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Trends of Climate Change and Perception of Local Fishermen around Lake Chamo, Ethiopia

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ABSTRACT

The effect of climate change on agricultural productivity is increasing from time to time. It has also a great effect on the production of fish in most lakes and rivers, hence this research was designed to investigate the trends of climate change and perception of local fishermen of Lake Chamo over the years. Semi-structured questionnaire and focus group discussions were used to generate primary data. A total of 149 respondents of three *localities* bordering the lake have participated in the study. The livelihoods of most of the respondents depend on fishing, and fish yield has been reported to show a decreasing trend. Only 50 (33.6%) of the respondents possess land holdings ranging from 0.5 to 5 hectares. However, the majority (99, 66.4%) of the fishermen do not have land. The respondents also unanimously agreed that they have observed a change in the climate of their area. The meteorological data analysis showed also that there has been a change in the pattern of the climatic variables in the study area over the last 20 years. Mean annual minimum and maximum temperature increased while the total annual rainfall decreased. The results of this study provide baseline information for researchers, government officers, policymakers…etc., about fishers' perceptions of fish production and climate change, and trends of metrological variable changes observed in the study area over the last two decades.

Keywords: climate change, fish yield, Lake Chamo, temperature

INTRODUCTION

Climate change is predicted to affect major climatic variables like atmospheric and water temperature, wind system, and precipitation of an area. Each of these factors has the potential to dramatically affect the dynamics of fish populations. Temperature increases of small magnitude can have significant impacts on fisheries resources causing shifts in species distributions and altering the accessibility of fisheries resources to specific fishing sites. According to IPCC (2007a), global average air temperatures rose by 0.74°C in the period between 1906 and 2005.

Rosenzweig et al., (2007) also reported that Lakes Tanganyika and Malawi were warmed by 0.2 – 0.7°C over the past 100 years. This was resulting in increasing thermal stratification, reducing the mixing of cold deep and warm surface waters, which as a result prevent upwelling of nutrients and lower primary productivities. Changes in the amount and timing of precipitation, flooding and flows can also have effects on current fishing methods. Besides, threats posed by population increase and related human development activities, such as overfishing, over-extraction of water, degradation, pollution and loss of key habitats are causing a huge challenge to the fishing industry in Africa. Lake Chamo, which is one of the commercial fishing grounds in Ethiopia and also has been serving the nearby society as a good source of income, is believed to face climatic changes and anthropogenic activities that change the surrounding ecosystem. This study was, therefore, planned to assess the change of climatic variables observed in the last two decades, and document the perception of fishers about climate change at Lake Chamo.

MATERIAL AND METHODS

Study Area

Arba Minch Zuria wereda is located in *Gammo Gofa* zone of the Southern Nation's Nationalities and People Regional State. The households and human population of the *wereda* are 33,508 and 163,955, respectively (CSA, 2007). Three localities (*Zeyse Elgo, Zeyse Wezeka, and Genta Kanchama Ochole*) were purposefully selected from the *wereda*. The lake watershed, which covers an area of about 2205 km^2 is situated at an altitude ranging from 1,105 m asl (lake level) to 3,546 m asl within a distance of 39.94 km (Alemayehu Hailemicael and Solomon Raju). It has a climate that varies from semi-arid to afro-alpine, with bimodal rainfall pattern having two peak rainy seasons. Lake *Chamo* is eutrophic and harbours hippopotamus amphibious populations, giant crocodiles, *Crocodylus niloticus* and variety of bird species including migratory ones (Alemayehu and Solomon, 2011).

Data Collection Methods

Purposive sampling of semi-structured questionnaire and focus group discussions were used to study the socio-economic aspects of the respondents, their perceptions about climate change, and fish production of the lake. Purposive sampling was used to identify those people who are in close contact with the lake. 149 respondents participated from three systematically selected *localities* bordering the lake: *Zeyse Elgo* (50), *Zeyse Wezeka* (50) and *Genta Kanchama Ochole* (49). Also, three focus group discussions (one in each *locality*) with elderly people were held to obtain data on climate change about the

