Ethiop. J. Biol. Sci. **21(1): 69–90, 2022**

ISSN: 1819-8678

RESEARCH ARTICLE

CONTRIBUTIONS TO THE LIVELIHOODS OF FISHERMEN AND DETERMINANTS OF FISH PRODUCTION FROM LAKE TANA AND RIFT VALLEY LAKES, ETHIOPIA

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ABSTRACT: This study aimed to identify determinants of fish production by fishermen living around Lake Tana and the Ethiopian Rift Valley lakes, specifically Lakes Ziway, Hawassa and Chamo over a course of one year production (2019). The study areas were selected purposively due to their higher total annual fish catches and fish contribution in the local and urban communities around fish production areas and cities of Bahir Dar, Ziway (Batu), Hawassa, Arbaminch and Addis Ababa. A total of 450 fishermen were randomly selected for this study. The data were gathered through the use of structured questionnaires and analysed using both descriptive and econometric analytical methods. Ordinary Least Square (OLS) estimation method of linear regression technique was used to test the determinant factors. Fishing is the first major source of income, accounting for 67%, 73%, 68.9% and 59.3% of fisher's livelihoods, respectively in Lakes Tana, Ziway, Hawassa and Chamo, respectively. Linear Ordinary Least Squares Regressions analyses showed that income of petty trades, the number of reed boats, gillnets, land owned for crop production and fishing trips were the determinant factors significantly influencing the volume of fish produced. The study further suggested that education and training, alternative income-generating activities, increased ownership of land owned, improving access to credit services, efficient government support and better-organized cooperatives should receive due attention to improve fish production and sustainably manage fish resources in Ethiopia.

Key words/phrases: Fish, Fishermen, Lakes, Production Lakes Tana, Ziway, Hawassa and Chamo.

INTRODUCTION

Fisheries have provided livelihood and economic benefits to those engaged in the activities related to the harvesting, processing and trading of fish. Moreover, fishery resources are important sources of proteins, vitamins and

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micronutrients, particularly for many low-income populations in rural areas, and their sustainable use is critical for future global food security (NRC, 2006). Fishermen in developing countries are faced with increasing poverty due to low harvest and lack of economic support (Platteau, 1989; Béné, 2004; Salagrama, 2006; Olale and Henson, 2012) and are referred to as ‘the poorest of the poor’ (Olale and Henson, 2012). Although this fact cuts across all fishermen in developing countries, it is more pronounced in Africa (Bene, 2004; Olale and Henson, 2012).

The total annual fish production potential of the major inland water bodies (lakes, reservoirs and rivers) is estimated to be 94,541 metric tons per year on an average sustainable yield basis (Gashaw Tesfaye and Wolff, 2014). The country’s river fishery potential is also estimated to be about 21,405 tons/year (Gashaw Tesfaye and Wolff, 2014). Of these, only less than 38% is being exploited on an annual basis (Aytegeb Anteneh, 2013). Despite its potential, the sub-sector remains underdeveloped, and its contribution to the economy is negligible. Fishing sustains the livelihoods of most rural communities with access to water shores, contributes to household food security source of supplementary incomes, employment and act as a natural safety net (Rahman *et al*., 2002; FAO, 2005; Omwenga, 2006; Navy and Bhattarai, 2009).

The Ethiopian fishery still uses traditional methods involving aging tools requiring high manual labour and time inputs and comprised of illegal fishing practices (Dawit Garoma *et al*., 2013) and inefficient administrative setup (Tesfaye Wudneh, 1998; Pattnaik, 2016). Based on these facts, it can be said that the Ethiopian fisheries is not managed well, as some stocks such as Nile tilapia are showing signs of overexploitation in Lakes Hawassa and Ziway and equally impacted Nile perch also in Lakes Chamo and Abaya. Most notably, there are no legal provisions to monitor fishing activities through fisheries regulations and the lack of clearly designed enforcement agencies (Pattnaik, 2016). Fishing practices in Ethiopia are thus still in their infancy stages (Abebe Ejigu *et al*., 2015) and fish is apparently not included in the diet of the Ethiopian population, except in shore areas (Assefa Mitike, 2014; Mathewos Temesgen and Abebe Getahun, 2016). The current annual *per capita* fish consumption in Ethiopia is 476 grams (Sintayehu Bedada and Seblewengel Lemma, 2017; Olale and Henson, 2012), which is extremely low, and its contribution to the national economy is the smallest of all agricultural outputs (Olale and Henson, 2012; Aytegeb Anteneh, 2013). As a result, the fishery in Ethiopia is one of the poorly developed sectors of the economy (Eshete Dejen *et al*., 2017). Vijverberg *et al*. (2012)

in the study of the composition of fish communities of nine Ethiopian lakes along a north-south gradient stated that Ethiopia has a diverse range of freshwater fish species. In addition, they explained that with growing populations, there is a need to feed an increasing number of people. However, the rapid population growth and the progressive shortage of livestock products have changed the situation to switch the demand for fish proteins and other fishery products (Anon, 1999; Kelil Abdurahman, 2002).

