




# Economic value of wetlands services in the Central Rift Valley of Ethiopia

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## Abstract

This study estimates the economic values of wetlands services in the Central Rift Valley of Ethiopia. A choice experiment valuation method was used to quantify monetary value of wetlands. The study used data collected from 405 households complemented with data collected using Participatory Rural Appraisals. Multinomial logit and random parameter logit models were used to analyze the data. The results have demonstrated the economic values of wetlands in the study area. Households ascribe the highest value for biodiversity (marginal willingness to pay value of US \$1.26 per percentage of biodiversity conserved), followed by water availability (US \$0.87 per ha increase in open water surface area). The statistical inferences, however, showed significant heterogeneity among households in their preference for wetland management alternatives. The probability of choosing improved wetland management is significantly reduced by age of the household head and distance; while, it is increased by education, income and location. The finding also revealed an average and aggregate willingness to pay of US \$7.5 and 694,141, respectively, for a change from status quo to high impact improvement scenario. It is, thus, recommended to take rehabilitation and conservation measures to ensure sustainable use and management of wetland resources in the area.

**Keywords** Choice experiment · Ecosystem services · Ethiopia · Valuation · Wetland

## 1 Introduction

Wetlands are among the world's ecosystems that provide hugely significant values to people worldwide in different ways: for their socioeconomic as well as ecological benefits (De Groot et al. 2016; McCartney et al. 2010; MEA 2005). Despite their

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multiple services and values, wetlands have been evil treated as ‘wastelands’, which have no value that has led to continued overexploitation, conversion, thereby rapid degradation and loss (Amsalu and Addisu 2014). Moreover, difficulty in reflecting and understanding the values of wetlands in economic term exacerbates their degradation and loss. The values of wetlands are often poorly understood among planners and decision-makers due to the absence of market value or zero market price for many goods and services of wetlands. Such lack of understanding of the values of wetlands has led to either their omission or less prioritization in public decisions and policy initiatives regarding protection and management of wetlands, which contributes to their degradation and loss (De Groot et al. 2016; Turner et al. 1998).

Like most other wetlands of the world, a large number of wetlands in Ethiopia are severely degrading and are at the verge of disappearance (Abebe et al. 2014; Menbere and Menbere 2018). The Central Rift Valley (CRV) lakes region is one of the environmentally very sensitive and vulnerable areas of Ethiopia. The overall resilience and sustainability of wetland resources<sup>1</sup> of the area has been threatened owing to overgrazing, conversion, water extraction, waste disposal and deforestation. The threats have continued resulting in falling lakes’ levels, worsened water quality, decline in biodiversity and overall deterioration of the ecosystem (Bezabih and Mosissa 2017; Pascual-Ferrer et al. 2014). The current growing threats to the wetlands of the CRV lakes imply that conservation and management of these ecosystems has gained little attention. To maintain the stream of benefits derived from these ecosystems, effective conservation and management of them is imperative. However, wetland conservation and management measures entail information on the economic value of wetland services. As Abebe et al. (2014) assert, wetland conservation and management decisions cannot be taken based on intuition alone, unless the values of wetlands are defined in economic terms. Since most planning and development decisions are made on economic ground, wetland goods and services need to be valued in monetary term if their conservation is to be chosen over alternative uses of the land and/or water (Chaikumbung et al. 2016; De Groot et al. 2016). In view of these and given the prevalence of threats to the wetlands of CRV lakes, a study on economic values of these wetlands is imperative and timely for informed decision on their conservation and management.

In Ethiopia, few studies (Abebe et al. 2014; Ali 2007; Yimenu and Rao 2015) were undertaken to estimate the economic value of wetlands. However, extensive site-specific wetland valuation studies in different contexts such as CRV, where virtually no such kind of study has yet been made, remain important. This is because, according to IWMI (2014), there is no universal response to the challenges of sustainability of wetlands, unless studies are conducted to understand local conditions and realities and design required conservation and management measures to specific needs and conditions. Each situation is unique and so the estimated economic values of wetland services vary enormously across wetlands with different biophysical characteristics. Moreover, the value people attach to wetlands

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<sup>1</sup> Wetland resources herein refer to open water of the lakes, the land surrounding the lakes that is saturated or covered with water; and the biodiversity—floras and faunas—found there.

emanates from the socioeconomic and cultural setting that differs from place to place. This study, therefore, aimed to address three objectives: (1) to estimate the economic values of wetland services in the study area using choice experiment (CE) method, (2) to examine socioeconomic factors that determine preferences of households (HHs) for wetland management plans, and (3) to estimate HHs' marginal willingness to pay (MWTP) and welfare impacts of improvements of wetland attributes. In so doing, it intends to bring the values of wetlands of the CRV lakes area to the attention of resource planners and decision-makers, thereby initiate better-informed, more efficient and sustainable wetland conservation and management measures. The study also contributes to the limited literature on wetland valuation studies in Ethiopia.

## 2 Theoretical framework: choice experiment method

The choice experiment (CE) method is a more efficient and appropriate value estimation and preferences modeling method for multi-attribute goods and environmental resources such as wetlands. The method is based on probabilistic choice theory named random utility theory (RUT) and utility maximization as a framework (Adamowicz et al. 1998; Merino-Castello 2003). RUT is consistent with Lancaster's characteristics theory of value that states consumers' utilities or preference orderings for goods (herein wetlands) are assumed to rank collections of goods indirectly through the characteristics/attributes/ they possess (Lancaster 1966). RUT assumes that utilities depend on choices made; and an individual's choices are based on attributes of the alternatives. In this study, it is presupposed that people derive satisfaction not from the wetlands themselves rather from the attributes that the wetlands possess. The attributes of the wetlands have different levels and so the alternatives include different combinations of the levels of the attributes. Sets of alternatives are assembled in choice sets and individuals choose their preferred alternative, with the highest expected utility. If there is a change in one of the attributes (or the level of the attributes) of the wetlands, it may result in a discrete shift in choice from one alternative to another and will affect the probability of choosing that alternative on the margin. However, as Kjaer 2005 noted, individuals' choices cannot be perfectly predicted because there are some uncertainties surrounding the choices. Hence, instead of identifying one alternative as the chosen option, each alternative is assigned with a probability to be chosen.