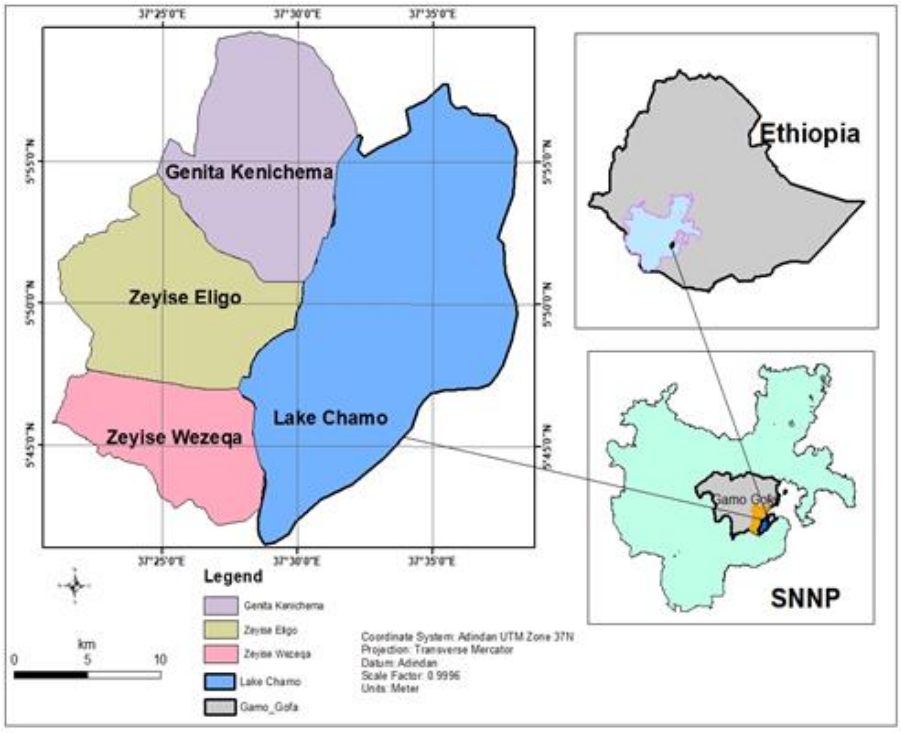

Figure 1. Map of the Study Area

situations that existed in the area before. The climatic data (rainfall and temperature) were obtained from the National Meteorological Agency, Addis Ababa.

Data Analysis

Data analysis (descriptive statistics) was done with SPSS. Trend analysis of the climatic data and its chart was sketched with Microsoft Excel (Microsoft Office, 2016). The study area was mapped with ArcGis software.

RESULTS

Socioeconomic Characteristics of the Respondents

In this study, 149 respondents participated from three systematically selected localities bordering the lake, i.e., *Zeyse Elgo* (50, 33.6%), *Zeyse Wezeka* (50, 33.6%) and *Genta Kanchama Ochole* (49, 32.9%). Their educational status was categorized as illiterate (32, 21.5%), attended informal school (9, 6%), elementary (91, 61.1%), high school (14, 9.4%) and college (3, 2%) levels. In the same way, their age was also categorized into three groups, 18 – 30 years of age (40, 26.8%), 31 – 43 years of age (74, 49.7%) and 44 – 67 years of age (35, 23.5%).

Majority of the respondents (124, 83.2%) were married, singles (20, 13.4%), and only (5, 3.4%) divorced. The number of household members of the respondents ranged from 1 to 13, with an average value of 5.10 (standard deviation 2.844). Out of the total 149, 131 (87.9%) of the respondents were a member of an organization working on environmental issues while the rest 18 (12.1%) of them were not a member of any organization. The time required to cover the distance between Lake Chamo and respondent's home, which is believed to affect the frequency of respondents' contact with the lake, ranged from 10 minutes to 2 hours, with an average of 1.30 hours.

The livelihood of the respondents depends on fishing (100%). Of the total respondents, 50 (33.6%) possess land holdings, that ranged from 0.5 to 5 hectares, with an average of 1.05ha. The majority of the respondents (99, 66.4%) do not have land. To understand familiarity with the study area, respondents were requested about the number of months/years they lived in the area and the result varied from 2 to 40 years, with an average value of 11.68 years (standard deviation 6.5). Responding to the question focusing on the type of fish they prefer to catch and their reason, the respondents put the species according to their preference: Accordingly, the preference put in the order of 96 (64.4%), 46 (30.9%), and 7 (4.7%) for *Oriochromis niloticus*, *Lates niloticus,* and *Clarias gariepinus,* respectively. The main reasons for such species preferences were indicated as better price and accessibilities during fishing. They were also requested about the amount of fish catch per trip in Kilogram, for which their responses ranged from 1kg to 18kg, with an average value of 5.29 kg (standard deviation 3.388). They go fishing on average 5.50 times (standard deviation 1.137) per week to achieve the indicated catch amount.