The determinants of income diversification, in particular, contribute to the increased income of fishermen (Olale and Henson, 2012; Dawit Garoma *et al*., 2013). Besides, education level, association membership, and access to credit are key features influencing income diversification among fishermen (Olale and Henson, 2012). Twumasi *et al*. (2020) found that household size, marital status, boat ownership and off-fishing income activity reduce the probability of being credit constrained (Abunyuwah and Blay, 2013; Nyang'aya and Onyango, 2013; Twumasi *et al*., 2020). Furthermore, there is a major difference between constrained and unconstrained fisher's fishing activity and financial status (Twumasi *et al*., 2020). In addition, credit facility and ownership of a fishing license affect the household's marketable supply of fish (Abebe Cheffo *et al*., 2016). However, the role of barriers producing marketable fish supplies and their determinants has been limited. Consequently, the unavailability of the previous studies on determinants of fish production hinders the potential gain that could have been attained from the existing opportunities. Hence, this study attempts to fill in these research gaps and provide evidence for policymakers so that the appropriate guidelines can be set to contribute to poverty alleviation efforts by developing the fishery sector in Ethiopia. The objective of the study was therefore to investigate the determinants of fish production by fishermen with a focus on those based on Lakes Tana, Ziway, Hawassa and Chamo with the goal to improving the livelihoods of fishermen (Fig. 1).

MATERIALS AND METHODS

Study area

The study was conducted at the north-western highland Lake (Tana) and Rift Valley lakes such as central Rift Valley lakes (Ziway and Hawassa)and the southern Rift Valley lakes (Chamo) (Gordon *et al*., 2007; Gashaw Tesfaye and Wolff, 2014) (Fig. 1 and Table 1). Among these, Lakes Tana, Ziway and Chamo contribute more than 65% of the total annual fish catches in Ethiopia (Assefa Mitike, 2014; Gashaw Tesfaye and Wolff, 2014; Mathewos Temesgen and Abebe Getahun, 2016). In addition, Lake Hawassa contributes 7% each to the total production (Gashaw Tesfaye and Wolff, 2014). Lake Tana is the largest lake, which constitutes half of the area of the lakes of the country (Vijverberg *et al*., 2012) while Lake Hawassa is the smallest in fish potential and surface area as compared to the study lakes (Fig. 1 and Table 1). Besides, there is fishing on all these water bodies, but commercial production (i.e. serving markets other than the local communities) is concentrated on the lakes (Tana, Ziway, Hawassa and Chamo) and particularly dominant in Lake Tana (Gordon *et al*., 2007). Moreover, people consume large amounts of fish in fasting days, in offshore cities, around production areas and towns, especially in Ziway, Arbaminch, Bahir Dar, Hawassa and Addis Ababa. The details below show baseline information about the study lakes.

Table 1. Baseline information on the study areas (Wondimu Tadiwos and Tenalem Ayenew, 2019; Haile Melaku Zigde and Mohammed Endale Tsegaye, 2019).

No.	**Parameters**	**Lakes**			
		Tana	**Ziway**	**Hawassa**	**Chamo**
1	Location	12°N, 37°15’E	70°54′N, 38°45′E	7°03′N, 38°27′E	5°42′N, 37°39′E
2	Elevation (m.a.s.l)	1,830	1,636	1,680	1,233
3	Watershed area (km^2)	16,500	7,025	1,250	2,210
4	Surface area (km^2)	3,200	440	91	551
5	Max. depth (m)	14	7	22	13
6	Mean depth (m)	8	2.5	11	6
7	Secchi depth (cm)	27–52.9	17.85–22.12	70–80	29–39
8	Salinity (mgL^{-1})	<110	350	455.6	1,000
9	Conductivity (μScm^{-1})	142–184	361.50–484.51	846	1,100–1,910
10	Potential yield t/year	15,000	3,010	611	4,500
11	Per unit area (t/km^2)	4.3	5.1	5.8	5
12	Major inflows	Gilgel Abbay, Megech, Rib, Gumara, Dirma, Arno-Garno and Gelda Rivers	Meki and Katar Rivers	Swampy area, Tikur-Wuha	Sile, Argoba, Wezeka, Sego and Kulfo Rivers
13	Major outflows	Blue Nile River	Bulbula River	No	Sagan River
14	Offshore cities	Bahir Dar, Gorgora, Delgie	Batu	Hawassa	Arbaminch
15	No. of fish species	28	7	7	19
16	Commercial fishes				
	Oreochromis niloticus	✓	✓	✓	✓
	Clarias gariepinus	✓	✓	✓	✓
	Labeobarbus spp.	✓			
	Cyprinus carpio		✓		
	Coptodon zillii		✓		
	Lates niloticus				✓
	Barbus spp.	✓	✓	✓	✓
	Bagrus docmac				✓