RUT states that an individual's utility from the choice made is not directly observable; however, an indirect determination of preference is possible (McFadden 1974). Hence, for any sampled individual  $i$  ( $i = 1 \dots J$ ), the indirect utility/benefit/ $(U_{ij})$  derived from any alternative of wetland management  $j$  ( $j = 1 \dots J$ ) from a choice set  $C_i$  is a function of the attributes of the wetland management scenario ( $Z_j$ ) and the socioeconomic characteristics of the individual ( $S_i$ ):

$$U_{ij} = V(Z_j, S_i) + e. \quad (1)$$

The indirect utility ( $U_{ij}$ ) is the sum of deterministic/systematic component ( $V$ ) of utility that can be estimated by the researcher and a stochastic/random aspect ( $e$ ) of utility which is unknown to the researcher is independent of the deterministic part and follows a predetermined distribution. The stochastic ( $e$ ) portion implies that predictions cannot be made with certainty, and so captures the difference between  $U_{ij}$  which is the true utility and  $V$  which is the observed utility or representative utility—part of utility that the researcher captures (Kjaer 2005; Train 2009).

### 3 Materials and methods

#### 3.1 Description of the study area

The Ethiopian CRV is located between  $7^{\circ} 10' E$ – $8^{\circ} 30' N$  and  $38^{\circ} 15' N$ – $39^{\circ} 25' E$ ; and covers about 1 million ha consisting of four lakes: Ziway, Abijata, Langanu and Shala, and four rivers: Bulbula, Meki, Katar and Horakelo (Pascual-Ferrer and Candela 2015; Hengsdijk et al. 2009). The specific areas covered under this study are wetlands of Lakes Ziway and Abijata. The wetland ecosystems of the two lakes have multiple socioeconomic and ecological significances. However, currently, they are at greater risks owing to increased human activities notably excessive extraction of water for irrigation farming and industrial purpose, increased conversion of wetlands and natural vegetation, overfishing, overgrazing and sand mining, that have resulted in pervasive shrinking in the size and quality of the lakes and the wetland resources (Gebeyehu et al. 2015; Menbere and Menbere 2018; Pascual-Ferrer and Candela 2015). The climate of CRV area varies along an altitudinal gradient, but is generally characterized by arid and semi-arid climate. The mean annual rainfall ranges from about 250–900 mm; with about 70% of the rainfall occurring from June to September. The temperature of the area ranges from 4.3 to 29.5 °C (Meshesha et al. 2012; Pascual-Ferrer et al. 2014). *Acacia* woodland and savannas are the dominant vegetation types. The major means of livelihood is mixed farming—livestock rearing and crop production. Maize is the dominant staple food crop of the area; whilst, haricot beans, wheat and *tef* (*Eragrostis tef*) are grown for cash (Pascual-Ferrer et al. 2014).

#### 3.2 Choice experiment design

Following the common approaches and steps of CE method used in different literatures (Abebe et al. 2014; Adamowicz et al. 1998; Birol et al. 2006; Kjaer 2005; Yimenu and Rao 2015), the CE design for this study includes:

- (i) *Defining attributes and their levels* For this, we consulted literature; conducted interview with professionals from Arsi University; Rift Valley Lakes Basin Authority and rural land administration and environmental protection bureaus of study *woredas* (districts); and participatory rural appraisal (PRAs) with com-

- munity leaders and development agents (DAs) of three *kebeles*.<sup>2</sup> Accordingly, three attributes of wetlands: biodiversity, water availability and recreational service; and a payment attribute were selected.
- (ii) Degradation in the stock and diversity of flora and fauna species is widely prevalent in the wetlands of Lakes Ziway and Abijata (Menbere and Menbere 2018; Pascual-Ferrer and Candela 2015). Hence, management strategies which include three different levels of improvement in biodiversity were proposed (Table 7). Significant decline and annual fluctuation in the water level, and shrinkage of the water surface area have been observed in the two lakes and associated wetlands (Gebeyehu et al. 2015; Temesgen et al. 2013). Moreover, currently, it is only in the summer season that water is adequately available (PRA finding). In view of this, three levels of improvement for water availability were proposed. The two lakes and associated wetland ecosystems are among Ethiopia's important places that have remarkable uses for recreation and tourism development (Menbere and Menbere 2018). However, these benefits are declining owing to, among others, inadequate provision of infrastructures, resting facilities and poor waste disposal (Ali 2007; Gebeyehu et al. 2015). Thus, two levels of improvement have been proposed. A monetary attribute was also included to estimate the value of wetland attributes in terms of respondents' willingness to pay (WTP). It is a one-off payment that each HH contributes, in the form of environmental fund, for improvement of wetland resources.
- (iii) *Experimental design and choice set determination* This involved combining the levels of the attributes to obtain optimal alternative scenarios; then assembling the alternatives into choice sets. The alternative scenarios generated using full factorial design from 4 attributes (3 with 4 levels and 1 with 3 levels) were 192 (i.e.,  $4^3 \times 3 = 192$ ). This is a very large combination that could not be feasible. Hence, we used fractional factorial design, which consisted of only the main effects. To develop an efficient and optimal design, we followed the principles of (1) *level balance* where attribute levels occur the same number of times within a choice set; (2) *orthogonal* where the frequencies for level pairs are proportional or equal and where attribute levels of the alternatives within each choice set are not correlated and (3) *minimal overlap* where attribute levels occur the same number of times within a choice set (Scarpa and Rose 2008). Since an orthogonal and balanced design was used the D-efficiency of the experimental design was 100%. In the OPTEX procedure of SAS statistical software using orthogonal design, 12 different improvement alternative scenarios were generated and randomly assembled in six choice sets. Each choice set encompasses three alternatives: two with different combinations of wetland improvement alternatives and a status quo alternative (Table 8).
- (iv) *Questionnaire development* Question items in the first section of the questionnaire elicit data about households' demographic and socioeconomic status, and their perception about the wetland ecosystems of the study areas. The CE section

<sup>2</sup> *Kebele* is the smallest administrative unit in Ethiopia.

had six consecutive choice sets each having three alternatives. The follow-up questions, next to CE, aimed at seeking information about the respondent's reason for the choice of alternatives in the choice set questions.

