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Local perceptions of ecosystem services and human-induced degradation of lake Ziway in the Rift Valley region of Ethiopia

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ABSTRACT

Ecosystems supply beneficial contributions to people's quality of life and well-being. Freshwater lakes provide diverse consumptive and non-consumptive ecosystem services (ESs) to people. This study examined ecosystem goods and services that Lake Ziway in the Rift valley region of Ethiopia supply and identified the anthropogenic pressures that impact the lake and its services. The lake currently supports investment projects and livelihoods of the local communities. It contributes to the local and national economy from the export of cut flowers. The biggest commercial floriculture investment in the country is located on the shore of this lake, depending mainly on its water. Assessing the views and knowledge of local communities towards the contributions of ESs to human life, well-being, and livelihoods is important to protect and prolong the long-term benefits of ESs. A total of 41 experts, 137 households, and 20 discussants from two districts were selected for interviews and focus group discussions (FGDs). Pearson's Chi-square tests were used to test the association between dependent and independent variables. Multiple regression models were developed to examine the ESs of the lake and human impacts. The result showed that respondents prioritize the ESs of the lake as provisioning > supporting > cultural > regulating services. The Chi-square results revealed a strong association among ESs with respondents' type and residence locations. The multiple regression results revealed that respondents' types and residence locations were significant determinants in prioritizing the importance of ESs of Lake Ziway ($p < .01$). The degradation of Lake Ziway is increasing along with the increasing human population and increasing demands for provisioning services. The major anthropogenic activities are intensive water abstraction, pollution, overharvesting of resources, wetland conversion, and the introduction of invasive species. Such human activities are degrading the capacities of the lake ecosystem and its ecosystem service provisions. Our results indicate that understanding the links between these human pressures on Lake Ziway and its ES provisions is crucial for the sustainable management of the lake. The study could serve as a reference for decision-making for prioritizing the conservation measures needed towards ensuring the sustainable use of the various ecosystem services of the lake. Conservation interventions by involving local communities as major actors are needed to minimize human pressures and ensure the sustainability of the lake and its ESs.

1. Introduction

Ecosystems have both beneficial and detrimental contributions to people's quality of life and well-being depending on the cultural and socioeconomic context (Brill et al., 2017; Stepniewska and Sobczak, 2017; Díaz et al., 2018). In recent years, the concept of ecosystem services (ESs) has been developed to describe the various values and benefits that ecosystems provide to people (Costanza et al., 1997; MEA, Millennium Ecosystem Assessment, 2005; Bennett et al., 2009; Fisher et al., 2009). One of the several challenges that ESs research faces is stemming from the plurality of interpretations of their current classification systems and the inconsistency across concepts and terminologies (La Notte et al., 2017). Yet, very few studies have primarily focused on comparing different definitions of the term (Danley and Widmark, 2016).

According to Costanza et al. (1997) and de Groot et al. (2002), ESs were grouped into different categories based on their benefits. However, MEA (2005) grouped ESs into four types as provisioning (those products which are directly obtained from ecosystems, e.g. food, water, materials, etc.), regulating (those benefits which are obtained from the regulation of ecosystem processes, e.g. climate regulation, flood control, water regulation, and purification, etc.), supporting (those processes which are

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necessary for the production of all other ES, e.g. primary production, nutrient cycling, soil formation, water cycling, etc.) and cultural (those which are non-material benefits, e.g. eco-tourism, aesthetic, spiritual, educational benefits, etc.). However, according to the Common International Classification for Ecosystem Services (CICES), as proposed by the European Environment Agency, ESs are classified into three - Provisioning, Regulating and maintenance, and Cultural ones (La Notte et al., 2017). These different types of ESs interact to generate benefits to humans in terms of providing livelihoods, regulating ecological systems, and supporting human life and well-being (Bennett et al., 2015; Fischer and Eastwood, 2016). Maintaining these beneficial contributions to a good quality of life for human societies has been one of the key motivations of the Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services (IPBES) (Díaz et al., 2018).

The interactions and interdependence between humans' livelihoods and ecosystems shape the ESs for human existence (Hein et al., 2006). It is therefore impossible to isolate humans' benefits from ESs (Cimon-Morin et al., 2013). Most rural communities in sub-Saharan Africa, for instance, greatly rely on different ESs for sustaining livelihoods from surrounding ecosystems (Dasgupta, 2010; Bhatta et al., 2015; Sinare et al., 2016). For example, traditional medicines use by over 80% of the people (WHO (World Health Organization), 2013), and 90% of cooking energy from fuelwood, charcoal, crop residues, and cow-dung is in use in sub-Saharan Africa (WHO (World Health Organization), 2016). Understanding these interactions between humans and ecosystems is vital to attain a sustainable and resilient future (Ostrom, 2010) and to formulate policies and strategies on nature conservation (Wu and Li, 2019), especially in developing countries. The core of sustainable development is also to maintain and protect the earth's ecosystems to support human life (Potschin and Haines-Young, 2011; Luederitz et al., 2015). For a society to transform and achieve a desirable future, the contribution of ESs is significant to the sustainable wellbeing of humans (Lin et al., 2019). Sustainable management of ecosystems is thus necessary for developing countries in their efforts to come out of poverty.

Different studies have been carried out on ESs since the second half of the last century (Costanza et al., 1997). Although the assessments and analysis of ESs have increased since then (Seppelt et al., 2011; Abson et al., 2014; Martinez-Harms et al., 2015), the majority of studies are from developed countries (Zhang et al., 2016), e.g., studies on the biophysical supply of ESs by Wolff et al. (2015), Laterra et al. (2016), and Boerema et al. (2017), the value and valuation of ESs by Schröter et al. (2012) and Villamagna et al. (2013) and how ESs contribute to human life and well-being by Daw et al. (2011) and Suich et al. (2015). Assessing the views and knowledge of local communities towards the contributions of ESs to human life, well-being and livelihoods are important to examine the rates of ecosystems' degradation (Nkonya et al., 2016), to protect and sustainably use ecosystems (Willock et al., 1999), to mainstream ESs in conservation policy formulation (Hauck et al., 2013; Orenstein and Groner, 2014; Poppenborg and Koellner, 2013; Wolff et al., 2015; Evers et al., 2018) and to improve environmental management and decision-making to prolong the long term benefits of ESs (Annis et al., 2017). Though ES assessment can contribute to support and improve decision-making and planning (Beier et al., 2008), integrating these views and knowledge into policy-making is rare in most countries (Förster et al., 2015). In sub-Saharan African countries, ESs have not been studied well (Zhang et al., 2016).

Freshwater lakes provide diverse consumptive and non-consumptive ESs to people (Sterner et al., 2020) such as water supply and fisheries, recreation and nature enjoyment, etc. (Allan et al., 2015; Angradi et al., 2016). However, human activities degrade the capacities of these ecosystems and their service provisions (Kreuter et al., 2001). Such degradation may affect the livelihoods of people that depend on ESs (Reed et al., 2013). Understanding the links between human pressures and ES provisions is therefore crucial for the sustainable management of aquatic ecosystems (Grizzetti et al., 2019). Assessment and characterization of ESs should first be carried out to develop sustainable management of natural resources and their use policies (Sagie et al., 2013).

In this study, ESs refer to the benefits people in the central rift valley region obtain from the Lake Ziway ecosystems. The rift valley region is one of the economic development corridors in Ethiopia. Investment projects and urbanization in this region have brought impacts on aquatic ecosystems including Lake Ziway. Though several published articles are focusing on Lake Ziway (e.g., Vallet-Coulomb et al., 2001; Ayenew, 2004; Ayenew and Legesse, 2007; Tamiru et al., 2006; Girum and Seyoum, 2012; Desta et al., 2017), there are no sufficient studies done specifically on the types of ES provisions by the lake to local people. In this regard, this study may add value to the field. To this end, this study addressed the following research questions: *Does Lake Ziway supply ecosystem goods and services for local people in Ethiopia? What are the anthropogenic pressures that are currently impacting the lake and its ecosystem services?* The study also helps to provide a scientific basis for a better understanding of the benefits provided by Lake Ziway. It could also serve as a reference for decision-making for prioritizing the conservation measures needed towards ensuring the sustainable use of the various ecosystem services of the lake.

