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Farmers' awareness and perception of Lake Ziway (Ethiopia) and its watershed management

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ABSTRACT

The article examines how heads of farmers' households perceive the socioeconomic benefits of Lake Ziway (Ethiopia), the causes of its current degradation, and the state of land and water use management in its watershed. The investigation was based on in-depth empirical field work including a survey with 635 heads of smallholder farmers' households via interview using semi-structured questionnaires. Further, water abstraction was estimated from three districts that border with the lake. Respondents believe that Lake Ziway provides a number of individual and collective benefits for local communities, private companies and public institution. They stated, however, that the lake is under pressure from the floriculture industry and other investment projects, high population growth and subsequent expansion of settlements and irrigation farms, high applications of agrochemicals, soil erosion, uncontrolled water abstraction, and deforestation in the watershed. The respondents further believe that these activities are degrading the lake water quality, shrinking its water volume and decreasing its fish population. After examining government's efforts to address these activities, the majority of respondents believe that the government role in the whole watershed is weak. This study contributes to better understand the local socio-ecological coherences and the problems Lake Ziway and its watershed are facing. It also provides information regarding long-term sustainable land and water use planning strategies for the lake and management of its watershed, which could also be applied to other lakes in Ethiopia, and beyond.

1. Introduction

Significant portions of the Earth's land and water resources are under increasing global pressure (Vitousek et al., 1997; Ramankutty and Foley, 1999). These resources are some of the most critical assets needed to support the livelihoods and socioeconomic development of human society; however, freshwater resources are now among the scarcest resources in some parts of the world due to rapid population increases, fast economic development, and mismanagement (Huang and Cai, 2009). Their watershed degradation is one among many critical environmental problems, mainly associated with human interactions with the physical environment (Bach et al., 2011). Such society-environment interaction processes at different scales over time and space are active components of resource use systems (Campbell and Olson, 1991). However, many of the causes for these critical environmental problems arise at the local scale from these interactions. Such impacts are especially prominent in developing countries due to the large demands of an ever-increasing human population, which are further aggravated by poverty.

Humans are also the main drivers of changes in watershed hydrology and processes (Roth et al., 1996; Tomer and Schilling, 2009) that lead to a decreased availability of different products and ecological services (Moshen, 1999). Anthropogenic factors, such as changes in land use and the handling of agrochemicals in a lake's watershed can have adverse impacts on the water quality and associated biological communities (Brooks et al., 1997; Kolpin et al., 2002). Moreover, lakes are harmed by direct abstraction of water for various human uses. Thus, as stated by Rast (2003) lakes are "barometers" of the impacts of human activities. Thus, the maintenance of water quality and quantity in lakes should be a considerable concern for humans (Cohen et al., 1996). Recognizing these facts, sustainable water resource management has become a priority on the agenda in many countries.

Lake Ziway is the largest freshwater lake in the Ethiopian Central Rift Valley (CRV). The lake and its watershed play a significant role in supporting the livelihoods of the approximately 2 million people in the watershed (CSA, 2013) and 1.9 million livestock (Derege et al., 2012)

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that inhabit it. According to Jansen (2007), the lake provides 7–8 million cubic meters (m^3) of water per year for domestic and livestock use alone. The municipality of Ziway Town has long been using this lake as a single source of water supply for town residents by abstracting thousands of cubic meters of water per day. The lake is also a source of water for open and closed farm irrigation. Water is freely abstracted from the lake, with no use charge because all water resources are the common property of the people and the state (FDRE, 2000). It is also a source of fish supply to huge market centers in the country. A large number of anglers, both in cooperatives and individually, depend on this lake for their livelihoods, including women and children involved in processing and selling the fish. According to Vuik (2008), besides its economic and livelihood values, the lake and its watershed support unique ecological and hydrological characteristics.

However, Lake Ziway is currently exposed to various human pressures due to the intensification of development activities in the watershed (Biswas et al., 2004; Willén et al., 2011; Pascual-Ferrer et al., 2013; Berhan et al., 2016). The expansion of small- and large-scale farms and the increase in the unplanned uses of agrochemicals in these farms have contributed to the growing deterioration of the lake's water quality (Zinabu, 2002; Girum and Seyoum, 2012; Malefia, 2012; Brook and Hayal, 2016). This is because agro-chemicals from the watershed ultimately end up in Lake Ziway – the final recipient in the watershed – via runoff. The western parts of the lake in particular are far more exposed to the various sources of pollutants than other parts due to the presence of many development activities, such as those of the floriculture industries and irrigation farms, including urban settlement, etc. Thus, the applications of excessive agrochemicals in these areas are increasing (Derege et al., 2012), especially by the floriculture industries (Hengsdijk and Jansen, 2006). As a result, some physicochemical parameters and nutrient levels in this part of the lake have exceeded both the national and international standards (Berhan et al., 2016).

Natural vegetation in the watershed, such as forests and woodlands, are also degrading at an alarming rate due to land use changes (WBISPP, unpublished, 2017; MoA, unpublished, 2017) which have rapidly increased in the watershed since the 1970s being manifested by the expansion of agricultural fields along with increasing of watershed population (Hengsdijk and Jansen, 2006). Expansion of agricultural fields, along with increased demand for water, has also greatly affected the hydrologic dynamics of the lake and its watershed.

Thus, it must be the responsibilities of government institutions under their own legal mandate from top to bottom structures to support and coordinate all stakeholders to best protect Lake Ziway and its watershed. However, there is no coordination and promotion actions in place by government institutions to make local farmer communities, private companies, fishermen and NGOs involve and work closely with local, regional, and federal government institutions towards the lake and its watershed management. Besides, the government institutions at any levels have not yet demarcated buffer zones for Lake Ziway to protect its shoreline areas from human impacts and investment projects for effective management of the lake environment. Furthermore, the government has no lake management plan that identifies responsibilities and priorities for monitoring and evaluation purpose. No budget is also allocated for the implementation of the lake conservation. Moreover, there are lacks of periodical inspections and follow up mechanisms on wrongdoers to solve the problems facing Lake Ziway, particularly effluent discharges into the lake from lake-shore based investment projects such as floriculture industries.

In Ethiopia one of the objectives of the Water Resources Management Policy is conserving, protecting and using water resources on sustainable basis (MoW, unpublished, 2017b). However, the private companies' short-term profit gains at the expense of the lake resources do not consider the longer-term 'environmental costs' on the lake. Thus, comprehensive action is necessary to prevent degradation of Lake Ziway and to ensure the sustainable management of land and water resources in its watershed. Upon this backdrop, it is therefore necessary to study the problems holistically and demand local communities' participation to broaden and conceptualize the value of land and water resources in the watershed, and to implement successful integrated watershed management plans (Klessig, 2001; Lubell, 2004; Sheil and Liswanti, 2006; Gurung, 2007; Conrad and Daoust, 2008; Romanelli et al., 2011).

Therefore, based on Panelli and Robertson (2006), smallholder farmers have been involved in this study since they can articulate their own individual and collective experiences, describe their perception of the environments in which they live, and mirror societal awareness of the different human-environment interactions that exist in their localities. Hence, the objective of this study was to examine how farmers' heads of households perceive the socioeconomic benefits of Lake Ziway, the causes to its current degradations, and the state of land and water use management and interrelated impacts in its watershed. In this regard, this article is timely to understand the problems Lake Ziway and its watershed are facing.

2. Methods

2.1. The study area

Lake Ziway watershed encompasses an area of 7032 km^2, falling between gradients 7° 22′36″N and 8°18′21"N latitude and 37°53′40″E and 39°28′9″E longitude (Fig. 1). The watershed lies in two Ethiopian administrative regions – 73.6% in Oromia National Regional State (ONRS) and the remaining part in Southern Nation Nationalities and People Regions (SNNPRS) – stretching from the edges of the Gurage Mountains in the west to the Arsi Mountains in the east and rising over 3500 m above sea level (masl). The watershed includes the rift floor, two escarpment areas, two major river inlets – the Katar and Meki Rivers – and one river outlet – the Bulbula River. The watershed in the rift floor is predominantly flat, with its altitude varying from 1601 to 1771 masl.