- (v) *Sampling and data collection* This study used primary cross-sectional data collected from HHs of three study *woredas*: Arsi Negelle, Ziway Dugda and Adami Tulu Jido Kombolcha (ATJK). The sampling procedure involved purposive and random sampling techniques. The study *woredas* are purposely selected since they are located in the catchments of Lakes Ziway and Abijata and border the two lakes. We need to target on bordering *woredas* because communities who live in these *woredas*, as compared to those who live in distant *woredas*, are more likely to use or benefit from wetland resources of the two lakes. Hence, the study finding can best help practical decisions regarding wetland conservation and management measures that demand involvement of local community since local communities are often at the forefront in conservation and management efforts. Then *kebeles* (the smallest administrative unit in Ethiopia) that are found in the three study *woredas* and which border the two Lakes were identified, in consultation with DAs. A total of 30 *Kebeles* (i.e. 21 Lake Ziway bordering and 9 Lake Abijata bordering) were identified, as primary sampling unit. From these bordering *kebeles*, six sample *kebeles*, three from Lake Ziway (Abine Germama, Senbero, Burqa Lemefo) and three from Lake Abijata (Daka Deltu Harengema, Galle fi Qello, and Desta Abijata) bordering *kebeles* were selected using simple random sampling method. Following this, using a probability proportional to size sampling technique 422 HHs—281 from male headed and 141<sup>3</sup> from female headed were randomly sampled from the six *kebeles*. The survey was administered by well-trained data collectors in a face-to-face interview with the heads of HHs. Prior to the main survey, the questionnaire was pre-tested using 30 individuals. The survey data were complemented with the data generated through PRAs. The data were collected from December 2016 to February 2017.

### 3.3 Method of data analysis

The data generated from 405 completely filled questionnaires, out of the 422, were used in data analyses. Descriptive statistics: frequency, percentage, mean and standard deviation (SD) were used to describe HHs' background characteristics and perception about status and problem faced by the wetlands of the study areas. LIMDEP 8.0 or NLOGIT 3.0 econometrics software was used to estimate random parameter logit models (RPLM) or mixed logit model. Multinomial logit models (MNLMS) were also estimated for comparison. In each CE model, there are three indirect utility functions; one representing utility from the status quo that was considered as a base category; and the other two utility from wetland improvement plan 1 and plan 2. Models estimations were based on 2430 observations that is the total number choices elicited from 405 respondents who were presented with 6 choice sets and

<sup>3</sup> This figure of female-headed HHs might be attributable to the prevalence of polygamy in the study area.

asked to choose one among the three alternatives per choice set (405 respondents \* 6 choices). Because the coefficients are confounded by a different scale parameter  $\mu$ , estimated parameter cannot be interpreted as the contribution made to utility by each attribute or variable in any absolute sense as they are (Yimenu and Rao 2015). Rather, the coefficients revealed the significance and direction of the impacts on the HHs' probability of choice between the status quo and wetland improvement plans; and so represent neither the actual magnitude of change nor probabilities.

### 3.3.1 Model specification

**3.3.1.1 Basic multinomial logit model (MNL)** The basic MNL is derived under the assumptions that each unobserved factor ( $e$ ) is independently and identically distributed (iid)<sup>4</sup> extreme value; and individuals' preference is homogeneous (Birol et al. 2006). The indirect utility is a function of wetland attributes only and the model estimates the direction of the impact of the attributes in explaining individuals' probability of choosing an alternative scenario. The model, therefore, can help to know how much the attributes selected for the study are significant factors in the households' choice of wetland improvement plan without accounting for households' preference heterogeneity. Indirect utility is given as:

$$V_j = ASC + \beta_{\text{Biod}} \text{Biod} + \beta_{\text{water}} \text{Water} + \beta_{\text{recreat}} \text{Recreat} + \beta_{\text{paym}} \text{Paym}, \quad (2)$$

where  $V_j$ , ( $j=0, 1, 2$ ) represents indirect utility from the status quo, wetland improvement alternative plan 1 and plan 2, respectively;  $\beta_{\text{Biod}}$ ,  $\beta_{\text{water}}$ ,  $\beta_{\text{recreat}}$ , and  $\beta_{\text{paym}}$  are coefficients of biodiversity, water availability, recreation and monetary payment, respectively. The alternative specific constant (ASC)<sup>5</sup> was specified to equal 0 for the status quo (the comparator), whereas 1 for the wetland improvement alternative plans 1 and 2 because we used generic format and an orthogonal design to develop the choice sets (Yimenu and Rao 2015).

*Extended MNL* Assumes that preferences are heterogeneous across individuals; hence, it accounts for this heterogeneity by including socioeconomic variables. However, because the socioeconomic variables do not vary across choice occasions for any given respondent, the variables were included as interaction with ASC.<sup>6</sup> Hence, indirect utility is specified as:

$$V_j = ASC + \beta_{\text{Biod}} \text{Biod} + \beta_{\text{water}} \text{Water} + \beta_{\text{recreat}} \text{Recreat} + \beta_{\text{paym}} \text{Paym} + \delta_1 (ASC * S_1) + \delta_2 (ASC * S_2) + \dots + \delta_n (ASC * S_n), \quad (3)$$

<sup>4</sup> The iid assumption is identical to IIA (*independence of irrelevant alternatives*) assumption—the probability of choosing an alternative is unaffected by the presence or absence of other alternative in the choice set (Kjaer 2005).

<sup>5</sup> ASC captures the average effects on utility of all attributes/factors that are not included in the model.

<sup>6</sup> Interacting socioeconomic variables with ASC is the common approach to introduce observed heterogeneity in many CEs. In that case, it will not affect the MWTP (Birol et al. 2006).