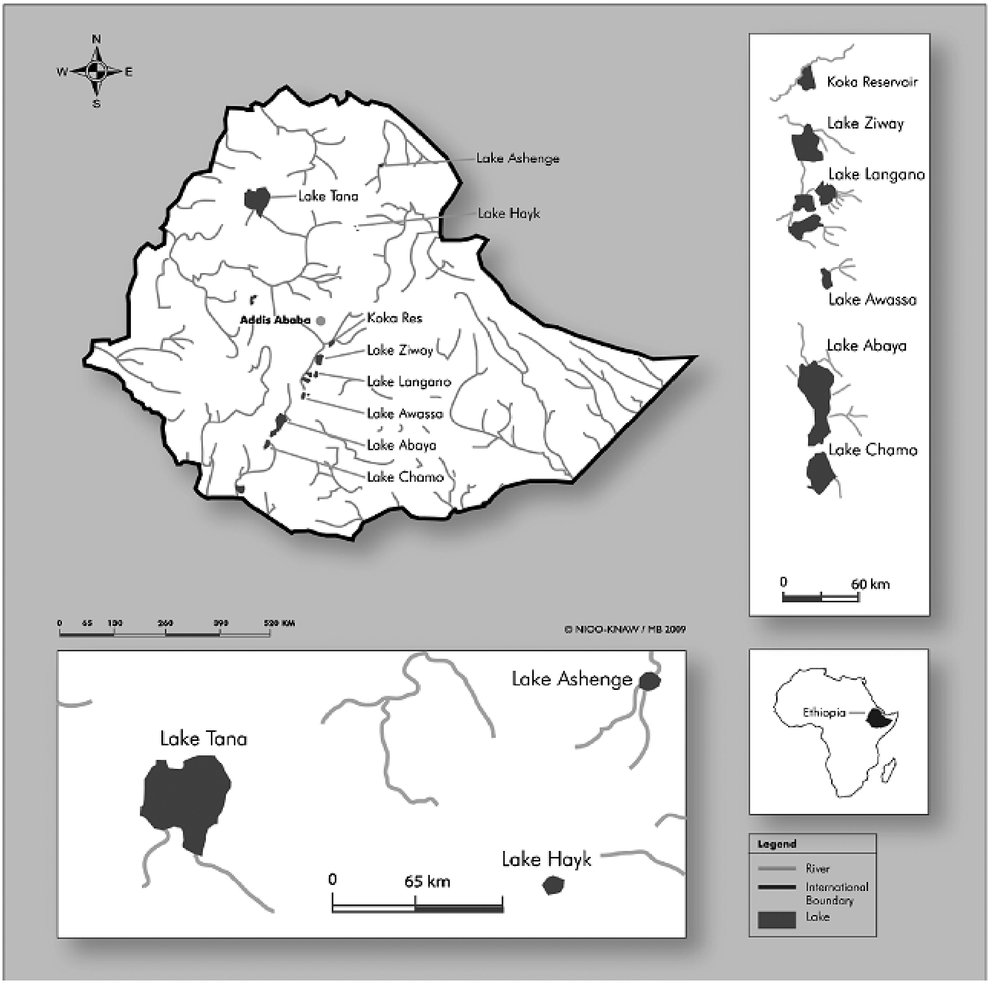

Fig. 1. Geographical locations of Lakes Tana, Ziway, Hawassa and Chamo (Vijverberg *et al*., 2012).

Data sources and data collection methods

Primary data collection tools

The data were collected through fishermen' interviews, structured questionnaires and focus group discussions (office, experts) which were conducted in 2019 at Lakes Tana, Ziway, Hawassa and Chamo. The structured questionnaires were pre-tested for the consistency of the questions and validity before the actual interviews were held. Some adjustments were made to the questionnaire and the final data used in the research were collected. Therefore, sampling was done to select a number of fishermen which are considered to be reliable representatives based on the proportionate system. In doing so, proportional random and purposive sampling methods were used. Sample size in each lake was determined based on proportion to size of the fishermen number in the Lake Tana (4,539), Lake Ziway (1,766), Lake Hawassa (1,495) and Lake Chamo (1,104). Then, 150,125, 90 and 85 fishermen were selected randomly at Lakes Tana, Ziway, Hawassa and Chamo, respectively, making a total of 450 fishermen. The data collected were used to assess the status and determinants of fish production by fishermen and additional information on socio-economic variables such as age, gender, education status, marital status, credit access, fish-fish products prices, income sources, fishing trip, gillnet size and number, family size, fishing ground distance, reed boat number, wooden boat number, distance to market centre and credit services problems associated with fish production.

Data analysis

The collected data were tabulated and organized in graphs, charts and tables and analyzed using descriptive statistics and econometric analysis using SPSS version 20.0 Statistical Software. Appropriate statistical methods such as frequency, average and percentage were used.

To address the household level marketable supply determinants, a regression model was fitted to different variables. For this particular study, the Ordinary Least Square Estimation (OLS) method of linear regression technique was used to analyze the determinants of fish production by fishermen. The study used the volume of fish production as a dependent variable and the factors that are expected to affect fish production as independent variables. The functional form of the regression equation is presented as:

$Y = f(X1, X2, X3 \ldots Xi)$……………………………..……………………1.

Where, Y is the average fish production given as a function of the independent variables, X's.

Estimating the sample linear regression function, as the most common method, is to use the OLS regression given that OLS assumptions are satisfied. According to Gujarat (2004) model, OLS regression can be specified as follows. The dependent variable (Yij) is defined as if j^{th} fishermen for i^{th} variable is marketable supply of fish (average fish production), otherwise (j ranging from 1–450). Therefore, the general model of volume of fish production has a form of:

$Yji = \beta_0 + \beta_1 X_{1j}, \beta_2 X_{2j}, \beta_3 X_{3j} \ldots \beta_i X_{ij} + e$ ………………………………2

Where; Y_j is the dependent variable; β_0 is a constant value that represents the Y intercept; β_1, β_2, β_3, …, β_i are coefficients or slopes of X_1, X_2, X_3, …, X_i, respectively, and X_1, X_2, X_3, …, X_i are explanatory variables, i is the number of coefficients and j is the number of observations, and e is error term.

The hypothesized independent variables for fish production function include:

Y = f (income, education level, fishing trip, gillnet number, credit access, fishing ground distance, fishing experience, boat number, distance to market and age).

The degree of co-linearity among the explanatory variables was tested using VIF and R^2. Besides, chi-square test is one of the most popular non-parametric tests in statistics. It is also referred to as distribution free test statistic. In order to analyze the determinants of fish production in the study lakes, chi-square statistics was used.