Lake Ziway is located at 160 km south of the capital- Addis Ababa, immediately to the east of Ziway town of ONRS. The lake extends over an area of approximately 434 km^2 and has a maximum of 9 m and an average depth of 2.5 m with a shoreline length of 137 km (Hengsdijk and Jansen, 2006). It is the most upstream of the CRV lakes of Ethiopia. Besides seasonal runoff and groundwater movement, runoff from the watershed drains into the lake through the two feeder rivers – the Katar and the Meki – which represent the opposing faces of the rift escarpments (Fig. 1). The retention time in the lake is approximately 1.5–2 years (Spliethoff et al., 2009). The lake exhibits fresh water quality and is an important element of the Ethiopian Central Rift Valley region because it currently serves as the water source for closed and open farm irrigation, and as the only potable water supply for the Town of Batu. It also supports the livelihoods of the fishing community. It is a habitat for biological diversity, such as fish, birds, and mammals like hippopotamuses, among others. The marshes around it also support several bird species and provide roosts for several thousand cranes, herons, ducks, geese, etc. (Spliethoff et al., 2009). Bulbula River is an outflow from Lake Ziway to the south, feeding the terminal lake, Lake Abijata. Groundwater flows from Lake Ziway towards the north-south gradient feeding Lakes Langano, Abijata, and Shala (Tenalem, 2001), all of which lie at lower altitudes, with Lake Shala being the final recipient. Therefore, Lake Ziway has great geochemical and hydrological significance for these immediate lakes.

The climatic conditions are not uniform throughout the watershed. The minimum and maximum annual precipitation in the watershed is 729.8 mm and 1227.7 mm respectively with the mean annual temperature of 18.5 °C. The wet season – June to September – accounts for about 55% of the annual precipitation, while the dry season contributes 45% (Billi and Caparrini, 2006).

The predominant land use in the watershed is smallholder agricultural lands, although other land uses types such as settlement,

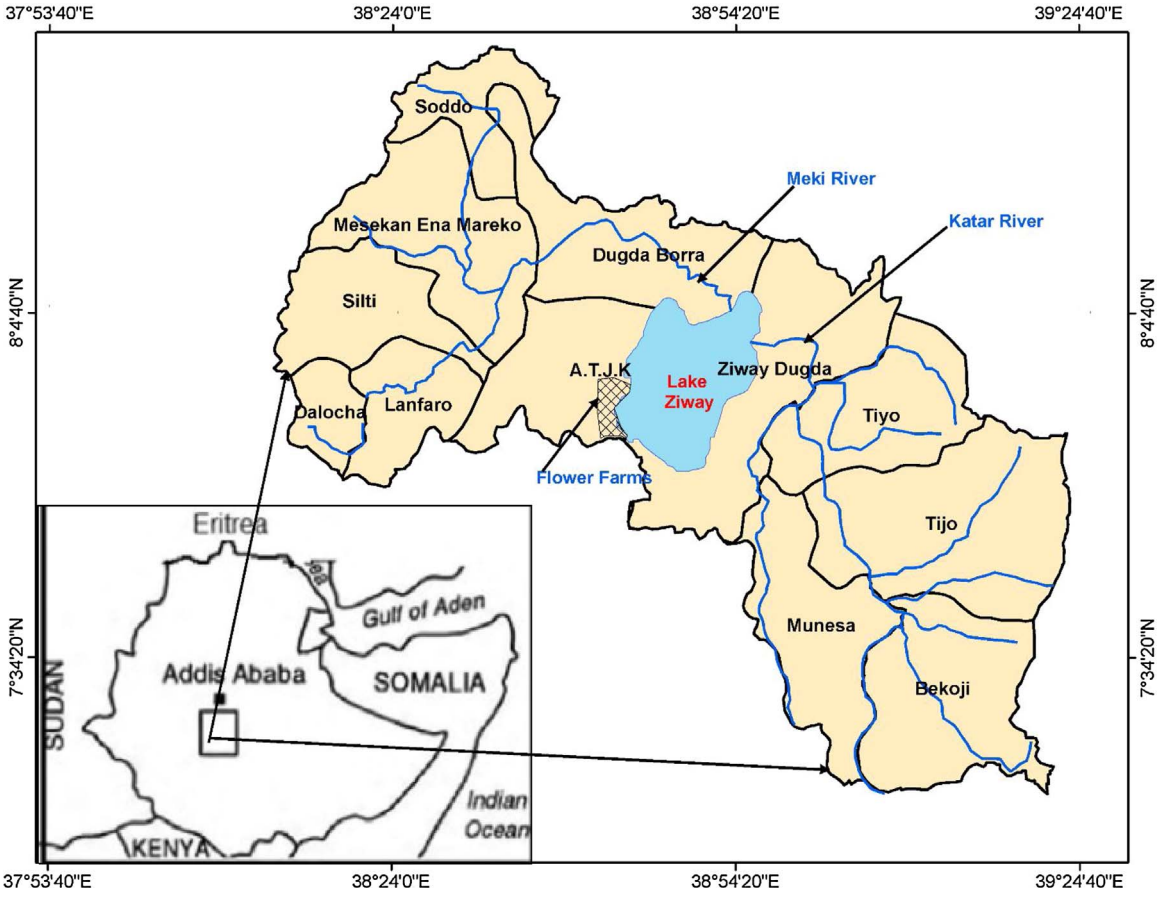

Fig. 1. Location of Lake Ziway and its watershed boundaries.

woodlands, etc. are present. Sparse acacia trees, patches of grassland, and extensive cultivated crop fields cover the watershed rift floor and lower slopes. The vegetation cover is characterized by extensively overgrazed Acacia combretum in open woodland (Zerihun and Mesfin, 1990), whereas deciduous woodlands occupy the escarpments (Mohammed and Bonnefille, 1991). The settlement pattern is typical of rural communities across Ethiopia (Stellmacher, 2015) where the average household farm land holding size is 1.98 and 0.88 ha in ONRS and SNNPR respectively (CSA and World Bank, unpublished, 2017). Livelihoods largely depend on smallholder agriculture. Land use change is massively and rapidly taking place, as elsewhere in the Ethiopian CRV (Dadi et al., 2016).

2.2. Methods of data collection

2.2.1. Survey with farmers

Between November 2014 and May 2015, a survey was conducted with 635 farming households in 13 districts within the watershed using a semi-structured interview. Seven of these are in ONRS – Adami Tulu Jido Kombolcha (A.T.J.K.), Bekoji, Tiyo, Tijo, Dugda Bora, Ziway Dugda and Munesa – while the remaining six districts are in SNNPR: Lanfro, Mareko, Meskan, Silti, Sodo, and Dalocha (see Fig. 1).

Data collectors who were fluent in the local languages were selected from members of the local communities in their respective districts. Representatives of the farming households were selected by data collectors using simple random technique, i.e., by choosing the first household randomly and then subsequently interviewing every tenth household, who went door-to-door in their localities. Respondents with 16 years of age and above were simply selected on the basis that they live within the watershed. Gender, age, and educational level of household head were included because they play an important role in shaping household perception (Lori et al., 2010).

The questionnaire was developed in English (see Appendix) and then translated into Amharic for data collectors. Then, interviews were conducted by translating Amharic into local languages (Oromifa in ONRS, and Guragegna and Siltigna in SNNPR). Data collectors were first informed of the aim of the interview, and some scientific terms in the questionnaire to explain to the respondents during the interview. Before commencing the full survey, the questionnaire was pretested with 10 farming household heads, i.e., five from A.T.J.K. and five from Dugda Bora. It was then modified based on the feedback from this pretest. The questionnaire was designed to focus on three main topics: the awareness about the socio-economic benefits of Lake Ziway, the principal reasons for changes at Lake Ziway and its watershed, and the preferences about the future with regard to more sustainable use and management of Lake Ziway and its watershed. One interview took approximately 40–50 min.