**Table 1** Description of socioeconomic-related variables used in the CE analysis

Dependent variable		Description and measurement			
Choice	HH's choice for wetland alternative scenarios (a discrete variable that take value of 1 if the alternative is chosen and 0 otherwise)				
Independent variables	Description and measurement	Type	Hypothesized relationship	Identified relationship in studies	
				Positive	Negative
AGE	Age of HH head (in years)	Continuous	(+)	Dahmardeh and Shahraki (2014)	Carlsson et al. (2003) and Yimenu and Rao (2015)
SEX	Sex of HH head (male = 1, otherwise = 0)	Dummy	Indeterminate a priori	Yimenu and Rao (2015)	Dahmardeh and Shahraki (2014)
EDUC	Education level of HH head (in years spent in school)	Continuous	(+)	Birol et al. (2006), Dahmardeh and Shahraki (2014) and Yimenu and Rao (2015)	
FAMSIZ	Family size (in number)	Continuous	(-)		Birol et al. (2006) and Yimenu and Rao (2015)
GHI	Estimated gross annual income of HH (in ETB <sup>a</sup> )	Continuous	(+)	Bateman et al. (1995), Birol et al. (2006) and Yimenu and Rao (2015)	
DIST	Distance from home to the nearest edge of the lake or associated wetlands (in minutes to walk)	Continuous	(-)	Birol et al. (2006)	Bateman et al. (1995)
LOCAT	Bordering lake (lake Ziway = 1, otherwise = 0)	Dummy	Indeterminate a priori		

<sup>a</sup>ETB is Ethiopian Birr—the unit of currency in Ethiopia

where  $V_j$  ( $j=0, 1, 2$ ) represents indirect utilities for the three alternative scenarios; ASC is the constant;  $\beta$  values are coefficients of the wetland attributes; and  $\delta_1$  to  $\delta_n$  are the vector of the coefficients of the socioeconomic variables ( $S_1$  to  $S_n$ ) included in the model (Table 1).



**3.3.1.2 Random parameter logit model (RPLM)** The use of RPLM was justifiable for two reasons. First, the standard MNLM involves the IIA assumption. Hence, the use of RPLM that does not exhibit the IIA property was imperative to address possible violation of IIA in the MNLMs. Second, the MNLM does not account for unobserved preference heterogeneity. Hence, RPLM was estimated to account for the unobserved preference heterogeneity. Although controlling for unobserved heterogeneity is the plus in the RPLM, the model cannot explain the sources of this heterogeneity unless controlling for socioeconomic variables. Accordingly, we also estimated RPLM with interaction that includes, in addition to the wetland attributes, the socioeconomic variables which are interacted with ASC. So, the random utility function in the RPLM for indirect utility derived by an individual  $i$  from an alternative  $j$  ( $j=0, 1, 2$ ) is given by:

$$V_{ij} \equiv V_{ij} + e_{ij} \equiv V(Z_j(\beta + \eta_i), S_i) + e(Z_j, S_i), \quad (4)$$

where  $Z_j$  represents the wetland attributes with parameters  $\beta$ , which due to preference heterogeneity may vary across respondents by a random component  $\eta_i$ , and  $S_i$  represents the socioeconomic characteristics included in the model (Table 1). In the RPLM, all other attributes except the monetary payment are assumed to be normally distributed random parameter. The payment attribute is assumed to be fixed (log-normal) because the distribution of MWTP for an attribute is given by the distribution of the attribute's coefficient (Birol et al. 2006; Carlsson et al. 2003).

The overall explanatory power and goodness-of-fit of the MNLMs and RPLMs were assessed using log likelihood ratio test (LL-test) and McFadden  $R^2$  (pseudo  $R^2$ ). In the MNLMs as well as in the RPLMs, the LL tests reject the null hypothesis that the regression parameters are equal at 5% significance level; revealing strong explanatory power of the models. Although the McFadden pseudo  $R^2$  values for the basic MNLM is 0.18, this was improved in the extended model  $R^2=0.26$  implying the good fit of the extended MNLM to the observed data by conventional standards.<sup>7</sup> The RPLM and the RPLM with interaction had better overall fit of the data with respective pseudo  $R^2$  values of 0.37 and 0.38. The LL value<sup>8</sup> of RPLM with interaction suggests improvement in explanatory power of the model over the others (Table 10).

### 3.3.2 Estimations of marginal willingness to pay

Marginal willingness to pay (MWTP), also called 'part worth' or 'implicit price', measures the estimated value of people's WTP for an additional unit of improvement in wetland attribute of concern. Following Birol et al. (2006), for linear utility, the MWTP—the rate at which HHs are willing to tradeoff price for improvement in any wetland attributes—is calculated as:

<sup>7</sup> McFadden's  $\rho^2$  values between 0.2 and 0.4 imply that the model fits the data well (Hauber et al. 2016).

<sup>8</sup> Models with less negative LL-test value better explain the pattern of the choice in the data (Hauber et al. 2016).

$$\text{MWTP} = -1 \left( \frac{\beta_{\text{wetland attribute}}}{\beta_{\text{payment attribute}}} \right). \quad (5)$$

The parameters ( $\beta$  coefficients) of the wetland and payment attributes estimated in the RPLM with interaction were used to estimate the MWTP.

### 3.3.3 Estimation of welfare measures

Economic welfare measure or compensating surplus (CS) measures the amount of money that an individual can give up for an increase in utility assuming that the individual has the right to have the initial utility level (Birol et al. 2006; Abebe et al. 2014). CS, therefore, reflects individual's WTP to benefit from an improvement in wetland management. It is estimated as:

$$\text{CS} = \left( -1/\beta_m \right) (V_0 - V_i), \quad (6)$$

where  $V_0$  and  $V_i$  represent the indirect utility values from the status quo levels and different alternative improvement scenarios, respectively; and  $\beta_m$  is the coefficient for monetary payment estimated in the RPLM with interaction, the model with the best fit and explanatory power.

