The Effect of El-Niño on Reservoir fish production in Ethiopia. A Review paper

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Abstract
Drought is defined as the protracted absence, deficient or poor distribution of precipitation and it is a natural phenomenon that occurs for a prolonged period of abnormally low precipitation. The underlying causes of most droughts can be related to changing weather patterns manifested through the excessive buildup of heat on the earth’s surface, meteorological changes which result in a reduction of rainfall, and reduced cloud cover, all of which results in greater evaporation rates.

Nowadays drought is the main problem in the world and also recently in Ethiopia. Ethiopia has experienced droughts for hundreds of years, with major events (i.e., ones involving famine or documented suffering) including 1888-92, 1899-1900, 1920-22, 1933-34, 1973-74, 1983-84, 1987-88, 1990-91, and 1993-94. Currently, Ethiopia has faced the ugliest drought in 2015/2016 which affects the environment and humans. Mostly the occurrence of drought in Ethiopia is related to El Niño Southern Oscillation (ENSO) events. Reservoirs are essential components of most irrigation systems worldwide and, together with those built for flood control and power generation, retain large volumes of water. In addition to their role in power generation and provision of water for agriculture, industry and homes, most of these reservoirs also play an important role in fish production and contribute significantly to the livelihoods of the communities along their shores. It is known that Ethiopia has huge reservoir fish production potential which is not revealed and unexploited. One of these reservoirs, Tendaho Reservoir, is found in Afar region located between Dubti and Mile. This large reservoir has faced a great problem being highly vulnerable for drought in which it has dried, at least, once in the last two years. Recently, in February 2016, it has totally dried due to El Niño and all living organisms in the reservoir were damaged. It has distracted community structure, habitat loss, decline and huge fish population has died out. In this area, there is a knowledge gap on cause and effect of El Niño in reservoir ecology; therefore it needs depth research which could be conducted on drought impact in reservoir in order to develop prevention techniques during drought season.

Therefore, the purpose of this review paper was to identify effects of El Niño on reservoir fish production by synthesizing current knowledge on effects of drought on reservoirs that would ultimately be used to recommend and identify research direction.

Key words: Drought, Reservoir, El Niño, fish production

1. Introduction
Drought is defined as a natural phenomenon that occurs after a prolonged period of abnormally low precipitation. Drought occurs in visually all climatic zone, but their characteristics and impacts on society vary significantly by region and country (Bamko, 2011). The horn of Africa is the most vulnerable to drought in Africa. The year 2011 has been exceptional, with the worst drought for 60 years is setting Djibouti, Ethiopia, Kenya, Somalia, and Uganda causing the Horn of Africa to experience the most severe food crisis in the world (Bamko, 2011). Drought in both standing and flowing water system can have major ecological effects, stressing and depleting both Flora and Fauna. Loss of habitat, poor water quality and biotic interaction especially predation all have a major effect on aquatic biota and ecosystem functioning (Balton, 2003).

Although there is much uncertainty about the long term impact of global warming on the distribution of freshwater resource around the globe, El Niño event is one weather phenomenon that can be predicted with greater certainty. El Niño is associated with the abnormal warming of sea-surface temperature in the Pacific Ocean that has severe effects on global weather. While it leads to scanty rainfall and drought in some regions of the world, in others heavy rainfall and floods are common.
Reservoirs are usually found in areas of water scarcity or excess, or where there are agricultural or technological reasons to have controlled water resources (Wetzel, 2000). The frequency and intensity of precipitation, as well as evaporation rates can cause wide ranges in the water level of freshwater ecosystems, especially in reservoirs. Reservoirs in semiarid climates are exposed to drastic variation in water volume due to the shortage of precipitation and human demand during drought seasons (Barbosa, et al., 2012).

Adverse effects on fish production and wildlife are usually prided during drought. Specifically, drought induced increased in water temperature along with decrease dissolved Oxygen levels can lead to Fish crowding, stress and death (Bamko, 2011). Climate change lower water quality causing more disease and increased competition with other water users which altered and reduced fresh water supplies with greater risk of drought. Climate change may affect fisheries directly by change plankton composition, more frequent harmful algal blooms; less dissolved oxygen; and predators and invasive species are present (Dereje Tewelde, 2011).