2. Materials and methods

2.1. Study sites

The study region is part of the African Rift Valley System (Fig. 1). Lake Ziway and its surrounding plains occupy the Rift floor in the Ethiopia Central Rift Valley region in Africa. The lake is at a latitude of $8^{0}00'36''$ and longitude of $38^{0}50'32''$ at an altitude of 1,649 m above sea level (masl). The surface area of the lake is 434 km^2 with a shoreline length of 137 km (Hengsdijk and Jansen, 2006). Its watershed encompasses 7,300 km^2 of area. The lake is shared by three administrative districts, namely Dugda Bora, Ziway Dugda, and Adami Tulu Jido Kombolcha (ATJK) in Oromia Regional State. Meki, the administrative center of Dugda Bora District, lies at an elevation of 1,663 masl, and Ziway/Batu, the administrative center of ATJK District, lies at an altitude of 1,651 masl on the floor of the Rift Valley (Fig. 1 and Fig. 2). Meki Town has a gross area of 959.43 km^2 while Ziway/Batu Town has 1,403.25 km^2. Meki and Ziway/Batu towns are located at 140 and 163 km, respectively, south of Addis Ababa, the capital of Ethiopia along the road that leads to Nairobi, Kenya. Lake Ziway is the most upstream of the Rift Valley lakes in Africa. Besides seasonal runoff and groundwater movement, runoff from the watershed drains into the Lake Ziway through the two feeder-rivers which represent the opposing faces of the rift escarpments, and Bulbula River is the outflow river of the lake (Fig. 1).

According to the projection from CSA (2017), the population sizes are 39,498 and 52,350 for Meki and Ziway/Batu towns, respectively. The local communities' most important economic activities are the traditional mixed crop-livestock agriculture. Agriculture is heavily dependent on rain, but irrigations are surrounding Lake Ziway areas. The major types of crops and vegetables produced around Lake Ziway are maize, tomato and onion, and fruits (Jansen et al., 2007; Hengsdijk et al., 2008; Derege et al., 2012). Crop production is mostly rain-fed, and animals reared are cattle, sheep, goats, horses, mule, and donkeys (Desta et al., 2017). Other livelihood systems include fishing and small trading.

2.2. Sampling design

Meki and Ziway/Batu towns including their surrounding rural areas and villages of the islands were selected as study sites as they share Lake Ziway in their administrative boundaries. These towns are the nearby market places of the lake's products. There are many local communities in and around these centers that have depended on Lake Ziway's resources for income sources. Studying by encompassing these sites provides an opportunity to compare ESs of the lake and human impacts happening on the lake. The impacts are due to economic dependence by

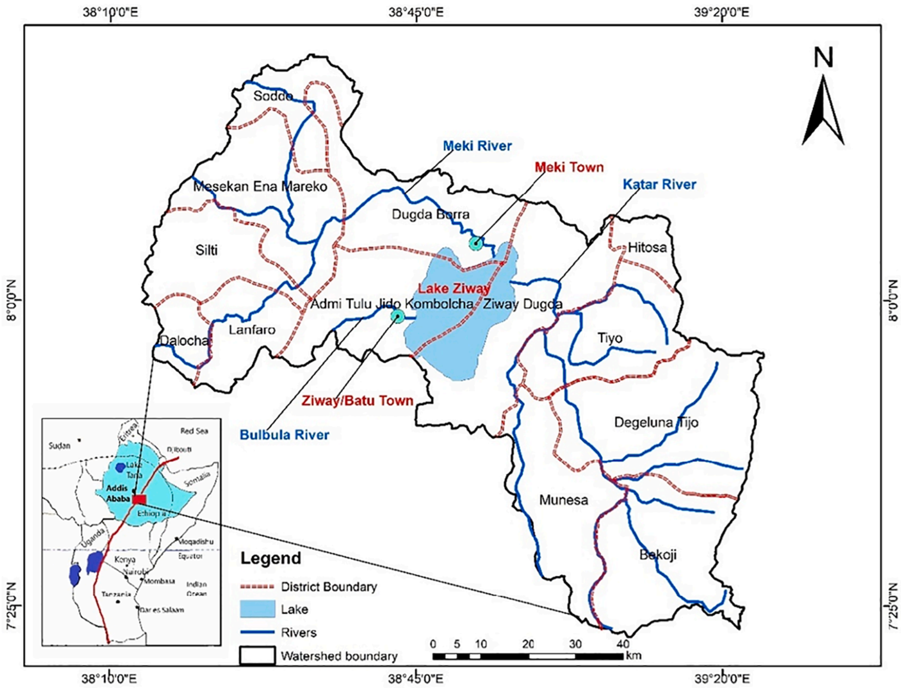

Fig. 1. Location of Lake Ziway and Meki and Ziway/Batu towns in the lake watershed.

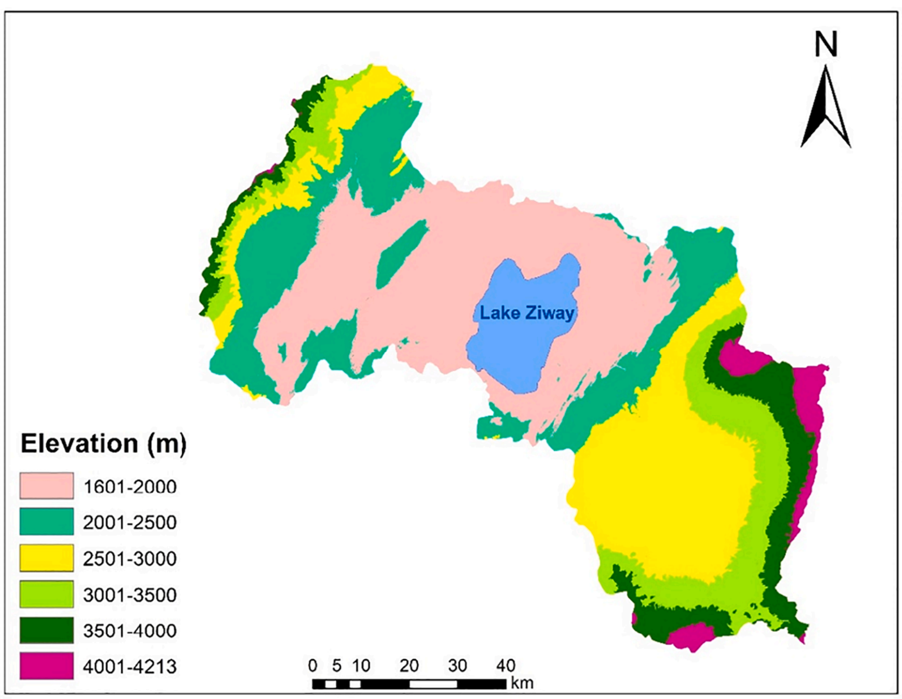

Fig. 2. Elevation ranges in the Lake Ziway watersheds.

local communities for their livelihoods and economic pressures to maximize profits by private companies.

The great majority of respondents (86%) who live or work within a distance of 5 km and less from the lake's shorelines were considered to capture information in both Ziway and Meki areas, including villagers on the islands. Individual households within the 5 km buffer from the lakeshores were randomly selected while experts whose major responsibilities are in the areas of natural resource management sectors at district levels were purposively selected for the study. A total of 178 (22 and 19 Experts from Ziway and Meki, respectively; and 69 and 68 households from Ziway and Meki, respectively) participated in the study. Both household and expert surveys were conducted using a semi-structured questionnaire.

Households that have lived in the area since birth were selected to participate in the survey as they exhaustively know the ESs of the lake ecosystem. Household heads were interviewed in each household. When the head of the household was not found or when the household refused to participate, another randomly selected household was selected to replace that household (Bong et al., 2016). The sampling units were head of a household and experts from district sector offices from the Natural Resources Sector while the unit of analysis was Lake Ziway. According to FAO (2005), a household is a group of people living together, having common arrangements for food and other essentials for survival. Before undertaking the survey, the questionnaires were pre-tested on 6 households and 2 experts in each Meki and Ziway to check for any errors and ambiguity and hence to improve the validity of the survey tools (Babbie and Mouton, 2014). Focus group discussions (FGDs) were also conducted to assess ESs, and human impacts on the lake and local management priority actions towards ensuring lake sustainability. According to Morgan (1995), FGD is the purposeful use of interaction designated to generate qualitative data. In this study, residents who have a good knowledge of the lake's uses to the local people and the current changes happening to it were purposively selected. A total of 20 discussants (10 for Ziway/Batu and 10 for Meki) participated in the discussion.