Data were tabulated and managed in an Excel spreadsheet. SPSS (Statistical Package for the Social Science) version 20.0 (IBM Corp., 2011) was used for data analysis. Chi-square distribution and contingency tables were applied to display the number and percentage of household respondents for each question (variable). Tests were used to determine whether two variables are independent of, or related to, each other using the test of independence of variables. Most of the data were designed to reflect a 95% confidence level to ensure statistical significance.

2.2.2. Water abstraction

Individual farmers, cooperatives, municipalities and private companies abstract water from Lake Ziway using pumps of different capacities. These pumps are registered in their respective district offices. These offices were first approached for the required data with letter of

cooperation and support from Addis Ababa University. Upon submission of the letter, data about the number of pumps being used along with their capacity was collected from Agriculture, Municipal Water Supply, and Water, Mine and Energy Offices of the three districts that share administrative borders of the lake, namely, A.T.J.K., Dugda Bora and Ziway Dugda to estimate abstraction from the entire lake. Abstraction was then estimated assuming six working hours per day as:

$$A = P \times C \times H$$

where:

A—Amount of water abstraction (liter/day),
P—Number of *pumps* being used,
C—Abstraction *capacity* of the pumps (liter per second), and
H—Abstraction *hours* per day.

3. Results

3.1. Background information

A total of 13 districts are found within Lake Ziway watershed. A map showing the districts' location relative to the lake and floriculture industries is shown in Fig. 1. The number of people living in these districts and their representation in this survey are indicated in Fig. 2. Of the total 635 interviewed households in the watershed, 352 (55.4%) respondents were from seven districts of ONRS and 283 (44.56%) from six districts of SNNPR.

The composition of the respondents with regard to household position, years of settlement in the watershed, age, and level of education was summarized in tables (Tables 1 and 2) and the graphs (Fig. 3). 84.2%, 10.9%, and 4.9% of the respondents were from the male-headed households, female-headed households, and other family members representing the heads of households respectively (Table 1).

35.1% of the respondents were within the age range of 31–40, followed by a nearly equal proportion within the ranges of 18–30 (24.9%) and 41–50 (23.6%) years of age, 11.2% of the respondents were within the 51–60 range, and about 5% of the respondents were above 60 years of age. Only 0.5% of the respondents were within the 16–18 range. More than 80% of the interviewees were males, mainly because more men were in their localities for various activities during the survey period. The median age was 31–40 years old.

Table 1
Proportion of respondents' characteristics by level of education and household position.

Level of Education	Household Position			Total
	Husband	Wife	Child	
Illiterate	97(15.3)	35(5.5)	1(0.2)	133(20.9)
Read and write	143(22.5)	21(3.3)	3(0.5)	167(26.3)
Primary school	233(36.7)	9(1.4)	9(1.4)	251(39.5)
Secondary school	57(9)	1(0.2)	11(1.7)	69(10.9)
Postsecondary	5(0.8)	3(0.5)	7(1.1)	15(2.4)
Total	535(84.3)	69(10.9)	31(4.9)	635(100)

a(b) is to mean frequency (percentage).

Among the randomly selected and interviewed respondents, the majority (40%) has completed their primary level of education (grades 1–8), followed by (11%) who completed their secondary level of education (grades 9–12). Very few respondents (2.4%) have attended postsecondary education programs (Technical and Vocational Training). The remaining were illiterate, and some with no formal education, but who can read and write (Fig. 3).

3.2. Demographic and socio-economic characteristics

About 86% of the respondents have lived in their current area for more than 20 years, of which about 3% are migrants. 74% of the respondents were born in the area (Table 2). According to this study, the average household size (the average number of family members per participating household) in Lake Ziway watershed is 5.9 persons. The main household income source for the great majority of respondents (96.5%) in this watershed is farming, mainly crops such as wheat and maize.

3.3. Land tenure

The overwhelming majority of the respondents (about 92%) chose to remain in the area due to the availability of land for cultivation. 57.3% of respondents replied that they inherited the land they own from their parents, 13.5% rented from the owners, and the remaining (29.2%) had both inherited and rented land. This study revealed that the average cultivated landholding size in the Lake Ziway watershed is

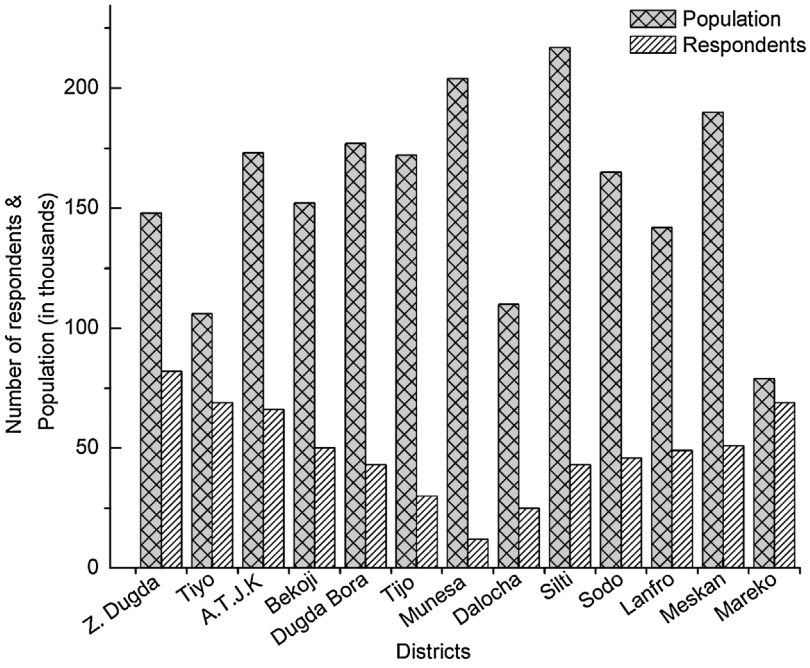

Fig. 2. Number of respondents and population by districts within Lake Ziway watershed.

Table 2
Years of settlement and origin to the area.

Years of settlement	Where they came from						
	Within the same village	From neighboring villages	Within the same districts	From neighboring districts	Within the same zone	From neighboring zones	From another region
< 5	–	–	–	–	–	7(1.1)	7(1.1)
< 5–10	4(0.6)	5(0.8)	4(0.6)	–	–		13(2)
< 11–15	10(1.6)	8(1.3)	3(0.5)	2(0.3)	–	2(0.3)	25(3.9)
< 16–20	27(4.3)	15(2.4)	3(0.5)	1(0.2)	–		46(7.2)
> 20	429(67.6)	60(9.5)	19(3)	8(1.3)	3(0.5)	9(1.4)	544(85.7)
Total	470(74)	88(13.9)	29(4.6)	11(1.7)	3(0.5)	18(2.8)	635(100)

1.59 ha. This study has also revealed that households in the watershed have on average used 2.03 quintals of fertilizers (mainly DAP – Diammonium Phosphate – and UREA) per annum.

3.4. Socio-economic benefits of Lake Ziway

Almost all respondents from three districts that border Lake Ziway – namely, A.T.J.K., Dugda Bora, and Ziway Dugda – replied they visited the lake and its surrounding area very frequently (many times in a week) for various beneficial activities such as animal watering, farming, grazing, etc. The great majority of respondents (74%) believed that local communities get different benefits from the lake, but 20% did not know whether or not the communities get these benefits. Yet few respondents (6%) believed that the communities do not get any benefits out of the lake. Respondents' views on the lake's benefits to local communities depended on their distance to the lake. Of those respondents from districts near to the lake, such as Ziway Dugda, A.T.J.K, and Dugda Bora, 100%, 98.9%, and 100% respectively believe that Lake Ziway benefits local communities including them and their household members in different ways. However, some of the respondents who reside far from the lake do not believe that the lake benefits them, whereas others are unaware of the benefits ($p < 0.01$).