Now a day’s drought is the main problem in the world and also recently in Ethiopia, particularly in Afar Region. Tendaho Reservoir is found in Afar region located between Dubti and Mile. It is home for various biological resources including fish, crocodiles and different bird species. The reservoir could offer several opportunities to support the Afar society especially to the displaced people of youth and women due to the reservoir formation (Hussen Abegaz et al., 2010). However, this large reservoir has a great problem which is highly vulnerable for drought such as at least it has been dried once times within a two year. Recently, it was totally dried during February up to May 2016 due to El Niño case and all living organisms in the reservoir becomes damaged, distract community structure, habitat loss, decline fish production, directly affects water quality and quality. However, there is no any research which conducted on evaluating of seasonal and unexpected such type of drought effect on aquatic resource in the country. Therefore it is necessary important to know how drought affect fisheries and other aquatic organisms in the reservoir and rivers. The purpose of reviewing such types of current issue used to recommend and indicate a research topic and also helps for develop and take protecting measures in order to create sustainable development.

2. Definition and Cause of drought

Drought is defined as the protracted absence, deficient or poor distribution of precipitation. It is as an extended period a season, a year, or several years of deficient rainfall relative to the long term average rainfall for a region. It is the inability of rainfall to meet the Evapo-transpiration demands of crops resulting in general water stress and crop failures (Abubakar and Yamusa, 2013). Droughts are major hazards to both natural and human dominated environments and those, especially of long duration and high intensity, can be highly damaging and leave long lasting effects (Nicholas et al., 2008).

Drought in standing water bodies occurs as surface runoff and stream inputs decline and, as droughts usually occur in times of high temperature, evaporation may increase sharply. As drought progresses, water levels recede from the normally highly productive littoral zone, standing some of the fauna(e.g. mussels, snails)and flora, such as rooted aquatic macrophysics (Purey et al., 2006).

The frequency and intensity of precipitation, as well as evaporation can cause wide ranges in the water of level of fresh ecosystem especially in the Reservoir. Wide water volume ranges can affect physic-chemical, biological and also water quality conditions in these systems (Wang et al., 2012; Straškraba & Tundisi, 2013). Reservoirs in semiarid climates are exposed to drastic variation in water volume due to the shortage of precipitation and human demand during drought seasons (Bouvy et al., 2003; Barbosa, et al. 2012). Reservoir is wide volume fluctuating during drought periods due to lack of precipitation and high evaporation. Wide water volume ranges can affect physic-chemical, biological and also water quality condition in these systems. In semiarid reservoirs have high nutrient concentration, conductivity, turbidity and algal biomass leading to water quality degradation (Mac Donagh et al., 2009).
2.1. Cause and reoccurrence of El Niño in Ethiopia

The underlying causes of most droughts can be related to changing weather patterns manifested through the excessive buildup of heat on the earth’s surface, meteorological changes which result in a reduction of rainfall, and reduced cloud cover, all of which results in greater evaporation rates. The resultant effects of drought are exacerbated by human activities such as deforestation, bush burning, overgrazing and poor cropping methods, which reduce water retention of the soil, and improper soil conservation techniques, which lead to soil degradation (Abubakar and Yamusa, 2013). Ethiopia is highly vulnerable to climatic hazards particularly drought and floods. Such hazards and associated disasters are not unique phenomena to Ethiopia, but what makes them unique is the scale of their consequences in terms of loss of life and damage to properties, livelihoods and to the national economy (Bamko, 2011).

El Niño is the name given to the occasional warming of surface waters in the central and eastern equatorial Pacific Ocean. Sea-surface winds blow from east to west towards the equator and pile warm water in the upper ocean of the western tropical Pacific near Indonesia and the Australian continent. As a result of this warm pool of water, the atmosphere is heated and conditions favorable for precipitation occur there. A weakening of the winds is the first sign that an El Niño event is underway. This is accompanied by the accumulation of unusually warm water off the coast of Ecuador and Peru with a peak around Christmas season. The fishermen who first observed it named it “El Niño” (“the Christ Child”). La Niña refers to the “cold” equivalent of El Niño (FAO, 1997).