## 4 Results and discussions

### 4.1 Local community perception of the status of wetlands

Descriptive analysis result shows that 69.4% of the sample HH heads born in their current place of residence. Out of those HH heads who claimed to have born in other place, 91% have lived for more than 10 years in their current place of residence. The longer life that majority of the survey HH heads spent in their localities could help them to easily observe the environs—the wetland resources and have better picture about the ecosystems. We, therefore, asked the HH heads about the status and problems of wetlands and its resources over the past 10 years. Majority of the HH heads (94.1%) affirmed that the resources are highly deteriorating. In a multiple responses question about the causes of wetland degradation, many HH heads (69.4%) mentioned climate change as a cause followed by different human activities. Among the human activities-related factors were overgrazing (59.8%), conversion to farmland (40.7%), water extraction (39.5%), expansion of settlement/population growth/ (20%), release of waste (11.6%) and deforestation (8.1%). Various studies (Abebe et al. 2014; Ali 2007; Schuyt 2005) have revealed that such human activities imposed unbearable impact and increasingly threatened wetlands' services.

The PRAs discussants have highlighted the absence of consistent and noticeable arrangement from the government or among the local community as to how to enhance sustainable use of the resources. Likewise, about 69% of the studied HHs claimed the absence of wise use and sound management strategies of the resources.

**Table 2** Descriptive summary of HHs' socioeconomic-related variables and responses in CE

Variables	Mean	SD	Minimum	Maximum
HH head age (years)	39.59	10.59	20	80
HH head sex (male = 1)	0.67	0.469	0	1
HH head education (years in school)	5.70	2.71	1	12
Family size (number)	6.69	2.39	1	9
Gross annual income of HH (ETB)	22,386.8	15,065.58	4000	120,000
Distance to wetland (minutes to walk)	46.82	38.43	5	180
Location (Lake Ziway area = 1)	0.54	0.499	0	1
Responses in CE	Frequency		%	
Status quo	252		10.4	
Wetland improvement plan 1	1008		41.5	
Wetland improvement plan 2	1170		48.1	
Total	2430		100	

The descriptive statistics result from the responses of the CE analysis revealed that 89.6% of the sample HHs has chosen wetland improvement plans (plans 1 and 2) implying that the majority of the HHs favors a policy change for the improvement of wetland resources. Studies of Abebe et al. (2014) and Carlsson et al. (2003) confirmed that wetland improvement plans are highly favored by majority of wetland community. Table 2 gives descriptive statistics for responses in the CE method and the sample HHs' characteristics with respect to some socioeconomic and physical variables.

## 4.2 Households' preference for wetland attributes

The basic MNLM results, in Table 3, have shown that the wetland attributes—biodiversity, water availability and recreation—are statistically significant at 1% level. This suggests that the attributes selected for the study were important factors in the HHs' choice of wetland management plans. The positive sign of the coefficients imply that, *Ceteris paribus*, improvement in the levels of these attributes increases HHs' probability of choosing wetland improvement plans over status quo. The possible explanation for this is that HHs expect socioeconomic and ecological benefits from wetland resources in terms of, for example, animal feed, fuel wood consumption, grass and wood for construction, water for domestic and farming use, fish for consumption and sale, job opportunity, recreational use, and improved climate. The PRA findings mostly revealed this. In conformity with our findings, previous studies (Birol et al. 2006, 2008; Carlsson et al. 2003; Dahmardeh and Shahraki 2014) have shown the significant positive impact of wetland attributes on the choice probability of wetland management plans. On the other hand, the payment attribute has a significant ( $p < 0.001$ ) negative coefficient that infers the probability of choosing an alternative decrease with higher payment level, *Ceteris paribus*. This is consistent with the demand theory indicating that HHs prefer alternatives with lower payment

**Table 3** Results of multinomial logit model and random parameter logit model

Variable	Basic MNLM		RPLM with interaction	
	Coefficient	Standard error	Coefficient	Standard error
ASC	0.360**	0.180	4.285***	1.413
Biodiversity	0.668***	0.425 <sup>E-01</sup>	1.278***	0.222
Water avail	0.522***	0.346 <sup>E-01</sup>	0.879***	0.131
Recreation	0.382***	0.796 <sup>E-01</sup>	0.234	0.144
Payment	- 0.056***	0.053 <sup>E-01</sup>	- 0.038***	0.201
ASC*age			- 0.843***	0.248 <sup>E-01</sup>
ASC*education			0.149*	0.635 <sup>E-01</sup>
ASC*income			0.100***	0.232 <sup>E-04</sup>
ASC*location			1.357***	0.497
ASC*distance				
Derived standard deviations of parameter distribution				
ASC			2.411**	1.031
Biodiversity			2.092***	0.506
Water avail			1.731***	0.379
Recreation			0.521	0.324
Log-likelihood		- 991.790		- 908.378
Pseudo $R^2$		0.180		0.383
Iteration completed		6		34
Number of observations		2430		2430

The status quo is the base category

\*\*\*, \*\*, \*Statistical significance at 1%, 5% and 10% levels, respectively

rate to that of higher payment rate. The finding also mirrors the results of several wetland valuation studies elsewhere (Birol et al. 2006, 2008; Carlsson et al. 2003; Dahmardeh and Shahraki 2014; Yimenu and Rao 2015). For ASC, we found a significant ( $p < 0.05$ ) positive coefficient which implies that a positive utility impact occurs as we move away from the status quo. So, design of wetland improvement plan in any move away from the status quo significantly adds to the HHs' or wetland community's utility from the wetlands. The result supports the findings of studies by Birol et al. (2006) and Birol et al. (2008) that revealed welfare improvement in any plan further than the status quo.