Respondents residing in close proximity to the lake get benefits from the lake. The major benefits stated were summarized as:

- Source of water and food, e.g. fish, irrigation, domestic water use, animal watering;
- Economic value, e.g. fishing, grass for sale, tourism;
- Transportation services and recreational and social value, e.g., cultural celebrations like *Erecha*, swimming, hot springs in its islands, wildlife viewing (birds, hippos);
- employment opportunities on farms which rely on the lake as a water resource e.g., irrigation farms, flower farms, etc.; and
- Source of various resources: e.g. grasses for cattle, house thatching/roofing using papyrus (*Cyperus papyrus*), mattress making using grasses, wood for fuel; and handcraft materials using lake shore plants such as *Aeschynomene elaphoxylon* (locally named as *Boffofe*).

According to two thirds of the respondents (67%), irrigation farming is increasing in the watershed since 1980s. Yet, only 28.5% of the survey respondents replied they practice irrigation. However, 31% of all who practice irrigation believed that such practice has an impact on the lake condition. The practice is more common in districts that share borders with Lake Ziway than others (Fig. 4). Respondents said they use different sources of water for irrigation. Districts in the upper watershed of Lake Ziway practice irrigation mainly by diverting rivers that feed into the lake, whereas those who are in the lower watershed and close to the lake use Lake Ziway as their major water source. Furrow irrigation is the only type being practiced by farmers in the watershed. 27% of the respondents believed that there are some profit-based private companies that benefit from Lake Ziway though this was not believed by 38% of the respondents. However, 35% of all respondents were unsure if private companies do or do not use Lake Ziway as a water resource. More than three quarters of the respondents

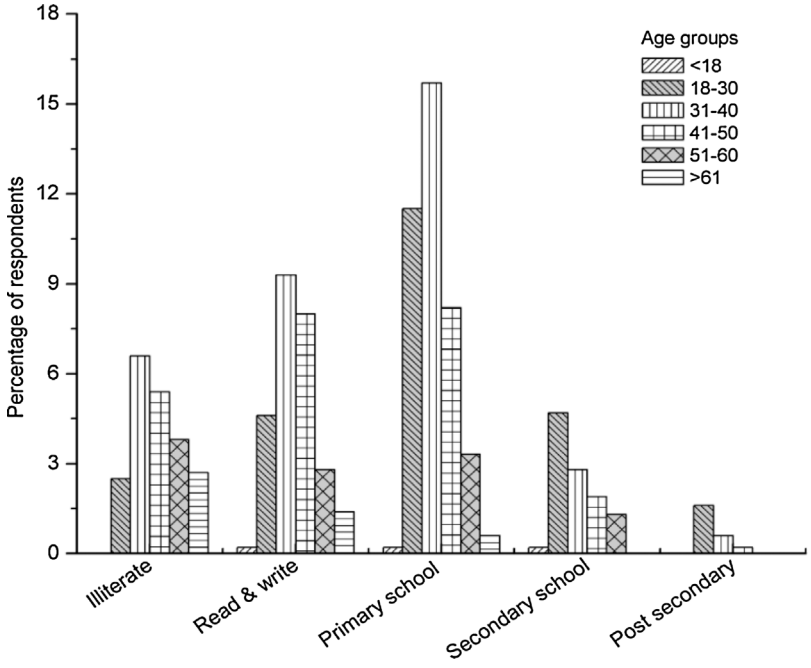

Fig. 3. Educational level of attainment by age group.

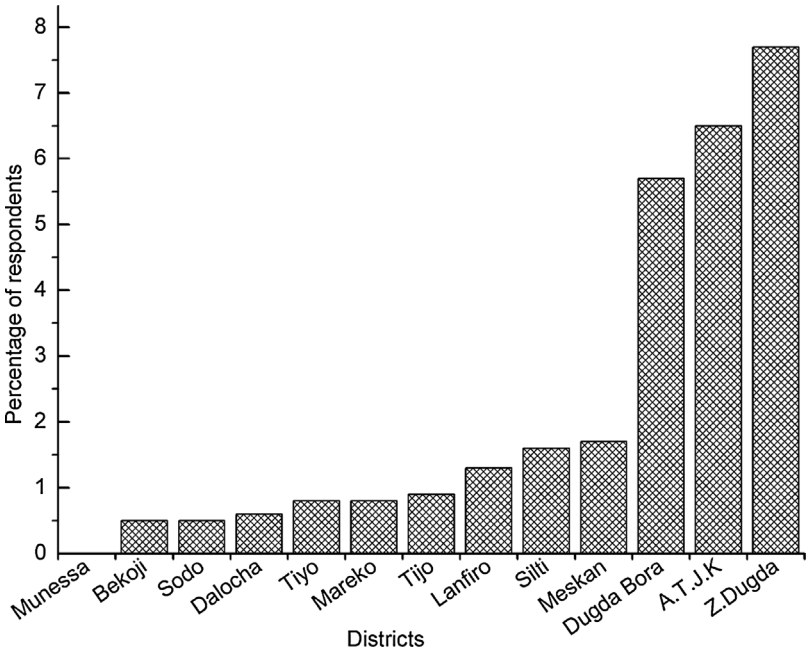

Fig. 4. Number of survey respondents who practice irrigation in Lake Ziway watershed.

(76%) from A.T.J.K district believe that there are companies that are entirely dependent on the lake for water. According to them, these companies are municipal water supplies, particularly Ziway Town Municipal Water Supply, various vegetable producing cooperatives, fishing corporations, fishers' associations, flower farms (mainly Share Ethiopia Flower Farm), and large scale irrigation farm holders, such as B.G.I, ETELCO, Catholic Mission, Ziway Federal Prison, Elfora, Segel Agriculture, etc.

3.5. Threatening factors to Lake Ziway and its watershed

A large proportion of respondents (about 40%) believed that the lake is exposed to the "undesirable" impacts due to human pressures (Table 3). A chi-square test of independence for the responses on the presence of human impacts on the lake revealed that the views of respondents were significantly dependent of the variations they have in level of education (χ^2 (8, N = 635) = 35.285, $p < 0.05$), distances from the lake, i.e., between districts (χ^2 (168, N = 635) = 432.169, $p < 0.05$), and years of settlement in the area (χ^2 (8, N = 635) = 17.635, $p < 0.05$), but such views were independent of the variations they have in their ages (χ^2 (10, N = 635) = 12.535, $p > 0.05$), i.e., respondents had no similar views across all age groups about this issue.

Those respondents who believe that the lake is under pressure from human activities gave the following possible reasons:

- Intensive application of agrochemicals (pesticides and fertilizers) for cultivated lands in the watershed (74%), which is creating lake water pollution via runoff;
- Uncontrolled water abstraction from both the lake and its feeder rivers (69%);
- Irrigation farming close to the shores of the lake (62%);
- Deforestation in the watershed (57%), which is causing soil erosion and siltation of the lake;
- Waste discharge to the lake (33%) especially from floriculture industries;
- Poor and unwise watershed management practices, particularly soil and water conservation activities (23%).

Table 3
Perception on human impacts on Lake Ziway.