Some findings stated that drought in Ethiopia has periodicity or quasi periodicity of 2 to 10 years, while some others argued that there is no long-term patterns, be it trend or cycle for Ethiopian drought. Ethiopia has experienced droughts for hundreds of years, with major events (i.e., ones involving famine or documented suffering) including 1888-92, 1899-1900, 1920-22, 1933-34, 1973-74, 1983-84, 1987-88, 1990-91, and 1993-94. Mostly the occurrence of drought in Ethiopia is related to El Nino Southern Oscillation (ENSO) events (EPA, 2007). This record shows the irregularity of the El Niño event taking place during the global weather calendar since 1877. Prediction of the event is therefore quite difficult. Yet, El Niño events have had different intensities and evolved differently in the past. The 1982-83 and 1997 El Niño events were the most intensive on record (Messer, 2000). Drought is not fully understood how ENSO events influence precipitation patterns in Ethiopia. It is thought that ENSO affects precipitation in Ethiopia by displacing and weakening the major rain bearing systems through its influence on the general circulation of the planetary atmosphere (Haile, 1988). Studies of drought events in Ethiopia indicate that the southern Atlantic and Indian sea-surface temperatures are influence the rain-bearing systems of Ethiopia not only all ENSO events correlate directly with drought in Ethiopia. The 1982-83 El Niño, for example, did not cause a particularly dry Kiremt, although one of the worst droughts in Ethiopian history occurred over 1983-84 (EPA, 2007).

Ethiopia has been experiencing one of the worst droughts in decades. Recently, in 2015/2016 the worst drought occurred in some part of the country. It starts in 2015 during main kiremt rainy season in June to September and followed by poor rain seasons during belg in 2016. This powerful El Niño-driven weather event has wreaked havoc on children’s lives and their families’ livelihoods as well as severely affect pastoral animals (livestock, sheep, goat, camels) and also destruction aquatic organisms in rivers and reservoirs (Humanitarian Requirements report, 2016).

2.2. The effect of Climate change on fisheries and aquatic ecosystem

The impacts of drought in general include mass starvation, famine and cessation of economic activity especially in areas where rain fed agriculture is the main stay of the rural economy like Ethiopia. It is common knowledge that drought is the major cause deadly conflicts over the use of dwindling natural resources, food insecurity and starvation, destruction of critical habitats and loss of biological diversity, socio-economic instability, poverty and climatic variability through reduced carbon sequestration potential. The productivity, distribution and seasonality of fisheries, and the quality and availability of the habitats that support them are sensitive to these climate change effects. Climate changes may affect fisheries and aquaculture directly by influencing fish stocks and the global supply of fish for consumption (Dereje Tewabe, 2011, EFASA, 2011)
Drought is the main cause for loss of biodiversity which adversely affect fish and wildlife. More than 200 fish species found in Ethiopia in all water bodies throughout the country. Specifically, drought-induced increases in water temperature along with decreased dissolved oxygen levels can lead to fish crowding, stress and death in lakes, reservoir, ponds, rivers and streams (Bamko, 2011). Rainwater scarcity would affect the aquatic life by deteriorating the quality and quantity of a water body. For instance, water insufficiency endangers the fish resource, which is the cheap source of protein and leads to food shortage.

The quality and flow of water in a stream can be substantially reduced during drought years, leading to direct reduction in living space for various life stages of fish species. During low-water years important spawning areas might be left dry, and fishes in habitating the stream may be forced in to small pockets of water in pool. However, Pooled water in the river course might be dried totally due to over withdrawn of river water for irrigation purpose and occurring severely drought which are main cause for decline and destructed of spawning migratory species and also residential riverine fish species (Gizachew Teshome et al, 2015).

High water temperature that may be accompanied by stratification and increasing conductivity (salinity) may, along with decreasing oxygen levels, severely stress aquatic fauna. The combination of high temperatures and low oxygen levels may eliminate some fish species. With stratification and stagnant condition, nutrients may build up increasing the risk of algal blooms during the drought, particular blooms of toxic blue green and golden algae which can cause extensive fish kills (Colley, 2004).

Generally, drought in both standing and flowing water system can have major ecological effects, stressing and depleting both flora and fauna. Loss of habitat, poor water quality and biotic interactions, especially predation, all have a major effect on aquatic biota and ecosystem functioning (Boulton, 2003). Aquatic ecosystems particularly fresh water ecology including lakes, reservoirs, ponds, wetlands, streams, and rivers are susceptibility for severely drought which affects their biotic and abiotic components (fig.1) (Tamar and Ostrovsky, 2010).