Results of the RPLM and RPLM with interaction have showed that despite improvement in their relative magnitude, the coefficients for biodiversity and water availability have similar sign and significance level with the respective coefficients in MNLM. However, the results in the RPLMs revealed significant derived SD values ( $p < 0.001$ ) for these attributes implying that HHs have significant choice specific unobserved preference heterogeneity for the attributes. A key lesson here is that the RPLMs provide less restrictive information that could not be revealed in the MNLMs. The finding suggests that certain HHs prefer lower levels of these attributes. A possible reason for this finding is that HHs may think the improvement plans

could result in restriction of resources use or area closure and so reduce their current benefits from these resources. For recreation attribute in the RPLMs, we found a positive but insignificant parameter estimate denoting that recreation hardly has effect on HHs' choice of wetland improvement plan when accounting HHs' unobserved preference heterogeneity. The ASC in the RPLMs has a highly significant ( $p < 0.001$ ) positive coefficient. Hence, wetland improvement plan in any move away from the status quo enhance utility to the wetland community. However, the significant SD for the ASC is an indication that certain HHs prefer the current situation which could also strength the fact that 10.4% of the respondents choose the status quo (Table 2). In this respect, our result coincides with the findings of Birol et al. (2006) and Yimenu and Rao (2015). Regarding the payment variable in the RPLMs, we found a negative and highly significant coefficient ( $p < 0.001$ ), alike the result in the MNLMs. In general, the findings of the MNLMs and RPLMs indicate that among the survey HHs, positive and significant economic values exist for higher levels of wetland attributes, particularly for biodiversity and water availability although the HHs do not need to pay high.

#### 4.2.1 Determinants of households' preferences for wetland management plans

The results of models estimations for the determinants of HHs' preference for wetland management plans are presented in Table 3. The RPLM with interaction that best fit the data includes the variables age, education, gross annual HH income and location (Table 3). Among the hypothesized variables, the variables sex, family size and distance to the wetland did not appear to have significant bearing in the estimation of the RPLM with interaction.

**4.2.1.1 Age of HH head** Although we hypothesized that awareness, concern and interest about improvement of wetland resources increase with longer life experience, the results have shown that, *Ceteris paribus*, age of the HH heads significantly decrease ( $p < 0.001$ ) the probability of choosing wetland improvement plans over the status quo. Older HH heads may perceive high opportunity cost of choosing improved management alternatives because they may expect a decline or loss of benefits that they have been deriving from the lakes and associated wetland resources in their lifetime. According to Van Liere and Dunlap (1980), youth support and accept environmental reform and pro-environmental ideologies more readily than elders. Our results concur with the findings of Carlsson et al. (2003) and Yimenu and Rao (2015); where the latter noted that older age HH heads have a fear of decline of income from improved management scenarios due to less awareness creation done before. However, the results contrast with the finding of Dahmardeh and Shahraki (2014) that reported older peoples more likely choose wetland improvement scenarios than their counterparts.

**4.2.1.2 Education status of HH head** It is apparent and likely that more years of schooling lead to greater awareness of the importance of the environment or wetland resources, thereby placing high values for improvement of the resources. In

agreement with the a priori hypothesis, the results have shown that with increase in years of schooling of the HH head, the probability of choosing wetland improvement plans increases. The results lend support to the findings of previous studies (Dahmardeh and Shahraki 2014; Yimenu and Rao 2015) that show the significant positive impact of education on choice probability of wetland improvement scenarios. However, in our study, the effect of education is marginally significant (at 10% level) suggesting that wetland issues might be less incorporated in schools' programs and curriculums. Hence, the important policy implication is the call for the schools' programs and curriculum that adequately address wetland issues.

**4.2.1.3 Gross annual income of HH** Gross annual income of HH was expected to positively influence the utility of choosing improved alternative plan. In agreement with the prior expectation, the gross annual income of HH significantly ( $p < 0.001$ ) increases the probability of choosing wetland improvement plans. The plausible explanation for this is that income reflects the ability to pay, and so an increase in income likely increase WTP for wetland improvement plans. In favor of our argument, Cambell (2007) asserts that WTP for landscape improvement is positively related to income. Likewise, studies by Bateman et al. (1995) and Yimenu and Rao (2015) have found that HHs with higher levels of income more likely prefer wetland improvement plans than their counterparts.

**4.2.1.4 Location** The relationship of the dummy variable location with the dependent variable was indeterminate a priori. The analysis result revealed that *Ceteris paribus*, location has a positive significant ( $p < 0.001$  in the RPLM) effect on the choice probability of wetland improvement plans. The probability of choosing wetland improvement plans increases for HHs residing around Lake Ziway areas. One possible reason for this could be that owing to the rapid shrinking of Lake Abijata and deterioration of its wetland resources (Menbere and Menbere 2018) HHs might perceive that improvement of wetland attributes will not enhance their benefits from these ecosystems, and so ascribe less value. Although difficult to make inference, we got substantiation from the findings of PRAs. In the PRA (trend analysis) with elderly community members residing in Lake Abijata bordering *kebeles* discussants claimed that the ecosystem services of the lake and associated wetlands have severely degraded over the past 30 years. For example, previously, in 1970s and early 1980s, they used to fish and get plenty of wetland grasses for animal feed and roofing, but nowadays it is hardly possible to get such benefits. To mention the account of a participant: "in our age it was with ease that we catch fish, but now one cannot find a single" (male, age 75, PRA-trend analysis, *Desta Abijata kebele*). The views of all discussants in the area vividly reflect their despairing feeling about the future of the lakes and wetland resources; and they seem to lack interest for wise use and management. In view of this, Engida and Mengistu (2013) noted that location with a better resource stock enhance the probability of HHs' participation in resource conservation and management.

**Table 4** Estimates of MWTP [ETB (1 US \$ almost equal to 27 ETB, during the study time) a one-off payment] for the wetland attributes

Attributes	Coefficient	Standard error (SE)
Biodiversity	33.63***	0.196
Water avail	23.13***	0.203
Recreation	6.16	0.325

\*\*\*Significant at 1% level

In general, positive and significant economic values exist for improvement of wetland resources although the findings of the RPLM with interaction revealed significant preference heterogeneity among the HHs.

#### 4.2.2 Households' marginal willingness to pay for wetland management

The MWTP values for the wetland attributes, estimated using the Wald procedure in LIMDEP 8.0 or NLOGIT 3.0, are presented in Table 4. Estimations were done using the parameters (coefficients) of the wetland and payment attributes estimated in the RPLM with interaction.