Reponses	Illiterate	Read and write	Primary school	Secondary school	Post secondary	Total
Yes	6.0	9.1	18.0	5.5	1.3	39.8
No	4.6	8.7	9.1	3.6	0.2	26.1
Don't know	10.4	8.5	12.4	1.7	0.9	34.0
Total	20.9	26.3	39.5	10.9	2.4	100.0

Having identified human activities that impact the lake, 68.8% of the respondents had shown concern over these human impacts (Fig. 5). A chi-square (χ^2) test of independence for the perceptions towards the degree of concern over the impacts of human behavior on Lake Ziway showed that the concerns were significantly dependent of the respondents' age (χ^2 (10, N = 603) = 23.397, $p < 0.05$), level of education (χ^2 (8, N = 603) = 18.642, $p < 0.05$), location in the watershed (χ^2 (24, N = 603) = 214.920, $p < 0.05$) and years of settlement (χ^2 (8, N = 603) = 41.399, $p < 0.05$). Irrespective of their differences in age, education, and distance from the lake, i.e., location in the watershed (districts) and years of settlement in the area, the great majority of respondents had similar concerns over the negative impacts of human behavior on Lake Ziway. 30% of the respondents (of which 56% having primary and above education) and 56% of the respondents (of which 83% had primary and above education) respectively stated that the water level of Lake Ziway is shrinking and that the trend of fish catch is decreasing accordingly. These findings were further supported by an analysis of the correlation between the respondents' views on lake volume and fish population, which revealed that the change in the volume of the lake and the trend of fish catch were significantly related, $r = 0.491$, N = 635, $p < 0.01$, two tails. However, more than a quarter of the respondents replied that they do not know about changes in the lake's water level (30%) or fish population (28%). A small number of respondents (7.8%) said the lake expands in size only during the rainy season, while others had not noticed any changes.

Respondents who believed that the lake is shrinking in volume thought possible causes could be:

- Uncontrolled deforestation in the watershed and absence of lake shore protection (78%);
- Intensive irrigation with high water abstraction from the lake and its feeder rivers in both lower and upper watershed areas (66%);

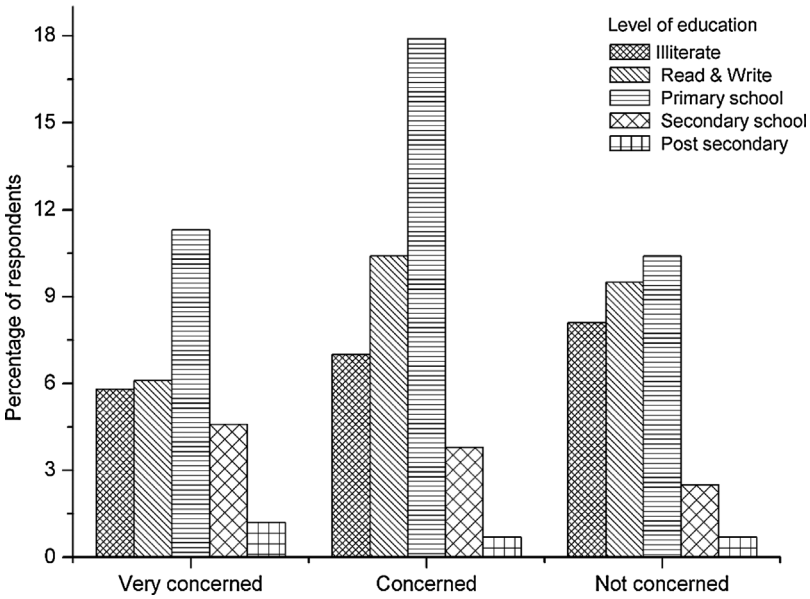

Fig. 5. Degree of concern over human impacts on the lake.

- An increase in population size and the subsequent pressure on the lake for water demand (46%);
- Inappropriate water use practices (27%);
- Land use changes mainly for cultivation (19%); and
- Climate change (10%).

Similarly, respondents who believe that the lake's fish population is decreasing over time thought possible threats were:

- Lake volume reduction due to water abstraction for irrigation and water supply (72%);
- Siltation of the lake through soil erosion due to deforestation (71%);
- Chemical pollution due to runoff from irrigated lands (65%);
- Uncontrolled and excess fishing practices (54%) due to the increasing fishing population over time (86%);
- Use of small mesh fishing nets (53%);
- Lack of government control over fishing (31%); and
- Lack of community involvement and sense of ownership of the lake (26%).

3.6. Water abstraction

It is recognized that there are more than 1200 pumps of various capacities (e.g., see Fig. 6) which are in operation all around Lake Ziway by individual farmers, farmers' cooperatives, Municipal Water Supplies, public farms, and private companies. Thus, the amount of water being currently abstracted by these pumps for irrigation and water supply alone has been estimated at about 612 million liter per day (Table 4). This study revealed that the great majority of respondents have recognized the impacts of such abstraction, and most have shown concern over the issue.

Table 4
Water abstraction from Lake Ziway (liter/day).

Districts	No. of Pumps	Pump Capacity (l/s)	Abstraction (in 'ooo)
Ziway Dugda	542	18	210, 729.6
Dugda Bora	367	18	142,689.6
	2[a]	764	33,004.8
A.T.J.K.	283	18	110,030.4
	7[a]	764	115,516.8
Total	1201		611,971.2

[a] Indicates electric pumps.

3.7. Watershed land use and management

Concerning the major changes that have occurred in land use and management in Lake Ziway watershed over the last 20 years, respondents put forward the following changes: the establishment and expansion of floriculture industries and other investment projects, such as lodges; high population growth and subsequent expansion of settlements and cultivated lands at the expense of other land use types, such as forestlands, woodlands, etc.; high applications of agrochemical inputs (pesticides, fertilizers, herbicides) to increase productivity; soil

Fig. 6. Images showing certain types of electric and small motor pumps being used to abstract water from the lake.

erosion; and, unabated deforestation practices for fuel-wood, charcoal, and farming.

32% of the respondents (of which 84% having primary and above education level) recognized the deleterious effects of agrochemicals (fertilizers and pesticides) being used in the watershed on the lake's ecosystem. A chi-square test of independence for the responses on the deleterious effects of agrochemicals on Lake Ziway revealed that respondents' views were significantly dependent of their age (χ^2 (10, N = 635) = 26.647, $p < 0.05$), level of education (χ^2 (8, N = 635) = 35.169, $p < 0.05$) and location in the watershed, i.e., districts (χ^2 (24, N = 635) = 165.753, $p < 0.05$). Regardless of their differences in age, education and living distances from the lake, respondents had similar views about the deleterious effects of agrochemicals on the lake. Yet, 23% the respondents believed that the agrochemicals do not have any undesirable effects on the lake's ecology. However, the great majority of respondents (45%) (of which 70% with primary and above education) did not know what effects the agrochemicals might have on the lake.

Views on the trend of vegetation cover in the watershed over time were also assessed against the age groups. In all age groups, the great majority of the respondents believe that forest cover within the watershed is declining. According to more than half of the respondents (59%), the watershed forest cover is declining mainly due to deforestation. However, still more than a quarter of the respondents (36%) stated that they were not in a position to compare past changes. A chi-square test of independence for the responses revealed that the views towards the decline of vegetation cover in the watershed were significantly dependent of the variation in the respondents' ages (χ^2 (15, N = 635) = 52.706, $p < 0.05$), level of education (χ^2 (12, N = 635) = 39.111, $p < 0.05$), location in the watershed (χ^2 (36, N = 635) = 185.641, $p < 0.05$) and years of settlement in the area (χ^2 (12, N = 635) = 92.615, $p < 0.05$). This perception of vegetation cover decline in the watershed converged significantly with all respondents irrespective of all their differences.

3.8. Management preferences

The great majority of the respondents (67%) did not know whether or not some parts of the Lake Ziway shoreline are protected from local communities' use. Only about 6% of respondents believe that there are protected areas, while 27% of the respondents believe that no protection measures exist. In the three districts bordering the lake, A.T.J.K, Dugda Bora, and Ziway Dugda, 65.2%, 81.4%, and 64.0% of respondents respectively believe that no part of the lakeshore areas have been protected so far from human use.

All respondents reacted positively to the existence of Lake Ziway. Those respondents who reside very close to the lake particularly stated that the lake is a means of livelihood for many of the poor who can't survive without it. Additionally, it was stated that the lake is a habitat for aquatic wildlife. The respondents have observed various bird species, fish, and hippopotamuses, all of which are major species to Lake Ziway.