RESULTS AND DISCUSSION

Demographic characteristics of fishermen

Fishermen were diversified in their demographic aspect (sex, age, marital status and education level). In the study areas under this investigation, 98.9% of the sampled fishermen were males while 1.1% of them were females. It implies that fishing activities were male dominated (Table 2). Majority of the fishermen 79.1% were married, 20.4% were single and the rest 0.4% divorced. In Lake Tana fishery, fishing is totally regarded as men's duty (Sewmehon Demessie, 2003). Béné (2003); Smith *et al*. (2005); Singh *et al*. (2003); Hoppe (2002); Mfinanga (2014) declared that fishing activity is thought to be male-dominated due to its stress and the need for a high level of manual physical work, active age rather than elders and require experience, wealth and quick decision-making abilities. It was also found that the age of the fishermen ranged from 18 to 70 years with a mean age of 38.2 years (Fig. 2) and the actively working age group was between 25–50 years old (Wubeshet Birhanu, 2015; Abebe Cheffo *et al*., 2016; Tekalign Tuluka *et al*., 2021). The mean age of heads of fishermen for all lakes showed almost equivalent distribution of 39.5 for Tana, 38.9 for Ziway, 38.5 for Hawassa and 34.6 for Chamo. Using chi-square test (χ^2) cross-tabulating characteristics fishers shows that there is a significant difference in age, education level and fishing experience within groups' fish production systems at a 5% level of significance ($p<0.05$) (Table 2).

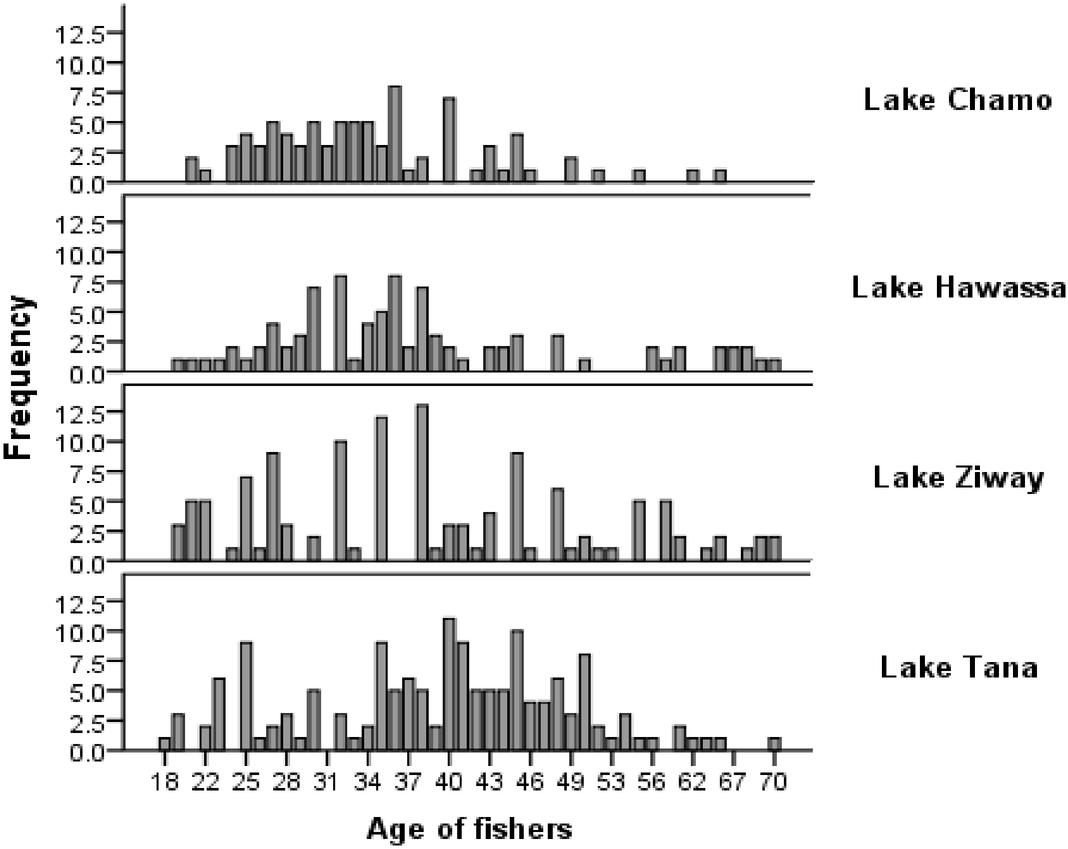

Fig. 2. Age distribution of the respondents (fishermen) in years.

The fishermen working experience ranged from 2 to 41 years with a mean of 17.8 years for all lakes which was 18.8 for Lake Tana, 19.1 for Lake Ziway, 16.9 for Lake Hawassa and 14.8 for Lake Chamo. As declared by Megerssa Endebu *et al*. (2015), most of the fishermen have long fishing experience ranging from zero (young fishermen) to fifty years (mostly old fishermen) on fishing activity at Lake Ziway. Most respondents have been involved in fisheries activities since the last ten years (Fig. 3). This also indicated that the fishery was inviting new fishermen as the fish resource utilization and source of income and effort increased from time to time in Lakes Tana, Ziway, Hawassa and Chamo. Tekalign Tuluka *et al*. (2021) also stated that the majority of the experienced fishermen felt a sense of ownership for fisheries resources better than the less experienced young fishermen. Therefore, fishermen with longer fishing experience were familiar with fish abundance area, fishing practices and harvested more fish.