Regarding the type of fishing gears used, 95 (63.8%) of the respondents reported that they usually use both hook and gillnets, while 32 (21.5%) and 22 (14.5%) of the respondents use gill net and hook, respectively. Majority of the respondents (103, 69.1%) agreed that they are not getting any support from the government related to fishing, while the remaining 46 (30.9%) claimed to have got some. When requested about the general activities going on in and around the lake, respondents mentioned several points. Deforestation is claimed to be one of the anthropogenic activities being observed in the study area by 93 (62.4%) respondents, though a considerable number of respondents (53, 35.6%) opposed its existence, some 3 (2%) with no clear idea about it.

Soil and water conservation activities around the lake are reported as poor by 94 (63.1%) of the respondents, though 54 (36.2%) of the respondents rejected and 1 (0.7%) said doesn't know about it. Agricultural activities as a threat are mentioned by 121 (81.2%) respondents, even though 28 (18.8%) considered it as a harmless activity. The existence of invasive alien plant species in the area was confirmed by 74 (49.7%) respondents, but the idea was rejected by equal 74 (49.7%) respondents, and an individual (0.7%) with no knowledge about it. Overfishing in the lake is reported by 84 (56.4%) but rejected by 62 (41.6%) of the respondents, while 3 (2%) of them reported that they don't know. The presence of illegal fishing activities in the lake is another issue reported by 113 (75.8%) respondents and its existence denied by 35 (23.5%) respondents, and an individual (0.7%) reported to not know this issue. An increase in the number of fishers in the area is reported by 131 (87.9%) of the respondents even though 17 (11.4%) respondents rejected its presence and an individual

(0.7%) replied to not know the subject. Responding to a question on flooding in the study area, 144 (96.6%) of the respondents said that there is a problem of flooding, while 5 (3.4%) of them said it doesn't occur. Regarding the lake volume, 144 (96.6%) respondents agreed that it is decreasing, however, this was not accepted by 5 (3.4%) of the respondents.

Respondent's Opinions/Views on Fish Production Status

Responding to the question focusing on the status of current fish production vis-à-vis when they first start fishing at the lake, 132 (88.6%) of the respondents agreed on a decreased fish production while 13 (8.7%) of them reported no observed change in fish production, 3 (2%) of the respondents reported increased production and a person (0.7%) with no knowledge about it. The main reasons given by those who said production decreased were illegal fishing (48, 32.2%), lakeshore farming (39, 26.2%), siltation (23, 15.4%) and climate change (22, 14.8%).

The status of fish production in the coming five years is predicted to decrease by 93 (62.4%) of the respondents, while 32 (21.5%) predicted an increase. However, 24 (16.1%) respondents predicted that there will be no change in fish production. As an intervention for the current problems observed in the lake, respondents were requested if they agree on an idea that there is a closed season/time when fishing is not allowed, and 102 (68.5%) agreed, 47 (31.5%) disagreed. They were also requested if they agree on an intervention to limit the number of people who should be allowed to fish, and 134 (89.9%) agreed, 15 (10.1%) disagreed. Limitation on the mesh size is raised as a solution for the ongoing problems in the fishing activity, and 141 (94.6%) respondents agreed, and 8 (5.4%) disagreed. The other point considered was licensing the fishers, and 142 (95.3%) respondents agreed and only 7 (4.7%) of them disagreed on this idea.

Perception of Respondents on Climate Change

To interpret the perception of respondents on climate change, some points related to climate change were forwarded to the respondents. The first was if they have noticed any climate change-related issues in their environment over the past five to twenty years, and all of them (149, 100%) unanimously agreed that they have observed.