2.3. Data collection

The administration of semi-structured questionnaires and FGDs were used as data collection methods. The questionnaire was prepared in English and individual questions were orally translated into local languages (Oromifa and Amharic) when it was administered to respondents by research assistants. Eight research assistants (four each from Meki and Ziway/Batu) who are fluent in local languages were trained to participate in household data collection while experts were interviewed by the researcher. The questionnaire included different sections including background data. Four ES classes as defined by MEA (2005) have been assessed on Lake Ziway in terms of their relative degree of importance. The views toward the lake ESs were assessed on a four-point Likert scale. In the process of the study, full anonymity was guaranteed to the respondents. Furthermore, two FGDs meetings were carried out in Meki and Ziway. These meetings consisted of 10 discussants per group. The information gathered from FGDs was used to validate data obtained from respondents' interviews to provide an in-depth understanding of the benefits local people get out of Lake Ziway and the human impacts imposed on it. In particular, issues such as ESs, human impacts, and management preferences for the lake were discussed. The meetings lasted approximately 45 min and were all moderated by the researcher. Minutes were written by a participant from the discussants in the local language.

2.4. Data analysis

The statistical analysis used was descriptive and inferential statistical methods. Basic descriptive statistics of numerical variables such as mean values, standard deviation, frequency counts, and percentages of observed attributes were employed. Respondents' perceptions about the various ESs of Lake Ziway and human impacts imposed on the lake were examined. Pearson's Chi-square test of association was used to show the levels of association between independent variables and the rate of ESs. Qualitative data from FGDs were analyzed through content analysis, whereby the discussions were objectively and subjectively analyzed (Hsieh and Shannon, 2005; Kamwi et al., 2015). Furthermore, to assess the different ES variables that were determinants of local communities and other user groups of the Lake Ziway resources, multiple regression models were employed. Data entry and analysis were conducted using the Statistical Package for Social Sciences (IBM SPSS) software version 25.

The multiple regression model is a suitable statistical tool when determining the influence of explanatory variables on the dichotomous dependent variables (i.e., with only two categories or values) (Nancy et al., 2015). Thus, the model used two explanatory variables such as types of respondents (Households and Experts) and residence location (Meki and Ziway/Batu). Gender is an important component of natural resource management issues. But, the great majority of rural households in Ethiopia are male-headed. Hence, gender was not included in the multiple regression model because there were only a few female-headed household respondents involved in this study. There were also few female experts working in the natural resource protection sector offices in the two districts so that they could not equally be represented as their male counterparts, thereby making them insufficient for inclusion in the model. The level of education was not also included as it was found no differences between education and types of respondents for inclusion.

The response (dependent) variable for the multiple regression model applied were the different ESs that local communities and business people get out of Lake Ziway. Rating of different ESs was examined using Likert scale variables as 4 for 'High', 3 for 'Medium', 2 for 'Low' and 1 for 'None' considering the level of Lake Ziway resource uses and observation of other benefits from the lake. Furthermore, the response (dependent) variable for the multiple regression model on drivers of human impacts on Lake Ziway was also defined using four-point Likert scale variables as 4 for 'High', 3 for 'Medium', 2 for 'Low', and 1 for 'None' perceived causes.

3. Results

3.1. Demographic characteristics of respondents

The demographic characteristics of the respondents from the districts are indicated in Table 1. Results from the 187 respondents showed that 51.1% ($n = 91$) were from Ziway and 48.9% ($n = 87$) were from Meki. Of the total, 46.6% ($n = 83$) had post-secondary education, with only 5.1 (n = 9) Technical and Vocational Training (TVT) and Diploma, and 41.6% (n = 74) accounted for Bachelor and above while 32.6% (n = 58) attended secondary education (Grade 7–12), 12.9% ($n = 23$) elementary education (Grade 1–6) and while 7.9% ($n = 14$) had never gone to school for formal education. Concerning the position of respondents in the communities, 77% (n = 137, Ziway comprising 69 and Meki 68) accounted for Households while 23% (n = 41, Ziway comprising 22 and Meki 19) for Experts.

3.2. Ecosystem services (ESs)

Respondents' views towards provisioning, regulating, cultural, and supporting ESs of Lake Ziway were assessed using twenty-nine items

Table 1
Demographic characteristics of respondents.

Respondents' Characteristics	Types	Districts/Areas Ziway	Maki	Total
Gender	Male	83	80	163 (91.6%)
	Female	8	7	15(8.4%)
	Sub-total	*91 (51.1%)*	*87 (48.9)*	*178*
Education	No Formal Education	6	8	14(7.9%)
	Elementary	7	16	23 (12.9%)
	Secondary	24	34	58 (32.6%)
	Sub-total	*37 (20.8%)*	*58 (32.6)*	*95 (53.4%)*
	Post-Secondary			
	TVT and Diploma	2	7	9(5.1%)
	Bachelor and Above	52	22	74 (41.6%)
	Sub-total	*54(30.3)*	*29 (16.3)*	*83 (46.6%)*
	Total	91	87	178
Respondents' Type	Experts	22	19	41(23%)
	Households	69	68	137(77%)
	Total	91	87	178

Table 2
Views towards Lake Ziway's ESs.

Lake ES	Percent 1*	2*	3*	4*	M	SD	Mdn	Mo
Provisioning Services					3.08	0.32	3.07	4
Food					3.09	0.54	3.0	4
Vegetable cultivation	0.6	2.8	30.3	66.3	3.62	0.57	4.0	4
Crops (e.g. maize)	10.1	23.0	32.0	34.8	2.92	0.99	3.0	4
Fish	1.1	2.8	11.8	84.3	3.79	0.54	4.0	4
Honey from beekeeping on lakeshores	59.6	35.4	2.2	2.8	1.48	0.68	1.0	1
Water					3.51	0.52	4.0	4
Domestic uses (drinking, bathing, washing)	1.7	19.7	51.1	27.5	3.04	0.74	3.0	3
Industries, hotels, etc.	8.4	24.7	24.7	42.1	3.01	1.01	3.0	4
Irrigation	0.0	3.9	15.7	80.3	3.76	0.51	4.0	4
Livestock drinking	0.0	2.8	12.9	84.3	3.81	0.46	4.0	4
Materials					3.42	0.66	3.5	4
Animal forage or grazing services	1.1	6.2	27.5	65.2	3.57	0.66	4.0	4
Fuel wood	6.7	10.1	47.8	35.4	3.12	0.85	3.0	3
Handcraft materials, e.g. mattress, mat, stools, etc.	6.2	25.8	44.4	23.6	2.85	0.85	3.0	3
Medicinal plants	62.4	30.9	5.6	1.1	1.46	0.66	1.0	1
Seedling raising	2.2	14.0	41.0	42.7	3.24	0.78	3.0	4
Reeds for thatching, boat, etc.	3.4	11.2	49.4	36.0	3.18	0.76	3.0	3
Other wetland plants, e.g. grass, papyrus, etc.	1.7	8.4	39.3	50.6	3.39	0.71	4.0	4
Regulating services					2.27	1.01	2.0	2
Flood control/mitigation	37.6	34.3	11.2	16.9	2.07	1.08	2.0	1
Microclimate regulation i.e., carbon sequestration; influence local climatic processes	39.3	23.0	15.7	21.9	2.2	1.18	2.0	2
Runoff and erosion regulation/protection	24.7	42.7	11.2	21.3	2.29	1.07	2.0	2
Sediment retention	20.8	52.2	7.9	19.1	2.25	0.99	2.0	2
Water purification/pollution control	51.7	25.3	11.2	11.8	1.83	1.04	1.0	1
Water regulation (hydrological flow and storage)	23.6	46.6	12.4	17.4	2.24	1.00	2.0	2
Cultural services					2.98	0.74	3.0	3
Aesthetic value	18.5	28.1	30.3	23.0	2.58	1.04	3.0	3
Education, training and research	8.4	29.8	36.0	25.8	2.79	0.93	3.0	3
Recreational and tourism	5.1	25.8	33.7	35.4	2.99	0.91	3.0	4
Spiritual	1.1	9.6	60.7	28.7	3.17	0.63	3.0	3
Supporting services					2.15	1.14	2.0	1
Accumulation of organic matter	27.5	39.9	11.8	20.8	2.26	1.08	2.0	2
Habitat for biodiversity conservation	41.6	22.5	7.3	28.7	2.23	1.26	2.0	1
Nutrient cycling	52.8	21.3	14.0	11.8	1.85	1.06	1.0	1
Support for pollinators	47.2	25.3	9.0	18.5	1.99	1.15	2.0	1

Note: *1 = None, 2 = Low, 3 = Medium, 4 = High, M = mean, SD = standard deviation, Mdn = median, Mo = mode

(Table 2): 15 provisioning services, 6 regulating services, and 4 each cultural and supporting services. Respondents rated the highest score for provisioning services such as fish (food), irrigation, and livestock watering (Table 2). The ratings of the respondents' views to the lake's ESs are shown in Fig. 3.