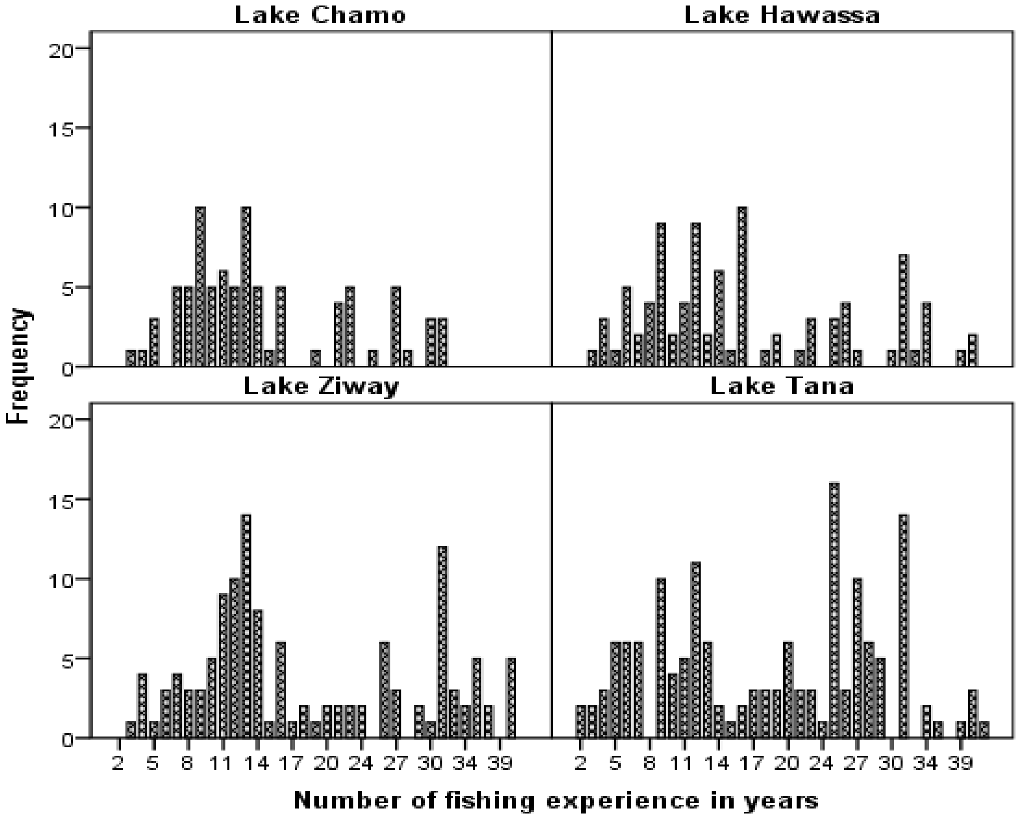

Fig. 3. Work experience of fishermen from Lakes Tana, Ziway, Hawassa and Chamo.

Table 2. Demographic characteristics of sampled fishermen.

Variables		Sampled fishermen in Lakes								Total	%
		Tana	%	Ziway	%	Hawassa	%	Chamo	%		
Sex	Male	150	100	122	97.6	89	98.9	84	98.8	445	98.9
	Female	0	0	3	2.4	1	1.1	1	1.2	5	1.1
Education level	Illiterate	25	16.7	17	13.6	24	26.7	21	24.7	87	19.3
	Read and write	35	23.3	10	8.0	12	13.3	22	25.9	79	17.6
	First cycle	32	21.3	39	31.2	17	18.9	5	5.9	93	20.7
	Second cycle	46	30.7	41	32.8	29	32.2	31	36.5	147	32.7
	High school	8	5.3	17	13.6	8	8.9	5	5.9	38	8.4
	Preparatory	1	0.7	0	0	0	0	1	1.2	2	0.4
	Above preparatory	3	2	0	0	0	0	0	0	3	0.7
	Religious school	0	0	1	0.8	0	0	0	0	1	0.2
Marital status	Single	28	18.7	27	21.6	16	17.8	20	23.5	91	20.2
	Married	122	81.3	98	78.4	74	82.2	63	74.1	357	79.3
	Separated	0	0	0	0	0	0	2	2.4	2	0.4
Total		150	100	125	100	90	100	85	100	450	100

Sources of income of fishermen

The sampled fishermen in Lakes Tana, Ziway, Hawassa and Chamo were engaged in fishing, crop production, animal husbandry, petty trade, causal labour and house rent (Fig. 4). Of sampled fishermen, the first major source of income contributed for 67%, 73%, 68.9% and 59.3% of fishing at Lakes Tana, Ziway, Hawassa and Chamo, respectively, which is comparable to the reports of 64.6% by Sewmehon Demessie (2003), 70% by Berihun Tefera *et al*. (2009) and 60% by Kidanie Misganaw and Addis Getu (2016) from Lake Tana. These findings also implied that there was relatively less crop production activities, 14.1%, 10.9%, 13.5% and 23.5% at Lakes Tana, Ziway, Hawassa and Chamo, respectively, which limited their livelihood diversification (Fig. 4). Megerssa Endebu *et al*. (2015) showed that in addition to fishing there are few fishermen who diversify their income sources to other activities such as gear making, crop production and animal husbandry. However, loan access to formal financial sources for fishermen that could be empowering in other non-fishing activities such as petty trade and animal husbandry which may reduce fishing dependence and better manage fisheries resources. As argued by Béné *et al*. (2007) and Mfinanga (2014), lack of access to land is one of the major barriers that significantly affected the fishermen’s livelihood and increased their open access in the lakeshore area. Likewise, Khan (2000); Kumar (1996); Mfinanga (2014) reported that land ownership is an important requirement in accessing credit from the formal banking system. Also, for many rural households in sub-Saharan Africa, land is considered to be a key asset and serves multiple uses including cultivation, sustaining livestock, storing wealth and providing collateral for financial credit (Lay *et al*., 2007).