However, about 33% of the respondents exposed fears that Lake Ziway might one day disappear if existing human pressures continue – as was the case in Lake Haromaya in Eastern Ethiopia – regardless of their level of education (Fig. 7), living distances from the lake and ages ($p < 0.05$). However, such fears were not comprehended by 20% of the respondents. Yet, 47% of the respondents felt they were not in a position to make any predictions about the lake's condition. However, large proportion of respondents (69.2%) who depend on fishing as their livelihood shared such a fear of the lake disappearance.The great majority of the respondents (74%) across all age groups and levels of education preferred the joint responsibilities of government and local communities for managing the lake and conserving its biological resources. The chi-square test of independence for the preference of responsibility revealed that the views were significantly dependent of the respondents' age (χ^2 (10, N = 635) = 26.442, $p < 0.05$) and location in the watershed (χ^2 (24, N = 635) = 89.935, $p < 0.05$), but were independent of their level of education (χ^2 (8, N = 635) = 4.072, $p > 0.05$) and years of settlement in the area (χ^2 (8, N = 635) = 4.935, $p > 0.05$). Respondents from different age groups and various districts had shown the same preferences towards the responsibilities of the lake management. The majority of respondents suggested two major reasons why they preferred joint management responsibilities between government and local communities. First, government has the task of setting rules and regulations for conservation activities; its involvement is mandatory to implement policies and regulations; it can mobilize local communities for conservation purposes; it is responsible for providing resource management training to local communities; and it could be successful with the full participation of local communities. Second, local communities are direct beneficiaries of resources, placing them near to their local problems and therefore making it easier for them to identify the causes and suggest solutions.

Only 26% of the respondents knew the presence of government organizations working towards the management of Lake Ziway and is watershed. 18% believed the government has no role and 56% did not know if government efforts to manage the lake and its watershed exist at all (Fig. 8). However, 66% of the respondents in the watershed replied that they had not seen or heard about any government efforts designed specifically to manage Lake Ziway.

Respondents stated the roles government bodies can play in the management of the lake and its watershed natural resources (Table 5). However, the great majority of the respondents (45%) did not strongly feel that the government had so far been successful in ensuring the protection of Lake Ziway and its watershed resources from degradation. 39% of the respondents believed that the government had been successful, while only 16% believed the government had failed (χ^2 = 16.445; N = 635; df = 8; $p = 0.036$). And all household respondents across all levels of education rated government efforts as poor (χ^2 = 45.666; df = 16; $p < 0.01$) towards conservation activities in the watershed.

The survey revealed that only 22% of the respondents knew of the presence of non-governmental organizations (NGOs) in the management of land and water resources in their respective districts. The great majorities were unaware of NGOs' activities in their respective localities, and others did not even know if NGOs were working in their areas at all. Those respondents who believed that NGOs are working in their localities stated their involvement in regarding the management of land and water resources in such activities as building terraces, planting trees, and providing public awareness to the local communities.

In general, nearly three quarters of the respondents showed a willingness to cooperate with any future management plans aimed at protecting Lake Ziway and its watershed. However, of those who were willing, the great majority across all age groups and levels of education were more in favor of the management plans to be done jointly by government bodies and local communities' engagement than NGOs, cooperatives, and farmers' associations.

4. Discussion

This study finds that the average household size in Lake Ziway watershed seems a bit more than the country wide average size for rural areas, i.e., 5.1 persons per household. However, the average household land holding size in this watershed is less than the country's average for rural areas, 1.77 ha (CSA and World Bank, unpublished, 2017). Lake Ziway provides a number of benefits to the local communities as well as private companies in its watershed. Many local people living near or along the borders of the lake, their livelihoods – principally fishing and irrigation – depend partially or entirely on it. These observations agree with Tenalem (2004), Tenalem and Degnachew (2007), and Spliethoff et al. (2009).

The majority of respondents also believed that the lake is the main

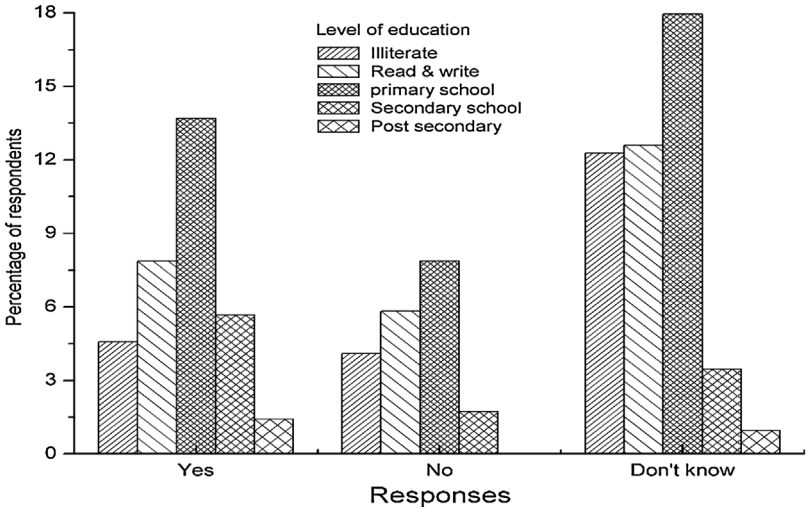

Fig. 7. Views on the fear of Lake Ziway disappearance.

source of irrigation water for profit based private companies. These views also support those of MoW (unpublished, 2017a), Michael and Seleshi (2007), Jansen et al. (2007) and Scholten (2007) who stated that large-scale irrigated agricultural activities in the CRV depends on this lake because of its suitable fresh water. However, the irrigation they practice is furrow type, which increases level of water losses and erosive potential.

Most respondents also believe that human pressures are higher on this lake than other lakes in the CRV. As has been observed, floriculture industries release their untreated wastewater directly to Lake Ziway (see Fig. 9). These agrochemical wastes from flower farms along with runoff from irrigation farms are the major causes of water quality deterioration in Lake Ziway (Willén et al., 2011; Pascual-Ferrer et al., 2013). Most respondents (32%), regardless of their differences in age, educational level, etc., have recognized the detrimental effects of these agrochemicals to Lake Ziway, and have voiced their concern over the issue.

However, pertaining to the water level of the lake over time, more than a quarter of respondents believed that the lake has shown remarkable water level reduction. These perceptions correlate with Tamiru et al. (2006), Michael and Seleshi (2007), Scholten (2007), Spliethoff et al. (2009), and Kloos and Dagnachew (2010). The lake's water level reduction due to siltation has also been stated by Hayal (2016). According to this author, the lake sub-watersheds have soil erosion prone areas (see Fig. 10), which contribute to high level of siltation to the lake, in addition to changing the micro climate patterns of the local environment. This has happened due to the decreased forest cover in the watershed because of the fact that the highest percentages of households use fuel wood as their major source of energy for cooking.

Table 5
Perception of state involvement in the management of the natural resources of Lake Ziway and its watershed.

State roles[a]	Responses
Encourage reforestation and conservation activities	101
Provide training on how to use and protect the lake	64
Support fishermen cooperatives	46
Pass legislations	41
Offer financial and material support for conservation practices	15
Total	N = 267

[a] Multiple responses.