The result revealed significant ( $p < 0.001$ ) MWTP for biodiversity and water availability implying HHs' positive WTP for an increase/improvement in these attributes. On the other hand, the MWTP value for recreation attribute is insignificant implying that the MWTP for this attribute hardly has contribution for the wetland improvement plans when considering unobserved information of HHs' choices. Looking closely at the MWTP finding it reveals that biodiversity has the highest MWTP followed by water availability and recreation insinuating that HHs place more value for biodiversity than water availability and recreation. This can also be noticed from the findings of the follow up questions (Table 5) that reveal HH heads' response statements that best describe their reasons and motivation for choice of alternative improvement plans in answering the choice set questions. The result revealed that majority (31.9%) of the HHs give weight to the management plan that provide highest improvement of the three attributes regardless of the payment level. HHs that account for 17.5 and 17.3% reported that they found biodiversity and water attributes more relevant, and so choose the plan with the highest level of these attributes, respectively. On the other hand, only 4.7% of the HHs give weight for recreation services and opt for plans with the highest level of this attribute. The results support the above findings that positive and significant economic values exist for higher levels of wetland attributes, particularly biodiversity and water.

#### 4.2.3 Wetland improvement welfare measures

Estimation of welfare measure or compensating surplus (CS) enables evaluation of values for a range of alternative ways of resource allocation thereby contributes to policy making in designing socially efficient wetland management plans (Carlsson et al. 2003; Yimenu and Rao 2015). To estimate HHs' CS, we developed five

**Table 5** Results of follow-up questions

Response	Frequency	%
I choose the plan with the highest level of all attributes whatever the payment level	129	31.9
I choose the status quo options whatever the levels of the attributes since I don't have the ability to pay for cost of improvement	42	10.4
I choose the plan with highest level of biodiversity attribute because I found that the improvement in this attribute is relevant	70	17.3
I choose the cheapest plan whatever the levels of the attributes	74	18.3
I found that the attributes of availability of water is important and chose the plan with the highest level of such attribute	71	17.5
I choose the plan with the highest level of recreational services	19	4.7
Total	405	100



**Table 6** Results of compensating surplus estimate for wetland improvement scenarios

Improvement scenario	Attribute levels			Mean WTP (ETB one-off payment)
	Biodiversity	Water avail	Recreation	
Low impact improvement I	1	1	1	112.76
Medium impact improvement I	2	1	1	146.32
Medium impact improvement II	2	2	1	169.53
Medium impact improvement III	2	1	2	152.55
High impact improvement	3	3	2	202.45

alternative scenarios of wetland improvement (Table 9). For estimation, we used the parameter estimates of the attributes in the RPLM with interaction (which is more explanatory compared to other models) and the attributes' levels in the respective wetland improvement scenarios. The results of CS estimates (Table 6) have shown that all improvement scenarios have positive CS values suggesting that the improvement scenarios will enhance the welfare of the HHs or the wetland community of the study areas. Prior wetland valuation studies (Abebe et al. 2014; Birol et al. 2006; Yimenu and Rao 2015) have also found out that local HHs have positive WTP for improvement in wetlands, thereby experiencing better utility. Looking closely at our study results, the HHs' WTP increase with increase/improvement/in the level of the wetland attributes, particularly biodiversity and water availability. A key finding is that HHs' WTP for medium impact improvement scenario III (152.55 ETB) is lower than medium impact improvement II (169.53 ETB) which is related to the recreation attribute. This suggests and further confirms HHs' expectation of low benefit from the improvement of recreation attribute.

The CS estimates reported in Table 6 can be aggregated over the entire sampling frame to obtain the total WTP value (the total economic welfare) for each scenario. Accordingly, based on the total HH size of the three study *woredas* (which amount to 92,575),<sup>9</sup> the aggregate WTP to achieve improvement of the wetlands, for example, in the low impact scenario is 10,438,757 ETB; while, it amounts to 18,741,808 ETB in the high impact scenario. These monetary values of wetland resources of Lakes Ziway and Abijata could be considered as lower bound; and it is worth to mention that if we had consider other ecosystem services of these wetlands (such as, flood and water regulation, local climate stabilization), their value might have been more. Hence, policy-makers can use these values to compare with estimated cost of improving the wetland attributes, in cost benefit analysis, thereby designing feasible program for improvement of the wetland resources of the study area.

<sup>9</sup> Sources: the *woredas*' rural land administration and environmental protection bureaus and *woredas*' agriculture and rural development offices.

## 5 Conclusions

Like most wetlands elsewhere, the socioeconomic and ecological services of wetland resources in CRV of Ethiopia are manifold, but, equally, the resources are under threat of degradation owing to different human activities. Conservation and management measures are pressing for sustainability of the wetland resources. To design feasible program for wetland conservation and management of wetland resources, monetary valuation of the resources is imperative. As the present study findings revealed, the economic benefits associated with the wetland resources are significant. Biodiversity followed by water availability are the important factors in the utility of the wetland community. This was implied by higher willingness to pay values for these two attributes of wetlands. Hence, it can be concluded that there is high tendency of public support for conservation and management of wetland resources. However, there is heterogeneity in HHs' preferences for these attributes which is reflected in significant derived standard deviations. This necessitates consideration when designing policy for conservation of wetland resources as well as provision of public goods. The variables that account for significant heterogeneity among the community are age, education, income and location.

The results further showed increase in CS estimates for the change from the status quo to scenarios with improved conditions of wetland resources, particularly biodiversity and water availability. Calculated CS value derived from improved wetland management scenarios is enormous which can highly contribute not only to the welfare of the local community but also to the national economy. The implication here is that the loss of benefits owing to absence of improved management and conservation of these wetland resources is equally great. Wetland improvement programs will therefore increase the ecological and socioeconomic utility from these resources. The finding of the study has policy relevance that aimed at a plea for policy makers' attention to design programs supported with scientific and legal measures that gear towards wetland rehabilitation and management. One plausible measure could be implementing a payment for environmental/ecosystem/service scheme (PES). PES works on the principle that those who manage the ecosystem to improve the flow of environmental/ecosystem/services are provided with an economic incentive and those who benefit from the services pay for the service provided. PES is indispensable measure towards rehabilitation and wise use of the wetland resources. It is also apparent that the majority of the HHs are willing to contribute for rehabilitation and conservation programs. Planners and practitioners can, therefore, involve the local community, to their best capacity, in designing and implementing strategies in conservation and management of wetland resources.