To investigate whether respondents differ in their types, i.e., as Experts and Households, on the '*High*', '*Medium*', '*Low*', Or '*None*' views towards the different types of ESs that local people get out of Lake Ziway, a Chi-square statistic was conducted. The Pearson Chi-square results indicate that Experts and Households are not significantly different on whether or not they have high, medium, or low ratings on such provisioning services as cultivated vegetables, Fishes, water for livestock drinking, water for domestic use, water for irrigation use, water for industries, hotel, etc. uses, fuelwood from wetland vegetation around the lake, animal forage/grazing services (Table 3).

Similarly, to investigate whether respondents differ in their localities, i.e., as in Meki and Ziway areas, on the '*High', 'Medium', 'Low*', or '*None*' views towards the ESs that people get out of the lake, a Chi-square statistic was also conducted. The results indicate that respondents from Meki and Ziway/Batu districts are also not significantly different on whether or not they have high, medium, or low ratings on some provisioning services such as water for livestock drinking, water for domestic use, water for irrigation use, fuelwood from wetland vegetation, animal forage/grazing services, wetland products, medicinal plants; on regulating services such as run-off and erosion protection, water regulation, water purification, sediment retention; on cultural services such as spiritual; and supporting services such as habitats and nutrient cycling (Table 3).

The highest proportions of perceived ESs of Lake Ziway were recorded related to provisioning services (36–59%), over a quarter to just over half (28–53%) corresponded to supporting services, followed by cultural services (23–35%) and regulating services (12–22%). This illustrates that respondents prioritize the ESs of Lake Ziway as provisioning > supporting > cultural > regulating services (Fig. 3).

Multiple regression was conducted to investigate the best linear combination of respondents' type (Experts and Households) and district/residence location (Meki and Ziway) for prioritizing the views on ESs. The means, standard deviations, and inter-correlations results are shown in Table 4.

This combination of variables significantly predicted provision services, regulating services, cultural services, and supporting services, with both variables (Respondent types and Location) significantly contributing to the prediction (Table 5). The beta weights in Table 5 suggest that respondents' type contributes most to predicting provisioning services and that being experts, having a good understanding of provisioning services, and respondents from the Ziway district also contribute to this prediction.

Harvesting of provisioning services is free from the lake and its wetlands for own use and commercial purposes. However, experts are not more likely than expected to have high ratings than households for the importance of some provisioning services such as cultivated vegetables, fish, water for livestock drinking, domestic, irrigation use and industries, hotel, etc. uses and fuelwood from the wetland plants around the lake, and animal forage/grazing services. There is also a tradition of using grass for daily coffee ceremonies and periodic festivals in Ethiopia. The lake was also the only source of water for Ziway/Batu town residents' water supply up until quite recently. However, recognizing the fact that the water quality of the lake has been getting deteriorated by

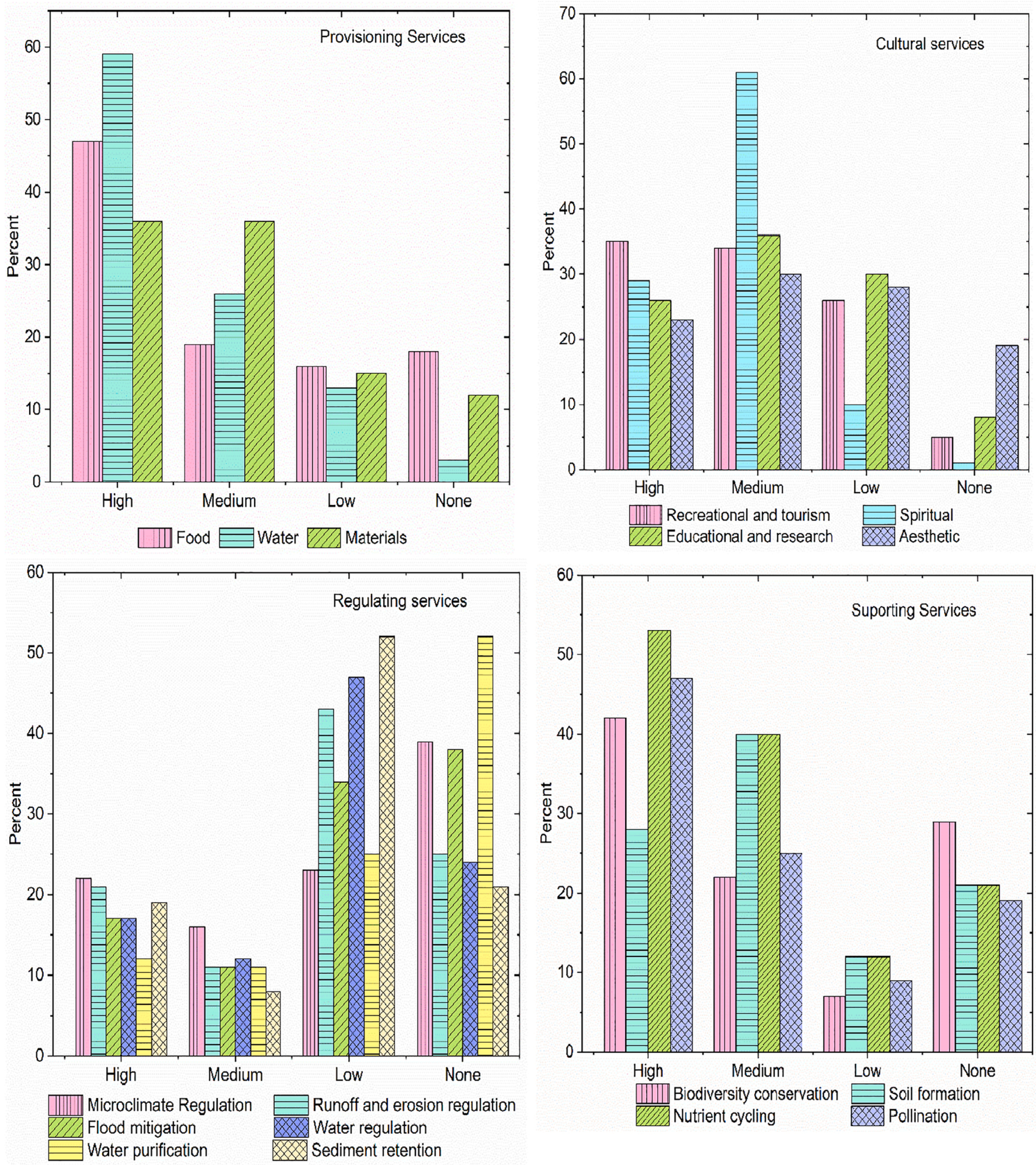

Fig. 3. Views on ESs of Lake Ziway (N = 178).

effluent discharges from flower farms, the municipality has ceased abstracting and supplying water from the lake to the town's residents since 2018. Similarly, respondents from Ziway/Batu are not more likely than expected to have a high ES rating than respondents from Meki district for provisioning services such as water for livestock drinking, water for domestic use, water for irrigation use, fuelwood, animal forage/grazing services, wetland products, and medicinal plants. Experts are not also more likely than expected to have a high ES rating than households for some regulating services such as run-off and erosion protection, water regulation, water purification, and sediment retention; for cultural service such as spiritual; and for some supporting services such as habitats and nutrient cycling.

As has been reported by the great majority of the respondents (96%) in both Meki and Ziway/Batu areas, some groups of local communities use the ESs of Lake Ziway as their livelihood income sources such as fishing (92%) and water for irrigation farms (84.4%) (Table 6). As to the respondents, the main fish species targeted in the lake are African Catfish *(Clarias gariepinus)*, Nile Tilapia (*Oreochromis niloticus)*, *Labeobarbus intermedius*, and Carp (*Cyprinus carpio)*, locally named as 'Ambaza', 'Koroso', 'Dube', and 'Jape', respectively. These resources support the livelihoods of fishing communities but are threatened by human pressures, e.g., over-exploitation, habitat degradation, pollution, etc., FGDs also ascertained that fish production is declining in Lake Ziway and has become unreliable to support income-generating activities among the local poor. For example, most discussants had this to say:

> *"Although fishing is a local livelihood for some members of the local people, there is no control over fishing. As a result, fish production is steadily decreasing and some fish species are disappearing from the lake."*

Next to fishing is irrigation farming using water from the lake. The great majority of the respondents (82%) reported that local communities harvest provisioning services from the lake not only for subsistence but also for commercial purposes.

During FGDs, the Lake Ziway was also examined in terms of its ES

Table 3
Chi-square analysis result for prioritization of ESs.

