***
fish_20	0.61259757	0.16663435	3.6763	0.0002366 ***
Rec_5	-1.05991634	2.91502149	-0.36360	.7161530
Rec_10	-1.78223193	1.88444274	-0.9458	0.3442706
price	-0.00200901	0.00054284	-3.7009	0.0002148 ***
WQ_high: Dist	0.28226122	0.08436175	3.3458	0.0008203 ***
WQ_high: lav	0.57535820	0.27678479	2.0787	0.0376431 *
WQ_high: age	0.16917240	0.07466153	2.2659	0.0234601 *
WQ_high:age2	-0.00209158	0.00079908	-2.6175	0.0088577 **
IR_10:lav	1.03909520	0.30438045	3.4138	0.0006406 ***
IR_10:EduTA	-1.33405928	0.53246361	-2.5054	0.0122297 *
IR_10:age2	-0.00188141	0.00090007	-2.0903	0.0365909 *
IR_15:lav	1.66809275	0.64626120	2.5811	0.0098474 **
Rec_10:Dist	-0.16492171	0.08402034	-1.9629	0.0496603 *
Rec_10:lav	0.62488774	0.30835188	2.0265	0.0427094 *
Rec_10:EduTA	1.32948047	0.51954332	2.5589	0.0104992 *

Log-Likelihood: -1102.7; Pseudo: 0.29; AIC: 2347; Pchisq: 1.197255e-158; Obs: 5712.
Note: *p < 0.1; **p < 0.05; ***p < 0.01.
Source own Competition based on data.

According to Kataria (2012), significant standard deviation of attributes of the resource being valued indicates that preference heterogeneity between respondents. This study also faced by preference heterogeneity in some level of attributes like water quality with high quality (WQ_high), irrigation expansion with 10% expansion (IR_10), irrigation expansion with 15% expansion (IR_15), recreation facility expansion with 5% (Rec_5) and recreation facility expansion with 10% (Rec_10). Pan (2011), random parameter logit model cannot provide justification why preference heterogeneity is happened. Most of the time individual specific characteristics are source of preference heterogeneity. It is possible to capture this heterogeneity by undertaking interaction of individual specific characteristics with choice specific attributes and/or alternative specific constant.

Therefore, this study also undertakes extended random parameter logit model through the interaction of alternative specific constant (ASC0) with socioeconomic variables. The result shows that all improved levels of attributes are positive and significant at 1% significance level. This implies that respondents will be better off while they prefer the improved level of attributes relative to the status quo. However, the monetary cost (conservation price) is negative and significant at 1% significance level. This means that as conservation price increases, the utility that individuals would derive from improved Lake Tana will

decrease. This is supported by the standard microeconomics demand theory. The alternative constant (ASC0) is positive but insignificant. The interaction between ASC0 and sex (ASC0: sex), ASC0 and family size (ASC0: Famsiz), ASC0 and distance away from Lake Tana (ASC0: Dist), ASC0 and age (ASC0: age) and ASC0 and educational status of respondents are insignificant. The insignificance of those coefficients suggests that there is no preference heterogeneity among options (opion1, option2 & option3). However, the interaction between ASC0 and expenditure (ASC0: Expend), ASC0 and land availability around the lake (ASC0: lav), and ASC0 and age square (ASC0:age2) have positive, negative and negative and significant at 1%, 1% and 5 % significance level respectively. As the level of individual-expenditure increases, the preference strongly tilts towards the option status quo. Those respondents who have land around the lake have strong preference for improved Lake Tana relative to status quo. Aged individuals have preferred the status quo relative to the improved Lake Tana.

As mentioned on the above the other technique that can capture preference heterogeneity is the interaction of attributes that have preference variation with socioeconomic variables. This study has also conducted such a model. The result is as follow as:

The interaction between high water quality and households' distance from the lake (WQ_high: Dist) have positive and significant effect at 1% significance level. This means that as the distance of households far from the lake increases, the more likelihood to prefer water quality with higher improvement. This is expected because households far from the lake have no chance to harvest fish and irrigation from Lake Tana rather, they can derive recreation utility by preserving water quality of the lake. The interaction between high water quality and land availability around the lake (WQ_high: lav) have positive and significant effect at 5% percent significance level. This means that households those who have land near to the lake have greater probability to choose water quality with high improvement relative to households do not have land near to the lake. This is also expected since households have to keep the water quality of the lake to reap other services from Lake Tana. The interaction between high water quality and age (WQ_high: age) has positive and significant at 5% significance level. However, the interaction between high water quality and age square (WQ_high:age2) has negative and significant effect at 1% significance level. This result is very convincing. Younger and older aged households may not have same preference for water quality with high improvement. It is expected that younger households have high likelihood to prefer high water quality but the aged-households might prefer other option.

The other interaction is between 10% expansion of irrigation (IR_10) and socioeconomic variables. Among the interactions that have significant effect are as follow as: The interaction between 10% expansion of irrigation and land availability (IR_10: lav) has positive and significant effect at 1% significance level. This is expected result since households who have land near to the lake have greater likelihood to prefer 10% expansion of irrigation relative to who have not land around Lake Tana. This is because the households who have land near the lake can be directly benefitted from the expansion of the irrigation-facilities. The interaction between 10% expansion of irrigation (IR_10) and education above the TVT and above (EduTA) (IR_10: EduTA) has negative and significant at 5% significance level. This means that households who attained education TVT and above have lower probability to prefer 10% expansion of agriculture by the lake. The interaction between 10% expansion of agriculture (IR_10) and age square (age2) (IR_10:age2) has negative and significant effect at 5% significance level. This is expected since aged households have not additional age to reap agricultural advantage from the improvement of Lake Tana.