The development of irrigation farms and flower farm investment projects around the lake (Fig. 11), the increase in population pressures in the watershed (see Fig. 12) and the subsequent increase in water abstraction using pumps of different size might also cause lowering of the lake level (Pascual-Ferrer et al., 2013). This could have negative repercussions on the lake's fish population by affecting their breeding sites. Higher fish production is associated with suitable water level of a

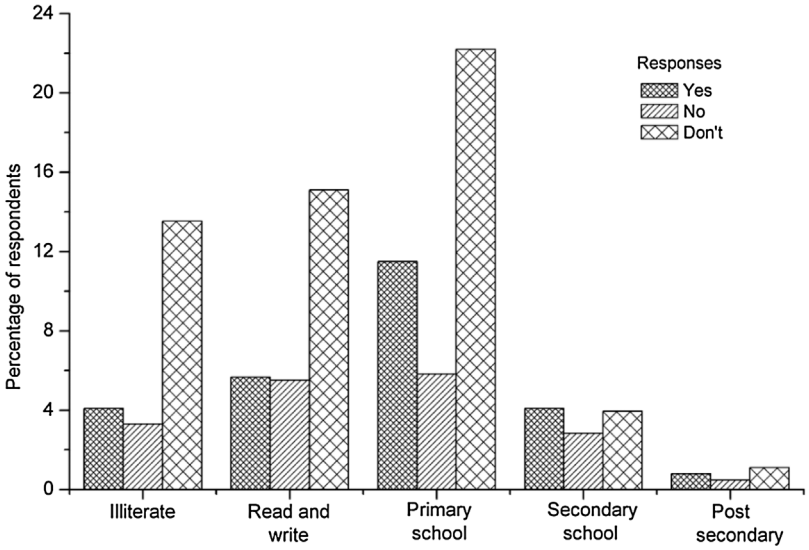

Fig. 8. Views on Lake Ziway management by government by level of education.

Fig. 9. Image showing wastes being discharged to Lake Ziway from floriculture industries.

lake. However, fishermen in particular asserted the fact that the fish catch is decreasing in Lake Ziway, and so is their livelihood income. This can push them to look at other means of additional livelihood incomes to compensate the incomes being dropped due to the declining of the fish catch.

Further decreases in water level may eventually turn Lake Ziway into saline (Jansen et al., 2007), which, if it happens, will obviously have major repercussions for the local communities who depend on the lake water for their domestic water supply, irrigation, and livestock watering. The major reasons given by respondents for lake level reduction (see Section 3.5) is consistent with Tamiru et al. (2006), Jansen et al. (2007) and Pascual-Ferrer et al. (2013). In conjunction with human impacts, according to Lijalem et al. (2006), the climate data from 1984 to 2014 also suggest the progressive increase in air temperatures, evapotranspiration, and decline in precipitation in the lake watershed area. This might imply that climatic factors could also affect the water volume of Lake Ziway. Dagnachew et al. (2004) further added on this issue that a decrease by about 4% of the rainfall in the watershed due to climate change would lead to a decrease of runoff by about 14%, which would in turn result in a 20 cm decrease in the lake water level. Water abstraction, mainly for irrigation, from feeder rivers has also contributed to the water level reduction of lake Ziway (Zinabu and Elias, 1989; Tenalem, 2001, 2004; Tamiru et al., 2006; Scholten, 2007). Such reduction in the water level could have also negative repercussion on the water level of the downstream lake, Lake Abijata, which gets its water supply from Lake Ziway through the Bulbula River.

Altogether, the great majority of the respondents from districts that border Lake Ziway believe the lake-shore areas of Lake Ziway are not protected from any human uses. Recognizing these problems facing the lake, they prefer the joint responsibilities of government intuitions and local communities' involvement to address the problems. This is necessary to incorporate local knowledge into decision-making for managing the lake (Chidammodzi1 and Muhandiki, 2015). However, Lake Ziway and its watershed successful management must not only involve government institutions and local communities, but also the views of other multiple stakeholders such as private companies, farm cooperatives, fishermen, NGOs, academic institutions, etc. as they are necessary to understand clearly what to do and improve the lake management (Nunan, 2006; Sharip et al., 2016).

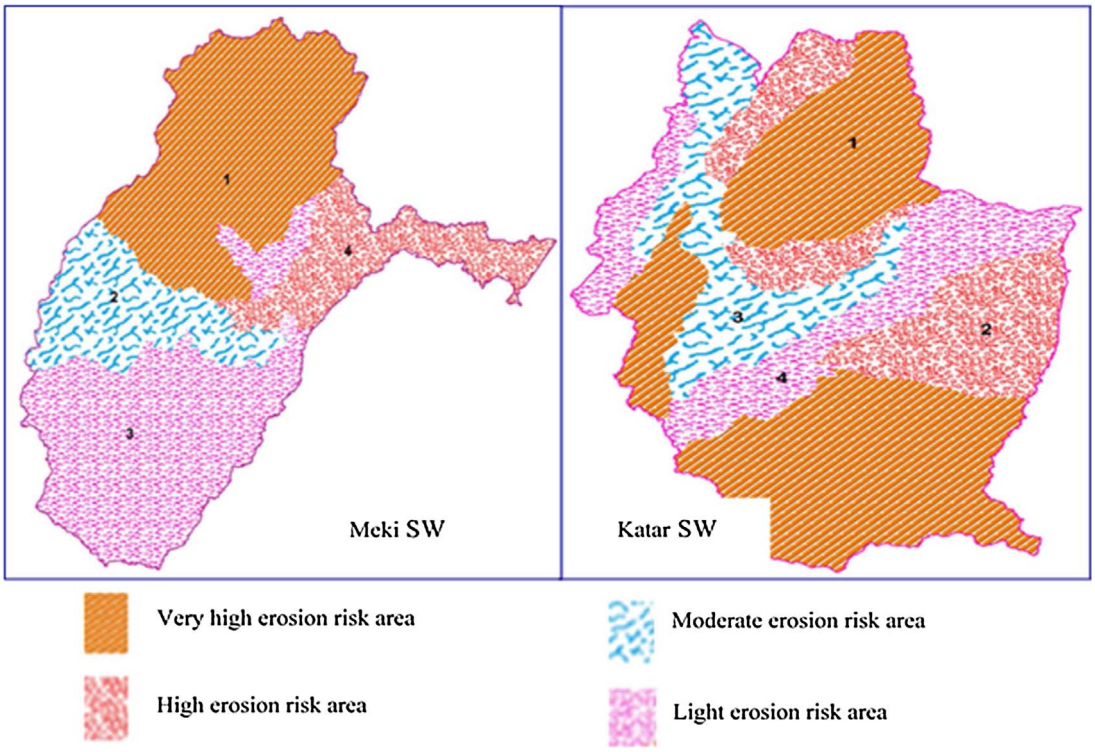

Fig. 10. Erosion prone areas in Lake Ziway sub-watersheds.
Source: Hayal (2016).

Fig. 11. Image showing parts of flower farms placed on Lake Ziway shorelines.

5. Conclusions

This study revealed that Lake Ziway and its watershed contribute significantly to the livelihoods of many poor people, and as profit source for some private companies. The views of farmers' communities have also ascertained the presence of major human impacts in the watershed. It is indicated that human pressures are higher on Lake Ziway than on other lakes in the CRV. Regardless of their differences in age, educational level, location in a watershed and years of settlement in the area, the majority of respondents have shown multifaceted reflections on the existing problems. They believed that the water quality and water volume of Lake Ziway are deteriorating, and its watershed is exposed to degradation mainly due to human activities.

The expansion of small-scale farms and large-scale investment projects, particularly floriculture industries and irrigation farms, and the subsequent intensive and unplanned applications of agrochemicals, untreated waste discharge, and poor watershed management practices, etc. are deteriorating the water quality of this lake. Furthermore, recent development of public and private works in the watershed mean that thousands of cubic meters of water are being abstracted per day, free of charge, from the lake and its feeder rivers. The reduction of the lake water level could also have resulted from siltation, due to the decreased vegetation cover through deforestation in the upper watershed. These activities are exploiting the lake, its feeder rivers, and its watershed resources, seemingly beyond their capacity, affecting both the water volume of the lake and its fish production.

Ethiopia has water resource use and management law (No. 197/2000), pollution prevention law (No. 300/2005) and land use law (No. 456/2005). However, these laws have not been well implemented at all user groups – local communities and investment projects. As the country's water use law declares common water use rights, no user groups are controlled each other or among themselves or by external body. Respondents also believe that the current efforts of the government towards this management issue are weak. Thus, this lake and its watershed needs comprehensive study and action towards ensuring the wise use and sustainable management. Otherwise, as to the majority of respondents' fear, Lake Ziway will be the second to go next to Lake Haromaya of eastern Ethiopia.