![Diagram of the pathways from loss of littoral habitat complexity to reduced species diversity and loss of ecosystem functions](image)

Figure 1. Conceptual diagram of the pathways from loss of littoral habitat complexity to reduced species diversity and loss of ecosystem functions

Climate change mostly affects sensitive ecosystems. As a result of rainfall variability and global warming, water scarcity may occur on wetlands and reservoir. The degradation of wetland environment has distinct negative impacts. The capacity of wetlands to grow grasses for dry seasons would decline and their potential as a breeding area for birds and fish would deteriorate (EPA, 2007).

2.3. Evaporation and seepage problems in reservoir ecology

Water levels of lakes fluctuate naturally in response to climatic and hydrological forcing and due to human over-exploitation of water resources leads to increased annual and interannual...
fluctuations of water levels. Man-made reservoirs tend to experience greater water level fluctuate than natural lakes. Droughts are increasing in frequency and severity in many regions of the world due to climate change. Water flow and volume decrease during drought typically led to increase salinity due to reduce dilution and concentration of mass and also due to excess evaporation. Temperature increases and enhance stratification occurred during drought in some system due to all temperature increases. This also enhanced algal production promoted toxic cyanobacterial blooms, and lowered dissolved oxygen concentration nutrient; turbidity and algal levels also often increased in the reservoir or lake system (Tamar and Ostrovsky, 2010).

Development activities based on water will be deteriorated as a result of water deficiency. There are found numerous man made reservoirs in the world which constructed for purpose of hydropower, irrigation and domestic and industrial usage. These reservoirs are fresh water ecosystems and sensitive for climate change. For example Tendaho Reservoir has been dried one times within two year and it was totally dried during drought period. The main causes of drying reservoir are seepage and evaporation due to drought, over withdrawn of tributary and main channels of upper part of the river for irrigation and other development purposes. It is known as Awash River Basin is the most developed endoric system which means it is endemic not flow out of the country. The area particularly the lower basin of Awash River found in semi-arid environment which exposed for excessive evaporation and seepage. Tendaho Reservoir is one of the most sensitive which affect by seepage and evaporation due to drought as shown in (picture 1) the reservoir was totally dried in 2016.

It is known as Ethiopia particularly Afar Region has been infested by unexpected severely drought due to El-Nho case in 2015/2016. According to the response of regional fish expert the reservoir has been dried one times within two years, it was dried in 2013 and also 2015/16. The reservoir water dried totally not only small volume and it also surprisingly dried within a month in a short period of time as shown in (Picture 1). Due to having serious drought in the region all communities of pastorals and agro-pastoral activities make high pressure starting from upper to lower part of Awash River course. Numerous small and large irrigation schemes including Tendaho and Koka reservoirs had built which are might be cause for dried by over withdrawn river and ground water resource in Awash River Basin. Based on the response of the pastoral community and experts, the surface area of the reservoir 170 km$^2$ declines from 53m and 11m the maximum and minimum depth reaches 31m and 9m respectively, due to unexpected drought in each year. However, on February in 2016, the reservoir water was dried totally and only remaining some pooled waters in the main channel of Awash River course.
2.4. Ethiopian reservoir fish production Potentials and its challenges

Reservoirs are an essential component of most irrigation systems worldwide and, together with those built for flood control and power generation, retain large volumes of water (Tsegay Teame et al., 2015). In addition to their roles in power generation and provision of water for agriculture, industry and homes, most of these reservoirs also play an important role in fish production and contribute significantly to the livelihoods of the communities along their shores (Tsegay Teame et al., 2015).

While Ethiopian is a land locked country, have huge fish resources potentials beside to have numerous types of water resource including lakes, rivers, reservoirs, small water bodies and ponds. Totally, the inland water body of Ethiopia is estimated to encompass about 7,400 km2 of lake area and a total river length of about 7,000 km. The major Ethiopian lakes and reservoirs fish production potentials estimated about 10,598 tonne/year and 2451 tonne/year, respectively. (Table, 1) (Assefa Mitike, 2014). However; the exact estimated fish production potentials of the country has no revealed. Now a day, in Ethiopia numerous reservoirs were found and new reservoirs are also constructing and considered to be built for different purpose which might have great contribution for increase fish
production potential. Reservoir fishery plays an important role in the economy of the country and the livelihoods of the people living adjacent to those reservoirs (Petr, 1998).