Finally, because in many cases decisions are simply made based on value judgment, it is usual to see most decisions favoring alternative uses of wetland resources. However, the benefit forgone from protection and sustainable management of these resources should be considered prior to any decision on alternative use of these resources. In view of this, to justify decisions on wetland resource uses decision-makers should aim at conducting cost benefit analysis by estimating the marginal cost of providing the different attributes of wetlands.

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**Author contributions** All authors contributed to the study conception and design. Preparation of data collection materials/instruments, data collection, data analysis and writing the manuscript were performed by [FD]. [FS, Ph.D., Associate Professor] and [DDG, Ph.D.] participated in the study design, shaped and commented on the data collection instruments, supervised the data collection, technically supported the data analysis and read, commented and revised the manuscript. All authors read and approved the final manuscript.

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### **Compliance with ethical standards**

**Conflict of interest** No potential conflict of interest was reported by the authors.

## **Appendix**

See Tables [7](#), [8](#), [9](#), [10](#).

**Table 7** Description of attributes and their levels used in choice experiment

Attributes	Descriptions	Levels
Biodiversity	The number and abundance of both familiar and endangered plant and animal species, and their habitats	(i) Status quo: biodiversity is deteriorating (ii) Improvement of biodiversity at small level (a 25% improvement) (iii) Improvement at medium level (a 50% improvement) (iv) Improvement at high level (a 75% improvement)
Water availability	Size of open water surface area of the lake that remains being covered by water and seasons with adequate water supply for different purposes	(i) Status quo: a decrease in the size of open water surface area of the lake and one season of adequate water supply (ii) A 5000 ha increase in open water surface area and two seasons of adequate water supply (iii) A 10,000 ha increase in open water surface area and three seasons of adequate water supply (iv) A 15,000 ha increase in open water surface area and four seasons of adequate water supply
Recreation service	The services for recreational purpose in terms of infrastructural development, provision of resting facilities, and waste monitoring	(i) Status quo: insufficient service provision and decline in recreational and tourism value (ii) Infrastructural development only (iii) Infrastructural development; provision of resting facilities and waste monitoring
Payment	A one-off payment in the form of an environmental fund	(i) Status quo: no payment (ii) 20 ETB (iii) 40 ETB (iv) 60 ETB

**Table 8** Sample choice set

<b>Attributes</b>	<b>Plan 1</b>	<b>Plan 2</b>	<b>Status quo</b>
Biodiversity	Medium: a 50% improvement in the level of biodiversity and their habitat	High: a 75% improvement in the level of biodiversity and their habitat	Biodiversity is deteriorating with no strict management
Water availability	Two seasons of adequate water supply and a 5,000ha increase in open water surface area.	Three seasons of adequate water supply and a 10,000ha increase in open water surface area.	Water is adequately available once in a year and the size of open water is decreasing.
Recreation /Tourism services	Improvement of infrastructures only	Improvement of infrastructures; provision of resting facilities and monitoring waste disposal.	Insufficient service provision
Payment	40 ETB <input type="checkbox"/>	60 ETB <input type="checkbox"/>	Zero (no Payment) <input type="checkbox"/>
I would prefer	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>

**Table 9** Alternative wetland scenarios and their attributes

Alternative Scenarios	Attribute levels
Status quo	Biodiversity is deteriorating with no strict management; water is available in one season and size of open water is decreasing; low provision recreational services
Low impact improvement scenario	Biodiversity is managed at low level (25% improvement); water is available in two seasons; infrastructural development only
Medium impact improvement scenario I	Biodiversity is managed at medium level (50% improvement); water is available in two seasons; infrastructural development only
Medium impact improvement scenario II	Biodiversity is managed at medium level (50% improvement); water is available in three seasons; infrastructural development only
Medium impact improvement scenario III	Biodiversity is managed at medium level (50% improvement); water is available in two seasons; provision of infrastructure, resting facilities and waste monitoring
High impact improvement scenario	Biodiversity is managed at high level (75% improvement); water is available in four seasons; provision of infrastructure, resting facilities and waste monitoring

**Table 10** Results of multinomial logit models and random parameter logit models

Variable	Basic MNLM		Extended MNLM		RPLM model		RPLM with interaction	
	Coefficient	Standard error	Coefficient	Standard error	Coefficient	Standard error	Coefficient	Standard error
ASC	0.360**	0.180	0.264	0.387	6.562***	1.771	4.285***	1.413
Biodiversity	0.668***	0.425 <sup>E-01</sup>	0.670***	0.426 <sup>E-01</sup>	1.745***	0.372	1.278***	0.222
Water avail	0.522***	0.346 <sup>E-01</sup>	0.523***	0.347 <sup>E-01</sup>	1.234***	0.255	0.879***	0.131
Recreation	0.382***	0.796 <sup>E-01</sup>	0.387***	0.800 <sup>E-01</sup>	0.296	0.169	0.234	0.144
Payment	- 0.056***	0.053 <sup>E-01</sup>	- 0.051***	0.053 <sup>E-01</sup>	- 0.048***	0.285	- 0.038***	0.201
ASC*age			- 0.406***	0.691 <sup>E-02</sup>			- 0.843***	0.248 <sup>E-01</sup>
ASC*education			0.607 <sup>E-01</sup> *	0.210 <sup>E-01</sup>			0.149*	0.635 <sup>E-01</sup>
ASC*income			0.412***	0.714 <sup>E-05</sup>			0.100***	0.232 <sup>E-04</sup>
ASC*location			0.326**	0.142			1.357***	0.497
ASC*distance			- 0.363**	0.186 <sup>E-02</sup>				
Derived standard deviations of parameter distribution								
ASC								
Biodiversity					2.081***	0.654	2.411**	1.031
Water avail					3.291***	0.765	2.092***	0.506
Recreation					2.935***	0.752	1.731***	0.379
Log-likelihood	- 991.790			- 948.471	0.300	0.254	0.521	0.324
Pseudo R <sup>2</sup>	0.180			0.256		- 940.840		- 908.378
Iteration completed	6			7		0.372		0.383
Number of observations	2430			2430		27		34
								2430

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