Accordingly, the adverse consequences of Lake Ziway water quality and quantity deterioration, together with the lack of concern of government bodies to involve all stakeholders in the lake planning and management call for environmental justice. Therefore, in order to achieve sustainable management of the lake within the framework of environmental justice, government body should play meaningful coordination roles to involve all stakeholders – local communities, farmers, private companies, fishermen, cooperatives, NGOs, academic institutions, etc. so as to: a) address the lake water quality and water level degradations-related problems, b) provide information and enhance understanding of these challenging problems to all user groups at all levels, and c) to provide accessible and locally-oriented suitable opportunities and platforms to all stakeholders to participate in the planning and management of the lake and its watershed towards ensuring a sustainable watershed in which to live and work.

Besides, government should demarcate the lake buffer zone to best protect the shoreline areas of the lake from human impacts. The government should also have lake management plan made in collaboration with all stakeholders and allocate budget for lake conservation. Free-access policy of the government should also be replaced by user-charge policy along with setting rules and regulations for water abstraction from the lake. However, the establishments of enforcement mechanisms or fines for those who do not accept or resist the legitimacy of the rules such as, for example, water abstractions, overfishing, and other access from Lake Ziway should directly involve all stakeholders. AS a whole, the management practices to be established should consider the local circumstances and all other stakeholders' views regardless of their age, gender, income, educational, etc., levels.

In this regard, this study can thus provide information for policy-makers to better understand the existing problems from the views of local farming communities and offer support for the establishment of long-term sustainable use strategies to protect the lake and its

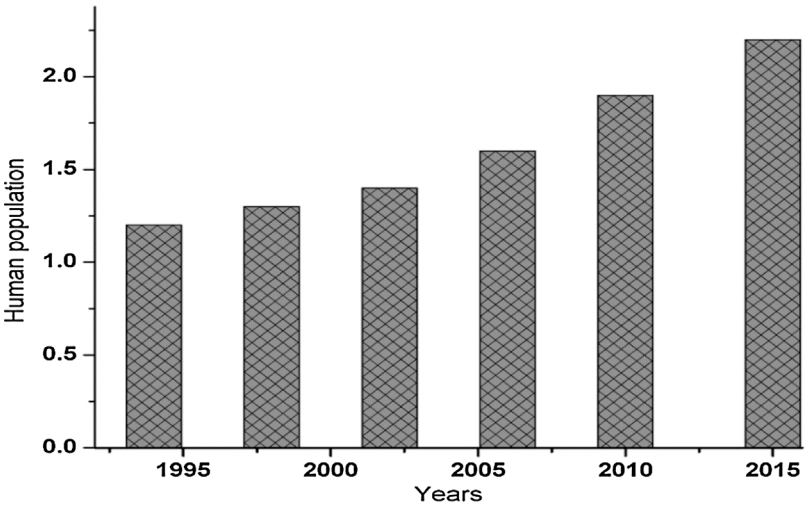

Fig. 12. Human population growth trends (in million) in Lake Ziway watershed (CSA, 2016).

watershed from severe future problems. The study could also contribute to the management of other lakes and their watersheds elsewhere in the country, and beyond to ensure sustainable utilization of resources.

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Appendix A

I. PERSONAL BACKGROUND INFORMATION

1.1. Region: 1. ONRS 2. SNNPR; and District: .....

1.2. Gender: 1. Male 2. Female

1.3. Position in the household: 1. Head 2. Wife/husband 3. Child 4. Other(specify)

1.4. Age: 1. < 18 2. 18 - 30 3. 31- 40 4. 41- 50 5. 51 – 60 6. > 61

1.5. What is your household family size?

1.6. What is your level of education?

1. Illiterate 2. Read and write 3. Primary school 4. Secondary school

5. Post-secondary 6. Others: specify

1.7. How long have you settled in this area?

1. < 5 2. 5 - 10 3. 11 - 15 4. 16 - 20 5. >20

1.8. If settled in the area for the last 15 years, where did you first come from?

1.9. Why did you choose to settle in the area?

II. SOCIO-ECONOMIC CONDITIONS OF HOUSEHOLDS

2.1. Currently, what are the main sources of income for your household?

2.2. What is the cultivated landholding size of the household family?

2.3. How did you acquire the land you own?

2.4. Do you practice irrigation?

If yes, what is the source of water for irrigation in your area?

2.5. What amount and type of fertilizers do you use per year on your farm?

2.6. How frequently do you visit Lake Ziway and its surrounding area for grazing, animal watering, farming, etc.? 1. Very Often (Many times in a week) 2. Often (once in a week)

3. Rarely (more than a week)

2.7. Do Lake Ziway and its shorelines have any benefits to you and the communities around?

1. Yes 2. No 3. I do not know

If yes, list the benefits you and the communities around get out of the lake?

2.8. Which Lake Ziway-based private companies are profitable in the area?

III. CONDITIONS OF LAKE ZIWAY

3.1. Are there any practices or uses in your area that may have negative impacts on the Lake Ziway? 1. Yes 2. No 3. I do not know

a. If yes, what are these practices?

b. What are the negative effects associated with these activities?

3.2. Do you think that human activities such as water abstraction, farming and fishing, etc. have undesirable effects on Lake Ziway? 1. Yes 2. No 3. I do not know

3.3. How concerned are you and your family about these impacts on Lake Ziway?

1. Very concerned 2. Concerned 3. Not concerned

3.4. What have you observed about the size of Lake Ziway?

1. Expanding 2. Shrinking 3. No change 4. Fluctuating

If expanding/ shrinking, what do you think are the possible causes?

3.5. How do you rate the following?

a. Number of fishing population over time on Lake Ziway

b. Volume fished per household over time

c. Trend of vegetation covers over time in Lake Ziway watershed

3.6. Do you think that the fertilizers and pesticides being used in the surrounding areas of Lake Ziway can have deleterious effects to the lake? 1. Yes 2. No 3. I do not know

3.7. What other human activities have you observed in the area that could affect the Lake Ziway and its resources?

3.8. What is the trend of fish production in Lake Ziway?

1. Increasing 2. Same (No change) 3. Decreasing

Explain your answer.

3.9. Do you want Lake Ziway to exist? 1. Yes 2. No

Explain why yes/no.

3.10. Do you fear that Lake Ziway may one day disappear like Lake Haromaya?

1. Yes 2. No 3. I do not know

3.11. What are the major animal species which you think are common to Lake Ziway?

IV. MANAGEMENT AND CONSERVATION ISSUES

4.1. Who do you think should be most responsible for managing Lake Ziway?

4.2. Have you seen or heard about any government effort designed to manage the lake?

1. Yes 2. No

If yes, in what ways have the concerned government bodies been involved in the management of the lake?

4.3. Do you think that the government is now successful in protecting Lake Ziway and its watershed from degradation? 1. Yes 2. No 3. I do not know

Please explain your answer.

4.4. Are there some parts of Lake Ziway shoreline that are not allowed for local communities to use? 1. Yes 2. No 3. I do not know

If yes, which parts of the lake shoreline are not allowed for local communities?

4.5. Will you be willing to cooperate with any future management plan to protect the lake Ziway even this will affect your livelihood? 1. Yes 2. No

If yes, how do you think will that be best done?

V. LAND USE CHANGES

5.1. How do you rate the major long term changes in land use that you have detected on Lake Ziway watershed over the past 20?

VI. POTENTIAL COLLABORATORS IN LAKE ZIWAY MANAGEMENT

6.1. Are there government organizations working towards the management of natural resources on and around Lake Ziway? 1. Yes 2. No 3. I do not know

If yes, what are the conservation activities being undertaken?

6.2. How do you evaluate the conservation efforts made by the government?

1. Excellent 2. Very Good 3. Good

6.3. Are there any NGOs involved in natural resource management in Lake Ziway watershed?

1. Yes 2. No 3. I do not know

If yes, what are the conservation activities being undertaken?

VII. ENERGY SOURCES

7.1. What energy sources do your household families use?

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