According to the respondents, the number of fishermen has increased over time. This implies that there is an increase in the number of fishing gear and pressure on the fishery resources of the study lakes and high level of completion among fishermen to improve their incomes. Roche (2007) and Mfinanga (2014) stated that fishing is the only easy accessible income generating activity to poor coastal people due to the free access nature of water bodies and the resources. It is inferred that water bodies are public property with free access to all and it becomes very difficult to implement conservation actions for sustainability of the resources. Furthermore, Silva (2006) and Mfinanga (2014) found that low initial cost of fishing influenced coastal people to be occupied in fishing as compared other activities that need high capital like agriculture which requires some assets like land and fertilizer. This scenario has made fishing the easiest and quickest income-generating activity when compared with other livelihoods such as crop and animal production, where farmers would have to wait months or years to reap the benefits whereas other activities like crop production and animal husbandry require staying for months to get returns (Fig. 4).

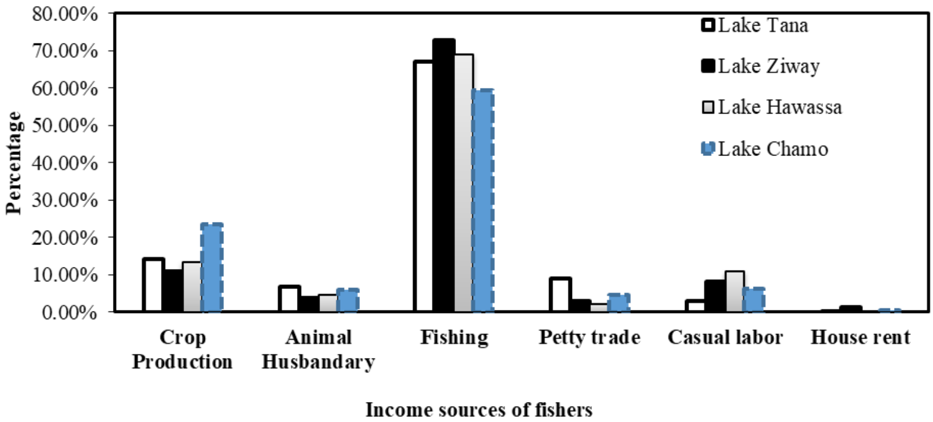

Fig. 4. Sources of income of fishermen at Lakes Tana, Ziway, Hawassa and Chamo.

The results also showed that fishermen spent 13 to 27 days (22.58 days, on average) per month or 8.92 months per year in fishery operations at Lakes Tana, Ziway, Hawassa and Chamo. The majority of the fishermen spent more than 8 months per year (Fig. 5). According to Sewmehon Demessie (2003), fishing ranged between 257 and 300 days at Lake Tana, but this survey result showed it ranged between 150.8 and 334.6 days per year at all study areas. The respondents at Lake Ziway spent 25.25 days per month or 10.1 month per year in fishery operations, which is more than any other of the studied lakes (Fig. 5). The fishery operation days were higher in the lakes due to increase in the number of fishermen, fishing boats and fishing gears in type and number. Despite the fact that efforts increased, total annual fish production from the lakes decreased. Megerssa Endebu *et al*. (2015) and Eshete Dejen *et al*. (2017) also stated that increase in the number of gears, boats and increase in pressure on fishery resources resulted in declining commercial catch.

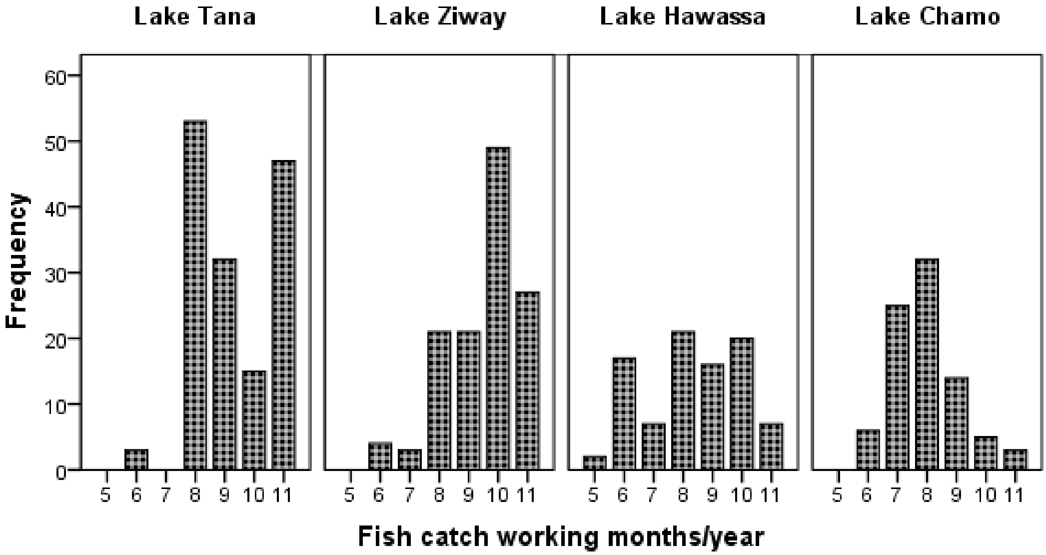

Fig. 5. Frequency of working months/year of fishermen in the study lakes.

Monthly incomes from fishing fluctuated from 350 to 15,000 ETB per month with an average of 2,039 ETB per month (equivalent to 45 USD) (Fig. 6). The average for all the study lakes is less than 5000 ETB. The level of mean monthly income from fish also significantly differed among the fishermen from the study lakes ($p<0.001$). The average income for fishermen was 8,334 ETB (Shewit Gebremedhin *et al*., 2013) and 13,492.86 ETB (Dagninet Amare *et al*., 2018). Shewit Gebremedhin *et al*. (2013) also stated that the minimum and maximum income of fishermen were 1,020 and 30,000 ETB respectively, in Lake Tana. The study result indicated lower average income source as a result of increasing pressure, and fishermen and many fish stocks are now depleted, which are again reducing the fish catches.