Regarding the climate change-related issues, 64 (43%) of the respondents reported having observed a less rain, 3 (2%) more rain, 79 (53%) erratic rain and the rest 3 (2%) said there was no change in the pattern of rain. Moreover, 141 respondents have reported hotter (94.6%), 2 cooler (1.3%) temperatures while 6 (4%) said no change in temperature. The existence of change in the frequency of flooding was reported by 114 (76.5%) of the respondents in the study area, even if 35 (23.5%) of them rejected it. The other point was a drought, which is reported to be observed in a varying frequency by 131 (87.9%) respondents. However, 18 (12.1%) of them disagree with the existence of drought in the area. Presence of soil erosion in the surrounding of the lake is also indicated by 128 (85.9%) of the respondents and opposed by 21 (14.1%) respondents. 142 (95.3%) respondents confirmed that intensified agricultural activities are going around the lake, but 7 (4.7%) of them rejected its existence.

Meteorological Data

In the present study, a trend analysis of meteorological data has been done. The temperature and rainfall data, which was recorded over 20 years (1997-2016) to compare the trend in every 6 - 7 years data were classified into three categories (1997-2003, 2004-2010, and 2011-2016). Results indicated that there was a shift in mean annual minimum temperature towards higher (long term average of 7, 7 and 6 years, respectively). The least mean annual minimum temperature was being 11.7°C in the first class, i.e. 1997 – 2003 (Table 1).

Table 1. Trend Analysis of the climatic variables at Lake *Chamo*

Years, categorized into classes	Mean Annual Minimum Temperature (^{0}C)					Mean Annual Maximum Temperature (^{0}C)				Total Annual Rainfall (mm)			
	N	Min	Max	Mean	Std. Error	Min	Max	Mean	Std. Error	Min	Max	Mean	Std. Error
1997 - 2003	7	11.7	20	17.27	0.31	27.2	29.1	30.52	0.69	0	273	84.00	24.35
2004 - 2010	7	12.5	19.4	17.86	0.25	26.8	35	30.32	0.47	0	311.1	76.1	17.85
2011 - 2016	6	14.4	20.4	18.16	0.37	27.3	35.5	31.22	0.74	0	305.8	69.45	23.21