Variables	Types of respondents χ^2	df	p	Districts χ^2	df	p
Provisioning Services						
Cultivated Vegetables	6.88	3	0.076	15.17	3	0.002
Crops	23.31	3	0.000	62.74	3	0.000
Fish	1.43	3	0.699	8.30	3	0.040
Honey	21.01	3	0.000	18.00	3	0.000
Water for livestock drinking	4.91	2	0.086	1.22	2	0.542
Water for domestic use	0.76	3	0.860	3.89	3	0.073
Water for irrigation use	4.76	2	0.093	0.37	2	0.831
Water for industries, hotel, etc. uses	4.54	3	0.209	48.52	3	0.000
Fuel wood	2.55	3	0.467	5.38	3	0.146
Hand-craft materials	42.38	3	0.000	9.25	3	0.026
Reeds	47.60	3	0.000	11.28	3	0.010
Animal forage/grazing services	7.05	3	0.070	1.79	3	0.616
Wetland products	15.02	3	0.002	5.57	3	0.135
Seedling raising	12.17	3	0.007	9.48	3	0.024
Medicinal plants	15.98	3	0.001	4.52	3	0.211
Regulating Services						
Microclimate regulation	81.40	3	0.000	8.80	3	0.032
Run-off and erosion Protection	103.47	3	0.000	4.83	3	0.185
Flood Mitigation	105.78	3	0.000	14.34	3	0.002
Water regulation	106.94	3	0.000	6.64	3	0.084
Water Purification	83.16	3	0.000	5.86	3	0.118
Sediment Retention	131.67	3	0.000	7.70	3	0.053
Cultural Services						
Recreational and Tourism	20.05	3	0.000	34.67	3	0.000
Spiritual	27.67	3	0.000	5.68	3	0.128
Education and Research	48.40	3	0.000	26.42	3	0.000
Aesthetic	75.19	3	0.000	23.63	3	0.000
Supporting Services						
Habitat for biodiversity conservation	87.39	3	0.000	6.62	3	0.085
Support accumulation of organic matter	120.11	3	0.000	14.85	3	0.002
Nutrient Cycling	91.66	3	0.000	7.14	3	0.068
Support for pollinators	98.32	3	0.000	11.20	3	0.011

Table 4
Inter-correlation results for ESs and predictor variables (N = 178).

Variable	M	SD	District/Location	Respondent Types
I. Provision service	46.25	4.74	-0.22*	-0.28*
Location	0.51	0.50	–	-0.03
Respondent Types	0.77	0.42	–	–
II. Regulating service	12.89	5.60	-0.78	-0.79*
Location	0.51	0.50	–	-0.03
Respondent Types	0.77	0.42	–	
III. Cultural service	11.53	2.86	0.22*	-0.54*
Location	0.51	0.50	–	-0.03
Respondent Types	0.77	0.42	–	
IV. Supporting service	8.33	4.19	-0.06	-0.76*
Location	0.51	0.50	–	-0.03
Respondent Types	0.77	0.42	–	
* P < .01				

M - Means; SD - Standard Deviation

benefits to local people. Discussants indicated that the lake is one of the major lakes in the country because of its economic advantages, for example, by providing significant benefits for fisheries and irrigation. Discussants stated that local vegetables such as tomatoes, peppers, cabbage, onions, etc. are grown using water from this lake are major local products and distributed to different parts of the country. Survey respondents also confirm that grasses, reeds, and some wetland plants found around the lake are used for the benefit of some members of the local communities. For example, when asked what benefits local people have been gaining from the lake, discussants in both Meki and Ziway/Batu recalled the benefits by saying that:

Table 5
Simultaneous multiple regression analysis results for variables predicting ESs (N = 178).

Variables	Source	B	SEB	β
Provisioning services	Location	−2.11	0.67	-0.22*
	Respondent Types	−3.17	0.79	-0.28*
	Constant	49.77	0.78	
	$R^2 = 0.13$; F (2,175) = 12.59, p < .001			
	*p < 0.01.			
Regulating services	Location	−1.12	0.51	-0.10**
	Respondent Types	−10.55	0.61	-0.79*
	Constant	21.58	0.60	
	$R^2 = 0.64$; F (2,175) = 153.54, p < .001			
	**P < 0.05; *p < 0.01.			
Cultural services	Location	1.18	0.35	0.21*
	Respondent Types	−3.64	0.42	-0.54*
	Constant	13.73	0.41	
	$R^2 = 0.34$; F (2,175) = 44.49, p < .001			
	*p < 0.01.			
Supporting services	Location	-0.69	0.41	-0.09
	Respondent Types	−7.59	0.48	-0.76*
	Constant	14.52	0.48	
	$R^2 = 0.57$; F (2,175) = 912.82, p < .001			
	*p < 0.01.			

B - unstandardized regression coefficient; SEB - standard error of estimate; β - standardized regression coefficient

Table 6
ESs of Lake Ziway as income sources for local communities.

Livelihood income sources*	Experts	Households	TOTAL
Fishing	40(97.6) **	124(90.5)	164 (92.1)
Agriculture/ Irrigation farm	38(92.7)	113(82.5)	151 (84.8)
Collection of materials from lakeshores for sales, e.g. grass, reeds, etc.	34(83.0)	70(51.1)	104 (58.4)
Fuel wood collection	33(80.5)	66(48.2)	99 (55.6)
Livestock grazing on wetlands around the lakeshores	32(78.0)	61(44.5)	93 (52.2)
Small trade around the lakeshores	29(70.7)	33(24.1)	62 (34.8)
Handcrafting from lakeshore plants	30(73.2)	17(12.4)	47 (26.4)

*Multiple responses, **Numbers in parenthesis are percentages.

> *"Some of us raised our children using this lake as income sources. It is also providing benefits for unemployed people. It is a lake that offers tourism. Because our region is rain deficient, our cattle, sheep, and goats are grazing along the shores of the lake. It is also a lake used for transportation and animal drinking. There are some groups of local community members especially women who cook fishes for sale around the lake as their income sources. The lake also maintains our local climate. Local communities also perform spiritual traditions on the shores of this lake."*

3.3. Human impacts

Many of the survey respondents (64%) confirmed that any users of the lake don't pay anything in whatever form like tax or other means for any uses of the lake. The majority of the respondents (75%) strongly believe that the local communities' easier and free access to Lake Ziway provisioning services would contribute to the degradation of the lake. FGD results indicated that human activities in the area were the major sources of impacts on lake sustainability. For example, discussants in both Meki and Ziway/Batu stated these impacts by saying that:

"Anyone uses the lake for free. The expansion of agriculture around the lake is having a major impact on the lake. An increase in population in the region is putting pressure on the lake in various ways. For example, the lake is being contaminated with wastes from Ziway/Batu town and chemicals coming out of the flower farms. We used to use the lake's water for drinking and domestic use, but now we are troubled because the lake is highly polluted after flower farms coming to the area."

Various human activities that affect the lake and its ESs and their level of impacts are indicated in Fig. 4. About 74% (83% experts and 71% households), 67% (78% experts and 64% households) and 64% (76% experts and 61% households) of the survey participants rated overharvesting of the lake biological resources, deterioration of the lake water quality and increasing of water abstraction as the main human impacts on Lake Ziway, respectively (Fig. 4). Furthermore, discussants in FGDs pointed out that:

"The lake's water is being drawn for large-scale irrigation farms, construction activities, etc. This has reduced the water level of the lake, and the lake is retreating year after year. However, local administration and communities have nothing so far to do with these problems on the lake."

Yet, the great majority of the respondents (87%) do not know the existing legal rules about lake management and uses. Almost all of the survey participants also witnessed that the local administrations are not informing the local communities if there are existing rules to help them implement for the management of Lake Ziway.

A Chi-square statistic was conducted to investigate whether the types of survey respondents, i.e. Experts and Households and their resident locations (Meki and Ziway/Batu) have differences on whether they have 'very high', 'high', 'medium', or 'low' rating to the different types of impacts on Lake Ziway that are associated with human activities. The Pearson Chi-square results in Table 7 indicate that respondents are not significantly different concerning their types and resident district/locations on whether or not they have 'very high', 'high', 'medium', or 'low' rating to human impacts on Lake Ziway due to population growth, habitat changes in the lake watershed, increasing level of water abstraction, water pollution, and overharvesting of the lake resources. The result indicates that the survey respondents concerning their types and resident locations are not more likely expected to have very high rating among themselves except for some of the human impacts on the lake such as land conversion (land use and land cover changes on the lake watershed) and water quality deterioration of the lake (Table 7).