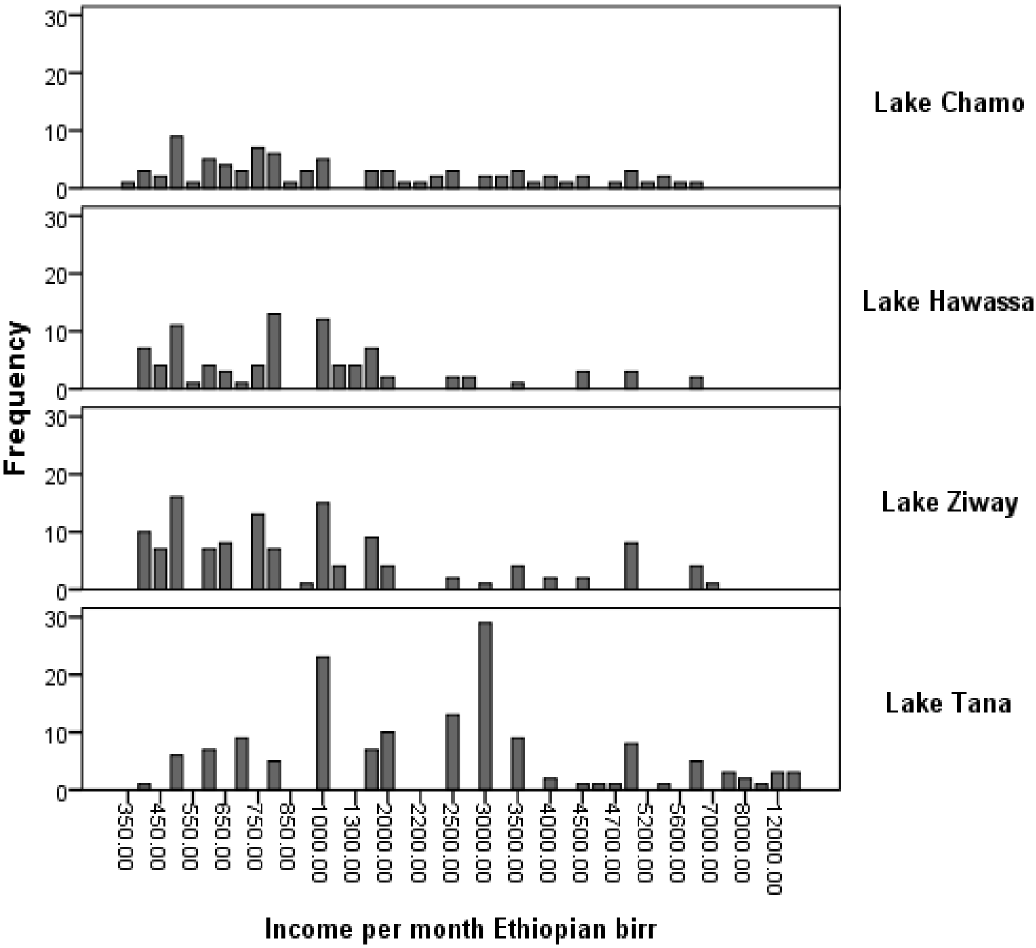

Fig. 6. Level of fishermen's income in Ethiopian Birr from fishing per month in the study areas.

Producing marketable supply of fish and its determinants

The degree of co-linearity among the explanatory variables was tested using VIF and R^2. The results for all VIF ranged between 1.140 and 8.251, and R^2 was 0.735. Hence, VIF was less than 10 and R^2 was below 0.90; multi-co-linearity may not be suspected.

The major determinant factors for producing a marketable supply of fish were estimated by linear the OLS regression model as shown in Table 3. Distance to the preferred marketing centre, petty trade income, number of gillnets and reed boats, land owned for crop production and fishing trip were found to have a significant effect on the fishermen's level of producing a marketable supply of fish.

Remarkably, the distance to the preferred marketing center is positively correlated to the supply of fish to the market. Hence, although the variable was meant to increase in distance by seven hours, the probability of producing fish supply increased due to less fishing gear, and market competition at the fishing grounds. Olale and Henson (2012) and Dawit Garoma *et al*. (2013) confirmed that fishing grounds have a significant impact and play an important role on fisheries returns. Onoja *et al*. (2013) found that fishermen who are nearer to the market outlet are more likely to sell their fish than those fishermen living in distant places. It is interesting to mention that fishermen that are at the same distance from markets also sell their fish on a regular basis.

In contrast, age of the fishermen is linked negatively and has statistically insignificant effect on producing marketable supply. However, Acquah and Abunyuwah (2011) and Mfinanga (2014) found that age was irrelevant in influencing people to become fishermen. This could be because some elders were also doing fishing by using less intensive fishing gears like cast net which does not need much energy.

It is fundamental to note that petty trade as an alternative source of income has a positive and significant effect on the production marketable supply of fish ($p<0.05$). These variables were meant to examine those involved in other income-generating activities that minimize their fishing activities (Dawit Garoma *et al*., 2013). This implies that the existence of alternative sources of fishermen’s incomes is a key factor in supporting fishery resource’s sustainability. A study made by Kan *et al*. (2006) confirmed that non-farm income has a negative impact on farmer’s decision to sell their farm output (market participation) negatively in rural Georgia.

The results also revealed that marital status had a negative and insignificantly impact on the production of marketable fish supply. The negative effect of the marital status implies that married fishermen had a lower probability of expanding marketable fish supply compared to those who were single. Olale and Henson (2012) found that married couples were able to jointly generate income that met their household consumption requirements. Additionally, some married couples may want to stay together and therefore, may prefer undertaking fish work collectively, rather than undertaking separate activities. For example, the husband may be fisher and the wife a fish trader and processer and both may be in service in the same lake, this is especially the case in Lake Tana.