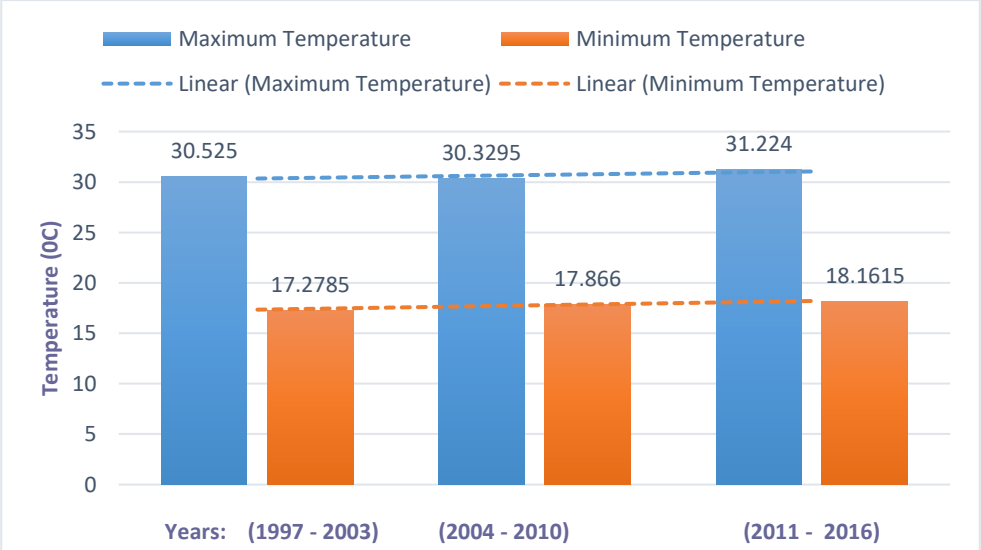

Figure 2. Temperature Trend Analysis at Lake Chamo

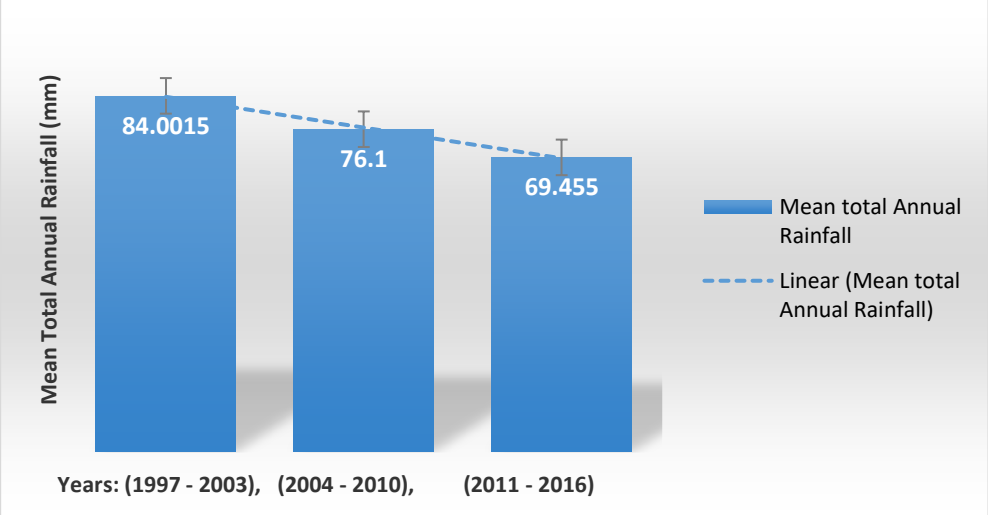

Figure 3. Rainfall Trend Analysis at Lake Chamo

The mean annual maximum temperature showed an increasing trend over the years 1997-2016, the last class (2011-2016) being the hottest with a value of 31.224°C and a standard error of 0.7497°C (Figure 2). However, the total annual rainfall values showed a decreasing trend over the years, the lowest value of 69.455mm in the last class, i.e. 2011 – 2016 (Figure 3).

DISCUSSIONS

A dramatic decrease in fish catch/production was reported (in the past five to twenty years) by the majority of the respondents (132, 88.6%), and in the coming five years, production is predicted to decrease even more. The average fish catch per trip is only 5.29 kg (standard deviation 3.338), with an average fishing time of 5.5 times (standard deviation 1.137) per week. Several anthropogenic activities can be responsible for the decrease in fish production at Lake *Chamo*. The increasing human population (CSA, 2007) of the area indicates the pressure that is being exerted on the lake. The ownership of a fragmented land (average 1.05 ha, standard deviation 0.769, of this study) is also forcing people to look for other alternative economic activities like fishing. Besides, those people involved in fishing are not getting any support from the government, exacerbating the already existing unsustainable utilization of the lake resources.

A change in climatic conditions of an area can be determined by many indicators. Temperature and rainfall are the major variables which can clearly show

the existence of relatively different or unusual climatic conditions in a specific area as compared to what was used to be observed. The mean annual minimum temperature of Lake *Chamo* is changing towards the highest values. The trend analysis indicated that there is an increasing trend of this variable in the study area. An increase of 0.88^0C was observed during the years 1997 – 2016. The mean annual maximum temperature is also changing towards the highest, though it showed a slight decrease in the years 2014 – 2010. This result is in line with what has been predicted before, in which the temperature across Ethiopia could rise between 0.9°C and 1.1°C by 2030 (NMA, 2007). Besides, the field survey result revealed that 141 of the total 149 respondents (94.6%) indicated that there has been a hotter temperature in their area in the past twenty years, which is in agreement with the climatic data analysis result. In the same way, in West Bengal (India), the average minimum and maximum temperatures have increased in the range of 0.1 - 0.9 °C throughout the state (Vass et al., 2009). An increased temperature of 1.3°C was also reported for Lake Tanganyika and an increase in air temperature between 2.2°C and 5.1°C is expected to be observed in the Mediterranean basin (Verburga et al., 2009; Rosa et al., 2012). Southeast Asia has already seen an increase between 0.1 and 0.3°C in the last half of the 20th century, with India showing an increase of 0.7°C during the 20th century and 0.6 - 1.0°C rise in mean temperature in the coastal area of Pakistan since the early 1900s (Cruz et al., 2007). Studies indicated also that warming of air temperature in tropical Africa by 0.26°C per decade since the 1970s was recorded (Cruz et al., 2007). According to Marcogliese, (2008) relatively small temperature changes alter fish metabolism and physiology, with consequences for growth, fecundity, feeding behaviour, distribution, migration and abundance. Increased temperature may cause thermal stress in aquatic animals, leading to reduced growth, sub-optimal behaviours (Harvell et al., 2002). On the other hand, extended increase in mean annual maximum temperature may have an indirect negative effect on the feeder rivers (e.g., *Kulfo* and *Sego* rivers) of Lake *Chamo* by increasing evapotranspiration. An increase in air temperature increases the rate of evaporation, resulting in water availability being further reduced (Junk, 2002). Lower river flows because of increased evaporation as a result of climate change is exacerbated by increased demand for irrigation water (Salik et al., 2015). It may also have an impact on the reproductive success and biology (maturation, hatching periods…etc.) of the fishes. Increased water temperature stresses fishes and facilitates the occurrence of diseases and parasites (Junk, 2002). Moreover, a decrease in oxygen level and water quality can happen which may result in a reduced survival rate and growth of fishes, in the worst scenarios. In the same way, it has been indicated that increased water temperatures, decreased dissolved oxygen levels and increased toxicity of pollutants, in lentic systems, can cause exacerbated eutrophication and pronounced stratification which could alter food webs and change habitat availability and quality (Ficke et al., 2007).