Multiple regression was conducted to investigate the best linear combination of respondents' types (Experts and Households) and their resident locations (Meki and Ziway/Batu) for assessing human impacts on the lake. The result in Table 8 indicates that this combination of variables significantly predicted the drivers of human impacts on the lake, $F(2,174) = 6.03$, $p < .01$; with both variables significantly contributing to the prediction (respondents' resident location, $p < .05$ and respondents' type, $p = .01$). The beta weights suggest that experts

Table 7
Chi-square analysis result for identification of human impacts on Lake Ziway.

Variables	*Types of respondents* (Experts and Households)			*Districts/Location*		
	χ^2	*df*	*p*	χ^2	*df*	*p*
Population growth	5.23	3	0.156	9.07	3	0.028
Habitat changes	7.61	3	0.055	2.31	3	0.510
Land Conversion	12.11	3	0.007	13.47	3	0.004
Increasing water abstraction	4.54	3	0.209	4.74	3	0.192
Pollution	6.07	2	0.048	17.80	2	0.000
Overharvesting	3.22	3	0.359	4.82	3	0.186

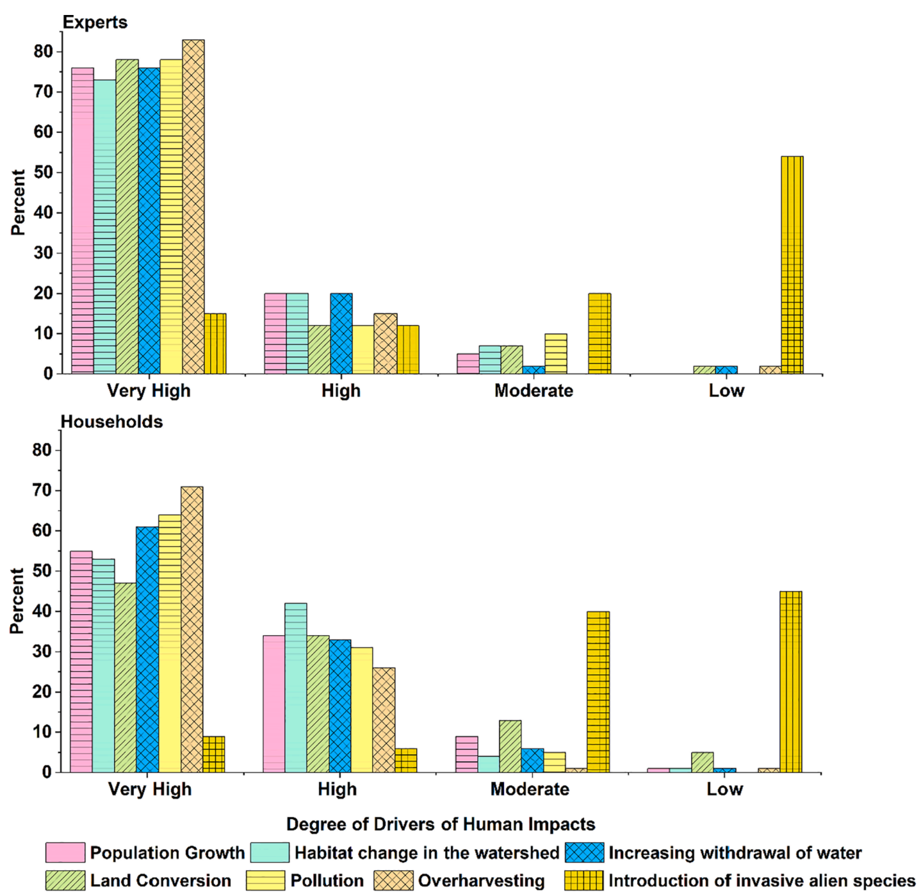

Fig. 4. Levels of human impacts on the ESs of Lake Ziway.

Table 8
Simultaneous multiple regression analysis results for predicting drivers of human impacts (N = 178).

Variables	Source	B	SEB	β
Drivers of Human Impacts	Location	-0.82	0.39	-0.15*
	Respondent Types	−1.33	0.47	-0.21**
	Constant	24.49	0.46	
	$R^2 = 0.07$; $F(2,174) = 6.028$, $p < .01$			
	$*P < 0.05$; $**p = 0.01$.			

contribute most to predicting human impacts on the lake (Table 8).

3.4. Management priority needs

Respondents had shown various priority preferences for the future best management of Lake Ziway (Fig. 5). The majority of respondents (92% of Experts and 88% of Households) showed 'high priority' preference towards the setting up of 'Mechanisms for the lake management' and 'Knowledge sharing platform among the lake users and decision-makers for future sustainable use and protection of Lake Ziway. As shown in Fig. 5, the great majority of respondents (80–91% in both groups) also showed high preferences for the future management and protection of Lake Ziway by the setting up of the following: Community awareness programs on how to use and protect the lake; Water use monitoring and efficiency management methods; Involvement of public and non-governmental organization (NGOs) for conservation intervention; Establishment of activities to reverse the degradation of the lake condition by local, regional and federal authorities; and Conducting periodical assessment on the lake by government authorities. During FGDs on the priority management needs for Lake Ziway, discussants from both Meki and Ziway/Batu suggested their preferences by saying that:

"Before approving any investment projects around the lake, it is important to first identify their impacts on the lake. To sustainably protect and use the lake, the participation of all concerned bodies and users of the lake especially irrigation users is needed to work together. Water use policy should be made available to all beneficiaries, especially to the profit-based investment companies. Awareness is also needed to educate the public on the existing problems the lake faces, and for this, the government's attention should be in place".

4. Discussion

4.1. Ecosystem services

The study described the ecosystem services provided by Lake Ziway's ecological functioning by assessing the perception of local people (households and experts) along with identifying the main anthropogenic pressures that are threatening the potential services of the lake. The concept of ecosystem services was originally developed to illustrate the benefits that ecosystems generate for society and to raise awareness for ecosystem conservation (Birkhofer et al., 2015). Water is involved in supporting, provisioning, regulating, and cultural ecosystem services (MEA, 2005). According to Diaz et al. (2018), ecosystems' contributions to people are categorized into three broads partially overlapping groups – material, non-material, and regulating contributions (Table 9). ESs from freshwater ecosystems can be categorized into three major groups as water supply, the supply of goods other than water, and non-extractive benefits (Postel and Carpenter, 1997). The ESs of Lake Ziway fall into each of these categories which are important for the livelihoods of the local communities and investment projects. Local perceptions of the ESs' benefits depend on the individuals, where they live or work, and their interactive relationship with the location (Scholte

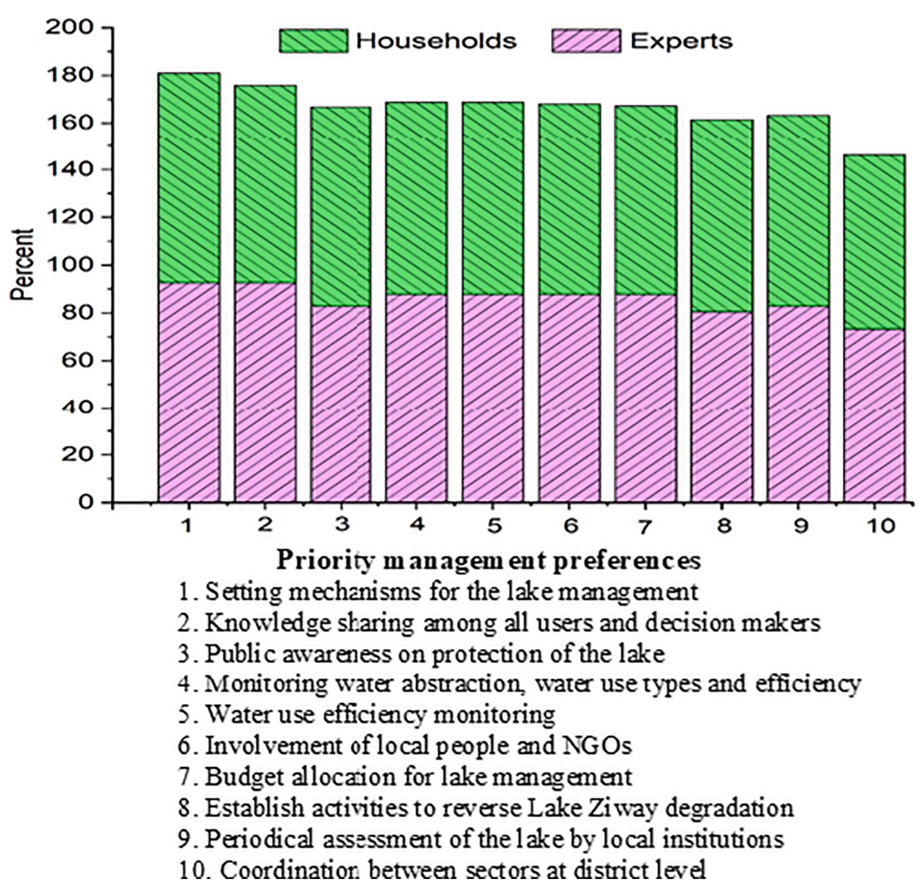

Fig. 5. Priorities for future management of Lake Ziway.