The other interaction is between 15% expansion of agriculture by Lake Tana and socioeconomic variables. Among the interactions only one interaction has positive and significant that is the interaction between 15% expansion of irrigation by the lake and land availability near to the lake (IR_15: lav). This implies the households who have land near to the lake have more likelihood to prefer 15% expansion of irrigation by the lake relative to households who do not have land near to the lake.

Table 10. Estimation of marginal willingness to pay.

Attributes with their improved levels	MWTP	95% CI
Basic Random parameter logit model		
WQ_medium	848.19	(339.19 1357.18)
WQ_high	1381.23	(649.99 2112.46)
IR_10	599.76	(241.37 958.15)
IR_15	1225.97	(479.34 1972.59)
Fish_10	465.34	(169.21 761.48)
Fish_20	363.15	(70.35 655.96)
Rec_5	688	(293.23 1082.77)
Rec_10	491.25	(245.57 736.93)
Extended Random parameter Logit model		
WQ_medium	827.98	(317.30 1338.65)
WQ_high	1324.42	(601.48 2047.35)
IR_10	569.80	(218.60 921.00)
IR_15	1299.20	(472.96 2125.44)
Fish_10	458.72	(162.67 754.78)
Fish_20	318.01	(38.41 597.61)
Rec_5	674.41	(274.52 1074.30)
Rec_10	500.92	(247.45 754.40)

3.3.3. Willingness to pay estimation

Maximum likelihood estimation can derive consumer surplus regarding changes in the level of attributes from random parameter logit model. The parameter estimates of attributes of the resource being valued is marginal utility of that attribute, and the coefficient of monetary cost indicates marginal utility of income. The ratio between the parameter estimate of a given attribute say(X) and monetary cost(P) is marginal willingness to pay to that attribute (Poirier and Fleuret, 2010).

$$WTP_x = -\frac{\beta_x}{\beta_p}$$

where β_x and β_p are coefficient of attribute X and monetary cost respectively.

Therefore, this study derives the marginal willingness to pay for Lake Tana's attributes identified by the study. As mentioned on methodology section of the study, this study has identified five attributes of Lake Tana including monetary cost. For the analysis purpose, the study has identified three levels for each attribute, and status quo of each attribute is considered as one level. The study set the status quo of each attribute as reference. Table 10 shows marginal willingness to pay for random parameter logit model .

The estimated marginal willingness to pay for each improved level of attribute implies that the households' willingness to pay formedium water quality, high water quality, expansion of Lake Tana irrigation by 10%, expansion of Lake Tana irrigation by 15%, increasing of fish harvesting by 10%, increasing of fish harvesting by 20%, expansion of recreation facility by 5%, and expansion of recreation facility by 10%.On an average, the households are willing to paybirr 1190.514 per year if government proposes to improve the water quality into high standard. The same is true for the remaining attribute levels.

4. Conclusion

The grand objective of the study was estimating the economic value of Lake Tana attributes using stated preference method of valuation in general, and choice experiment method in particular. The study has identified four attributes of Lake Tana with the help of experts and focus group discussion with local community. These are fishery resource, water quality, irrigation, and recreation. Each attribute has three levels

including their corresponding status quo. The study has identified two scenarios which can describe the improved situation of Lake Tana. However, the current situation (status quo) also presented with the improved scenarios of the lake. This is because to expand the choice of the household.

Choice experiment provides series of choice set to respondents to choose one of alternatives in the series of choice set. This study has surveyed 238 individuals to obtain relevant data then to meet the objective of the study. Face to face interview was applied to collect data from individuals. Each respondent was provided with eight series choice set question. Choice experiment has attempted to elicit the marginal willingness to pay/willingness to accept for the resource being valued by identifying the characteristics (attributes). The study has conducted random parameter logit model and extended random parameter logit model. The result shows that attributes of the Lake Tana that are included in the model are positive and significant in all models. This means that households are better off due to the improvement of the lake. The study has also estimated marginal willingness to pay for improved level of attributes of Lake Tana. The marginal willingness to pay is positive for all improved attributes.

5. Recommendation

The final task of a given study is suggesting recommendation for policy makers, general public, and researchers. This study also gives some recommendation based on the findings.

- ✓ Government should protect Lake Tana from any problem by raising fund from each household since Lake Tana's attribute like fishery production, its water quality, recreation and irrigation are valued by households. Households' willingness to pay to Lake Tana attributes indicates that the responsible body, like environmental office could improve Lake Tana's attributes by collecting fund from households. Currently, Lake Tana has exposed to water hyacinth and sedimentation so that government should save Lake Tana from such kind of problem since households are willing to pay to improve the quality of the lake in terms of its attribute.
- ✓ The study indicates that Lake Tana has several importance, particularly in terms of irrigation for households who have land near to the lake. These households are the right stockholders to protect the lake from any threat to reap different advantages from the lake particularly for irrigation. Government should encourage these households to preserve the lake from any problem, and government can improve households' utility from Lake Tana.

Declarations

Author contribution statement

Asmamaw Getnet: Conceived and designed the experiments; Analyzed and interpreted the data; Contributed reagents, materials, analysis tools or data; Wrote the paper.

Tefera Berihun Taw: Conceived and designed the experiments; Analyzed and interpreted the data; Wrote the paper.

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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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