The mean total annual rainfall showed a dramatic drop from 84.0015mm (standard error 24.35) in the first class (1997-2003) to 69.455mm (standard error 23.21) in the last class (2011 – 2016). In line with this result, Trenberth (2011), reported that there have been decreases in precipitation in the subtropics and tropics outside of the monsoon trough, which is especially evident in the Mediterranean, southern Asia, and throughout Africa. The same decreasing trend of rainfall has also been reported by Nugroho and Wilis (2018), in which a significant declining trend on the total annual precipitation, an increasing trend of the number of days without rain and a decreasing frequency of the number of days with precipitation of more than 50 mm in the Batang Kuranji Watershed (Indonesia) have been identified. In Thailand, Hiroshi et al., (2008) have examined the decreasing trend in rainfall during the late summer monsoon season (September) from 1951 to 2000 and concluded that the 50-year time-series of September rainfall over Thailand showed a significant decreasing trend.

The analysis of meteorological data revealed that there are changes in climatic patterns (temperature and rainfall) in Lake *Chamo*. The local community's perception from the results of questionnaire-based interviews and focus group discussions also revealed that there are changes in climatic conditions, confirming the actual climate change that is happening in the area. As a result of the meteorological data analysis, which showed an increase in both mean annual minimum and maximum temperature, the local community also perceived the same. However, the meteorological data analysis showed a sharp drop in mean total annual rainfall over the years, but the local community perceived as if there has been an erratic (79%) and less rainfall (64%) in the area.

A considerable number of respondents (131, 87.9%) have also indicated that drought has been observed in a varying frequency in their locality, witnessing the increased temperature. This result is in line with the findings of Trenberth (2011), which indicated that increased heating leads to greater evaporation and thus surface drying, thereby increasing the intensity and duration of drought. Several climatic change indicator points and anthropogenic activities affecting the lake's ecosystem have been reported by the local community; among them extreme flooding as the major one. Land-use change, development activities and climate change can be considered as the main cause of flooding in many parts of the world. Climate change-induced impacts on land-use change and regional development are highly relevant and may even amplify the complex interactions (Yan et al., 2013). In particular; cropland, forest, water area, urban, and grassland are more sensitive to these changes than unused lands. The existence of frequent flooding was confirmed by 76.5% of the respondents. Majority of the respondents (121, 81.2%) in the study area agreed that there are an intensified agricultural activities going on near the shores of the lake, exposing the area for flooding during the rainy seasons. Increased deforestation rate, which is also a phenomenon in Lake *Chamo* area, can be a cause to increased sedimentation rate in the lake, affecting the breeding area/site of fishes, lake water level, amount of oxygen etc., because of increased turbidity which by nature decreases primary production, hence reduced growth of fish and total lake faunal communities (decreased fish biomass of the lake). Lake Chamo was referred to be threatened by an increased number of fishers, illegal fishing, poor soil and water conservation activities and overfishing.

CONCLUSION

This study identified that the fish production of the lake is decreasing from time to time, mainly because of the presence of illegal fishing, lakeshore farming, siltation and climate change. The fishermen perceived that there has been a change of climatic variables over the years, in which a hotter temperature, less and an erratic nature of rainfall were reported. This, of course, has been confirmed by the meteorological data (temperature and rainfall) analysis that indicated an increasing trend of both minimum and maximum mean annual temperature, and a dramatic drop in rainfall over the years.

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