The educational level of the fishermen has positive values in improving the fish production process and the market supply. Those fishermen with a higher level of education have a higher chance of being involved in fishing activities, because their education level helps them to understand fishing practices and the technology better (Mwakubo *et al*., 2007). Besides that, fishermen with good knowledge can adopt better practices than illiterates. Holloway *et al*. (1999) argued that education had a positive significant effect on the quantity of milk marketed in Ethiopian highlands. Education helped to improve the technical skills of fishermen and to improve fisheries resource management.

Furthermore, land ownership had a significant negative effect on the production of a marketable production of fish ($p<0.05$). Increase in ownership of land in hectares decreased the probability of participation in fishing. The result implied that increased ownership of land owned in hectares had a lower chance to participate in fishing activities. Elbers and Lanjouw (2001) and Mfinanga (2014) found that land scarcity is related to participation in a low-return non-agricultural activity, such as fishing.

The number of gillnets and boats used in fishing operations also positively affected the market supply ($p<0.01$) by influencing the volume of fish supplied to the market. In practice, fishermen who own gillnets and boats are more likely to produce more fish for the market. Moreover, the fishing trip has a statistically significant positive effect on producing fish ($p<0.005$). This indicates that fishermen in Lakes Tana, Ziway, Hawassa and Chamo show a tendency to use the traditional reed boats, wooden boats with more working days in a month and fishing trip, implying that the higher the operating costs, the higher the fish production.

Table 3. Determinants of fish market surplus (OLS result).

Model	Un-standardized coefficients		Standardized coefficients	T	Sig.	Co-linearity statistics	
	B	**Std. Error**	**Beta**			**Tolerance**	**VIF**
Nearest market	5.555	50.739	0.007	0.109	0 .913	0.882	1.134
Fishing ground	-45.081	31.462	-0.085	-1.433	0 .156	0.875	1.143
Age of fishermen	-15.395	11.448	-0.187	-1.345	0 .182	0.162	6.189
Income of petty trade	6.397	2.974	0.144	2.151	0 .034*	0.698	1.432
Income per month	0.008	0.043	0.015	0.197	0 .844	0.538	1.860
No. of reed boats	1532.998	245.074	0.959	6.255	0.000**	0.133	7.545
No. of gillnets	126.948	11.895	1.710	10.672	0.000***	0.121	8.251
Marital status	-61.423	124.983	-0.034	-0.491	0 .624	0.637	1.569
Educational level	34.367	37.676	0.059	0.912	0 .364	0.735	1.360
Land owned for production ha	-955.043	406.650	-0.140	-2.349	0 .021*	0.877	1.140
Fishing trip	179.800	62.394	0.284	2.882	0.005**	0.322	3.110
Constant	-2383	781.740		-3.049	0.003		
R^2 /R Square/	0.735						
Adjusted R Square	0.698						
F Value	19.692						

Dependent variable: Production of fish quantity in kg per year

Note: *** represents significance at 0.1%, ** at 1%and * at 5%.

CONCLUSION

This study investigated the determinants of fish production by fishermen in Lakes Tana and the rift valley Lakes of Ethiopia. Primary fishing was observed totally as men’s duty in the study lakes. This might be due to the lack of capital by females, family leadership and ownership goes for males and the actual fishing operations need for a high level of manual physical work that is disconnected from looking after kids and the elderly. The study also identified fishing as one of the main sources of income that contributed 67%, 73%, 68.9% and 59.3%, respectively at Lakes Tana, Ziway, Hawassa and Chamo. Moreover, Ordinary Least Square (OLS) regression results revealed that income of petty trade, number of gillnets and reed boats, land owned for production and fishing trip were statistically significant determinants producing marketable production of fish. Accordingly, producing fish supply was influenced not only by demographic, but also socio-economic and technological factors that were affecting the practices.

Distance to the preferred marketing center requires adequate fish transportation and marketing chains which should be transformed into fish processing plants close to landing sites, build market centres, cold chains (storage and transportation), packaging materials, transportation logistics and better communication in fish markets at all lakes. Additionally, women appear to participate more in gillnet making, fish processing and marketing of fish in Lake Tana. There is need to provide incentive to female fishermen such as training them, supporting them with credits, and reducing their household and family responsibilities and allow them some level of ownership in the family; so that they can meet the challenges of producing fish, process and market it. Therefore, stakeholders should be given a great role in most significant determinants; they may also deal with those having moderate effects and to enhance sustainable development of fisheries and fish production. Based on the findings the following recommendations are suggested:

- Integrate relevant government sectors that can reorganize fishermen’s’ cooperatives with significant females’ involvement and provide accurate fish supply information to enhance fish production and maintaining stocks towards attaining yearly sustainable fish production potentials.

- Possible alternative income-generating activities should be promoted so that livelihoods of fishermen could be diversified as a safety mechanism in case fish productions get limited in some seasons.

- Access to finance can be improved by encouraging and supporting fishermen and women to provide affordable credit in order to get standard fishing gear and boats.
- Governmental organizations design strategies to facilitate plan and promote massive awareness creation programs to influence society especially fishermen towards sustainable fish resource utilization.

ACKNOWLEDGEMENTS

This research was financially supported by Addis Ababa University and the University of Gondar, both in Ethiopia. The authors acknowledge the support of the Ministry of Agriculture, Addis Ababa, Bahir Dar Bureau of Agriculture, Bahir Dar, Ziway Agricultural Office, Hawassa Bureau of Agriculture, Arbaminch Agricultural Office, and most importantly the fishermen and fish traders of the study lakes.

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