Table 9
Categories of nature/ecosystem contributions to people as per the IPBES (Díaz et al., 2018).

Categories of nature's contributions to people	Regulating	Material	Non-material
1. Habitat creation and maintenance	■		
2. Pollination and dispersal of seeds and other propagules	■		
3. Regulation of air quality	■		
4. Regulation of climate	■		
5. Regulation of ocean acidification	■		
6. Regulation of freshwater quantity, location, and timing	■		
7. Regulation of freshwater and coastal water quality	■		
8. Formation, protection, and decontamination of soils and sediments	■		
9. Regulation of hazards and extreme events	■		
10. Regulation of detrimental organisms and biological processes	■		
11. Energy		■	■
12. Food and feed		■	■
13. Materials and companionship		■	■
14. Medicinal, biochemical and genetic resources		■	■
15. Learning and inspiration		■	■
16. Physical and psychological experiences		■	■
17. Supporting identities		■	■
18. Maintenance of options	■	■	■

et al., 2015; Zoderer et al., 2016), and priorities assigned to the ESs depend on perceived benefits (de Juan et al., 2017). This study indicated that respondents assigned the highest priority on provisioning services (material contributions) from the lake, followed by supporting, cultural, and regulating services, respectively (Table 3), a contrasting result to some other studies (Castro et al., 2011; Martín-López et al., 2012; Paudyal et al., 2018). Irrigation agriculture and fish harvest are being dominant as provisioning services. They help to reduce food insecurity for local people living near the lakes (Sterner et al., 2020). Fish harvest has also benefited in terms of the fishing job to provide economic benefits to locals. However, fish catch has been declining in Lake Ziway (Abera, 2016), with an annual average of 2500 tons in 2000, 1200 tons in 2010, and 1157 tons in 2011(Hailu, 2011). This decline may be due to human pressures. Besides, rural communities still use the lake water for both domestic and drinking purposes including livestock drinking.

The regulating contributions of ecosystems are functional and structural aspects that regulate the generation of material and nonmaterial benefits (Díaz et al., 2018). These regulating services affect people's well-being (SEP, 2015). The majority of respondents described Lake Ziway in terms of its regulation on local microclimate, run-off, flood mitigation, and sediment retention (Table 2 and Fig. 3). Experts' views and field observations also showed that the lake has supporting services, as perceived by 42% of the respondents (Fig. 3). The wetlands around the lakeshores provide supporting services such as nursery refugia, breeding, and feeding sites for different species of fishes such as *Oreochromis niloticus, Clarias gariepinus*, *Cyprinus carpio, Labeobarbus intermedius,* and *Tilapia zilli* (Abera, 2016). It also provides habitat supports for macroinvertebrates, reptiles, birds, and mammals such as hippopotamuses as observed in the survey. It supports habitats for bird species such as cranes, heron, ducks, geese, and other several waders of intra-African species (Spliethoff et al., 2009). According to Girma (2014), the lake also provides habitats for some endemic bird species. Transportation is another important ESs from lakes (Sterner et al., 2020). Though it is not well perceived by the great majority of respondents, Lake Ziway provides transportation corridors for people living in its five islands. Lake Ziway also contributes to the local and national economy from the export of flowers. The biggest commercial floriculture investment in the country is based on the shore of Lake Ziway, depending mainly on the Lake's water.

Cultural ES services support activities like outdoor exposure, social interaction, income generation, etc. (Sterner et al., 2020), though they are often neglected from ecosystem services studies due to the difficulties in their operation such as uncertainties on their generation and people's demand for them (Chicharo et al., 2015). As has been reported by the respondents, Lake Ziway supports a variety of cultural services like aesthetic, spiritual, educational, recreation, and tourism (Fig. 3). This includes '*Erecha'* and epiphany festivals (Fig. 6) which are annually celebrated on the lake shorelines in Meki and Ziway/Batu areas. There is also ritual gathering by the Oromo community at "Chafa Jila" wetland from the Ziway-Dugda side (Fig. 1). The lake also provides research opportunities for Fishery Research Centers and university students. It is also used for ecotourism, mainly for bird watching. Respondents, however, rated lower importance of the lake towards the cultural, regulating, and supporting services as they have non-material benefits. In general, identifying anthropogenic impacts on service-providing units (ecosystems) and ecosystem services, accounting for dynamics and uncertainties in models of ecosystem service provisions, analyzing relationships between multiple ecosystem services, and understanding temporal dynamics of service provision to develop sustainable management and conservation strategies are the current challenges in ecosystem service research (Birkhofer et al., 2015). Yet, ESs assessments have been given importance in international initiatives such as the MEA,

Fig. 6. Orthodox church followers gathering to celebrate epiphany at the shore of Lake Ziway.

the Economics of Ecosystem and Biodiversity (TEEB), and the Intergovernmental Platform on Biodiversity and ESs (IPBES) (Oteros-Rozas et al., 2014) so that these assessments have become common in recent times (Braat and de Groot, 2012). However, a small number of studies have addressed lake ecosystem service values (Zheng et al., 2008; Liu, 2014).

4.2. Livelihoods

The lakes in the Rift Valley Region of East Africa provide sustenance and livelihood to millions (Sterner et al., 2020). According to information from households, experts, and FGDs, some local communities living around Lake Ziway depend on the lake's ESs for their livelihoods. These are mainly provisioning services such fishing, growing crops,

Fig. 7. Some of the provisioning services of Lake Ziway to the local communities.

horticulture mainly vegetables, livestock rearing, collection of thatching grass and reeds like Typha and Papyrus, etc., and handcrafting of wetland products, such as stool-making from stems of *Aeschynomene elaphoxylon*, wetland plant locally named as 'Bofofe', reed boats and mattress from wetland grasses (Fig. 7). Provisioning services such as crop and vegetable farming and fish harvest are the major sources of livelihoods (Desta et al., 2015). Small trades around the lakeshores, boat transportation, and daily labor in flower farms and irrigation farms are also common income sources that happen because of Lake Ziway. These employment opportunities are attracting people from other regions.

4.3. Human impacts

Many of the world's freshwater lakes are under human pressures (Burns et al., 2009) due to population growth, economic development, and urbanization (Martin-Ortega et al., 2015). They are also exposed to the threat of climate change (Bates et al. 2008), though they mitigate the effects of climate change via carbon sequestration and hydrological buffering (Schallenberg and Winton, 2013). The pressures can be over-harvesting of fish, changing land uses, habitat degradation, introducing invasive alien species, and pollution (Pereira et al., 2012; SEP, 2015; Hampton et al., 2018). These pressures have a direct impact on the functioning of aquatic ecosystems (SEP 2015), mainly in agricultural-dominated rural areas of Africa (Soni and Bhatt, 2008; Moges et al., 2018; Wondie, 2018). Lake Ziway is a typical example of the human stressed lakes in Africa. Fifty-five percent of its watershed is agricultural land use type (Desta et al., 2017). The degradation of the lake is also increasing with time due to the increasing population and the subsequent economic activities adjacent to the lake (Desta and Fetene, 2020), similar to other lakes elsewhere in the world (Zhang et al., 2017; Feng et al., 2018). According to Aznar-Sánchez et al. (2019), the deterioration of aquatic ecosystems has become a major global challenge.

Increasing water abstraction using motor and electric pumps (Fig. 8) from Lake Ziway for large-and small-scale irrigation has been perceived by the majority of the respondents. Irrigation is highest in Meki and Ziway districts as the lake is the source of water for year-round irrigation to provide an economic opportunity for smallholders to grow cash crops, and for flower farmers to grow year-round. Diversion of rivers flowing into lakes and the abstraction of water from lakes are the main modifications to the natural hydrological regimes that affect lakes (Schallenberg and Winton, 2013). Besides diversions of feeder rivers in the upper catchments, abstraction from Lake Ziway was recorded as 6.2 million liters per day for agriculture and commercial flower farms (Desta et al., 2017). This has a sustainability threat to the lake taking into account Ketar and Meki Rivers' inflows (0.418 and 0.273 $km^3\ yr^{-1}$, respectively) to the lake and Bulbula River outflows (0.157 $km^3\ yr^{-1}$) from the lake, and precipitation on the lake surface (753 mm yr^{-1}) (Vallet-Coulomb, et al., 2001). The government of Ethiopia is expanding irrigation to help ensure food security (Ahmed, 2019). Meki and Ziway districts have become centers of this due to the presence of Lake Ziway. Experts also reported that local authorities in both districts are promoting irrigation farming as a means to create jobs for job seekers, increase crop productivity, and improve the livelihoods of locals. However, intensive draining of wetlands for cultivation is degrading the lake (Pascual-Ferrer et al., 2014; Teklu et al., 2018). This can degrade the lake's ESs and hydrological natures (Jogo and Hassan, 2010; Moges et al., 2018). The current fish harvest is not also sustainable due to a lack of scientific and overfishing control practices. These practices may decrease biodiversity and jeopardize future harvests (Sterner et al., 2020).

Lake Ziway and people from other parts of the globe are indirectly connected through the flower farm investments based on the lake shorelines. There are flows of ecosystem services such as cut-flower trades from Ziway/Batu to Europe and other regions. These ESs are there due to Lake Ziway for people far away from the lake. The consequences of these telecoupling effects, i.e., all direct and indirect socio-economic and environmental interactions from distant places, have demonstrated negative implications on the lake sustainability and local communities' well-being (Liu et al., 2019). As has been observed and confirmed by the respondents and discussants, effluent discharges from flower farms (Fig. 8) are affecting the lake's water quality. Earlier studies by Derege et al. (2012) and Pascual-Ferrer et al., (2014) have confirmed this. The flower farms are deteriorating Lake Ziway's water quality (Tibebe et al., 2014), exceeding both national and World Health Organization's standards (Teklu et al., 2018). Such anthropogenic activities have made the lake eutrophic due to accumulations of nutrients.

Fig. 8. Electric pumps for water abstraction, flower farms, and waste discharges on the lake shores.

This has brought invasive plants, namely, water hyacinth (*Eichornia crassipes*) as has been observed on some parts of the lakeshores, impacting the lake's valued biota and ecosystem services, a similar result to other studies (Ricciardi and MacIsaac, 2011, Schallenberg and Winton, 2013).

The Federal Government of Ethiopia has set the national water resources management Proclamation (No. 197/2000) to determine how water resources would be properly managed and utilized for various development purposes in the country. Besides, the Oromia Regional State has the decision-making mandate regarding the proper management of water resources found within the region following the federal water resources management proclamation (No. 197/2000). Yet, both parties have not played an active role regarding the protection and proper use of the water resources of Lake Ziway.

4.4. Management

Management of lakes should first identify priority actions for implementation (ILEC (International Lake Environment Committee), 2005). The great majority of respondents (88–92%) have suggested various priorities including water quality monitoring and participation of local people in the best management of Lake Ziway. Water quality monitoring is the prerequisite before, during, and after lake management actions (Burns et al., 2009). Besides, funding and governance are needed for effective lake management actions (Lin and Ueta, 2012). WLVC (World Lake Vision Committee) (2003) has further strengthened the fact that lake management actions should be implemented from the perspectives of ESs by involving multiple stakeholders including local communities as their information and participation is an important procedure for the decision-making process (Chicharo et al., 2015). Based on the assessment that Lake Ziway was subject to increasingly competing for claims from various stakeholders, the Horn of Africa Regional Environmental Network of Addis Ababa University and the Wageningen University of the Netherlands developed the Participatory Land Use Planning Program along with conducting a detailed inventory of birds, vegetation and habitat types along the western shore of the lake between 2008 and 2011. However, though planned, a water allocation plan has not yet been developed for implementation in the lake sub-basin (http://www.aau.edu.et/hoarecn/major-projects/environmental-governance/). The management of vulnerable lakes like Lake Ziway requires management strategies to tackle human impacts by taking into account the local people's values and beliefs (Lin and Ueta, 2012). Community values and local knowledge have been one of the essential components of natural resource management for several decades (Sherren et al., 2010).

In recent years, ESs have been widely used in land-use management, policy support, and human well-being (Bateman et al., 2013). Considering the relationships between ES provisions and management interventions, identifying the effects of anthropogenic interventions on ecosystems at different spatial scales along with coupling ES provision research with conservation-oriented research are important in the ES research (Birkhofer et al., 2015). In support of this view, this study might contribute to pointing out human impacts and providing recommendations for the better management of Lake Ziway's ecosystem and its ESs. According to Danley and Widmark (2016), ESs help identify an appropriately wide range of environmental variables for policy and management.

As a whole, the ecological structure and functioning of lakes provide a wide range of ESs that can be valued in monetary terms (Schallenberg and Winton, 2013). Various valuation methods have been used to estimate both the market and non-market components of the values of ESs (Costanza, et al., 1997). But, studies of ESs and valuations are subject to uncertainties both at the provision of the services and the meaningfulness of valuations (Johnson et al., 2012). Lakes provide some ESs that can be quantified in terms of monetary contributions to the economy like commercial fishing and others (Schallenberg and Winton, 2013). This study aimed to assess a range of the various ESs provided by the Lake Ziway ecosystem. However, the study did not integrate valuations of Lake Ziway's ESs to show the lake's ecosystem contributions in economic terms to the local people and the profit-based companies based around the lake like floriculture industries, resort hotels, etc. This limits the full description of the resulting assessment of the ESs of the lake. Given the limitations and uncertainties encountered, there should be further research on the Lake Ziway ecosystem to study and estimate the values of the various types of ESs in monetary terms.

Despite the limitation, this Lake Ziway-focused research would contribute to generating knowledge of its ESs and the ecological, economic, and social significance of these services. It would also contribute to identifying the main drivers currently impacting the lake and its ESs. The results of this study are therefore useful not only to develop better protection and conservation strategies for governmental institutions and development agents working on the management of water resources, but it can also be useful to set future research directions for researchers on the subject area of ESs and estimation of their monetary values linked to lakes and other aquatic ecosystems elsewhere in the country or region. The results generated from this study can also inform policy, planning, and regulatory decision-making for the lakes' better management in the country, besides raising local people's awareness of the significance of the Lake Ziway ESs in the ecological, economic, and social frameworks.

5. Conclusions

This study generated knowledge on local people's perceptions of the ESs of Lake Ziway, and drivers of changes impacting the lake ecology. The ESs of Lake Ziway support socio-economic development at the local and national levels. The lake provides all types of ecosystem services - supporting, provisioning, regulating, and cultural ones. However, the ESs of the lake are mainly related to provisioning services. It provides a variety of ecosystem goods and services that are primarily a source of livelihood for some of the local people. Anthropogenic pressures are however currently impacting the lake and the sustainability of its ESs provision. The impacts are aggravating due to the ever-increasing demography, habitat/land-use changes, excessive water withdrawals, pollution (effluent discharge from flower farms), and overharvesting of the lake's resources are among the major drivers of the Lake Ziway ecosystem changes. Although respondents claim that the flower farms are responsible for polluting the lake, agrochemical runoffs from smallholder vegetable and crop production in the lake watershed are also contributing and aggravating the lake's water quality deterioration. Accordingly, given the dramatic increase of human pressures on the lake and expecting the future impacts of these pressures on the ESs of the lake and its sustainability, conservation measures should be considered by multiple stakeholders such as local government institutions and decision-making bodies, local communities living around the lake, companies invested along the lake shorelines, and other development partners like NGOs. They all should participate in the planning and implementation processes of conservation activities to ensure the sustainable use of the lake and its ESs. These conservation actions should include the implementation of some sort of financial payment mechanisms linked with the Rift Valley Lakes Basin Authority for the use of ESs particularly for water uses as direct funding sources for conservation. Strong measures should also be envisaged on floriculture industries to reduce their impacts on the lake. The government irrigation policy should aim at providing credits or any other supportive means for smallholder farmers and investment subsidies for investors that have integrated water conservation activities as their major components.

Dissemination of ecosystem services' knowledge can strengthen public awareness about the role and values of ecosystems (Chicharo et al., 2015). Awareness should thus be given to the lake user communities about the anthropogenic pressures that are currently impacting the lake and its ecosystem services towards setting conservation practices. Along with this, encouraging adaptation strategies particularly diversification to other livelihood activities is important for lake-dependent local communities as the majority of poor people in Ziway/Batu are dependent on the services of Lake Ziway. Local actors' involvement is also crucial to improve the acceptability of the lake conservation through the development of management plans and implementation processes. In this regard, the involvement and participation of local actors such as investors-flower farmers, and local communities that use Lake Ziway's water resources is important to enabling shared responsibility for the lake's sustainable use and conservation.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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