Table 1. Major reservoirs and dams with their fishery potential

<table>
<thead>
<tr>
<th>Reservoir</th>
<th>Area (Km²)</th>
<th>Fishery potential (tone/yr.)</th>
<th>Catch tone</th>
</tr>
</thead>
<tbody>
<tr>
<td>Koka</td>
<td>251</td>
<td>1,194</td>
<td>625</td>
</tr>
<tr>
<td>Fincha-Amerti</td>
<td>250</td>
<td>1,330</td>
<td>333</td>
</tr>
<tr>
<td>Beseka</td>
<td>39</td>
<td>205</td>
<td>41</td>
</tr>
<tr>
<td>Dembi</td>
<td>72</td>
<td>383</td>
<td>77</td>
</tr>
<tr>
<td>MelkaWokena</td>
<td>82</td>
<td>434</td>
<td>109</td>
</tr>
<tr>
<td>Aba Samuel</td>
<td>44</td>
<td>234</td>
<td>59</td>
</tr>
<tr>
<td>Alwero dam</td>
<td>74</td>
<td>394</td>
<td>79</td>
</tr>
<tr>
<td>Hashengie</td>
<td>20</td>
<td>106</td>
<td>21</td>
</tr>
<tr>
<td>Small abaya</td>
<td>12</td>
<td>66</td>
<td>13</td>
</tr>
<tr>
<td>Wedecha</td>
<td>10</td>
<td>53</td>
<td>11</td>
</tr>
<tr>
<td>Tendaho</td>
<td>170</td>
<td>1,345</td>
<td>500</td>
</tr>
<tr>
<td>Tekeze</td>
<td>160</td>
<td>1,065.63</td>
<td>583</td>
</tr>
<tr>
<td>Sub total</td>
<td>1184</td>
<td>6810</td>
<td>2451</td>
</tr>
</tbody>
</table>

N.B. Shading reservoirs are including in this reviewing paper. (Assefa Mitike, 2014)

Although only these reservoirs were studied fish production potentials, there are more reservoirs are not studied where found in the country which have huge potentials for fish production. For example, in Amhara Region: Ribb irrigation reservoir, Megech Reservoir, Geray reservoir, Koga Reservoir and there are also small and large reservoirs found in Tigray and Oromiya Region. All of these reservoirs have not studied in detail on their production potentials.

2.4.1. Fish Production trends and challenges in Tendaho Reservoir

Afar region fish production depends on Tendaho Reservoir and currently its status is increase from time to time due to the office creating awareness for consumers and producers. Before construct the reservoir some pastorals has trend to catch and consume fish from Awash River but it was very rare and uncommon in most pastorals. Now a day the region has been infested harsh drought which affects the aquatic resource and pastoral main livelihood depend on their livestock. The production of fish in the reservoir starting from 2004-2008 was varied due to fluctuate of reserve water (figure 2).

![Fish production status in Tendaho Reservoir](source regional livestock pastoral office)
The reason of fluctuate fish production in the reservoir is due to unexpected drought occurring in the region. The main cause for decline fish production is drying of reservoir due to evaporation, seepage, over withdrawn of flowing water in Awash River and its tributary of river. During 2014, fish production was decline as shown in (figure.2) due to the occurrence of drought which makes cause of decrease water volume in the reservoir. After end of drying season in 2014, fish highly increases by restock 180,000 Juvenile fish to the reservoir. In 2016 the reservoir fish production was dynamically damaged due to El Niño, the reservoir was totally dried (picture, 2).

During reservoir dried, fishermen easily harvest or catch much fish without fishing gears in the bed of Awash River, from Tendaho irrigation channel and at the bed of Tendaho Reservoir. However, production was over from demand of the community and then finally peoples leave to consume fish meat. Surprisingly, during February, 2016 reservoir water totally dried and then it raise bad simile around Logia town due to spoilage of fish as shown in (picture.2), finally those peoples where found around the reservoir deny to eating fish meat.

According to the response of regional fishery expert, there are two fisheries group has been established and which have 70 members per each co-operative. Therefore, this serious drought affects all fishermen and their family livelihood directly. They were shocking when they observe numerous fishes become die because have no never ever seen excess fish resource in the area while reservoir has 1345tone/year fish production potential (Hussen Abegaze et al., 2010).

There was found huge died fish in the bed of the reservoir (picture 3). During drying the reservoir water, fishermen were tried to harvest high fish product while they couldn’t get consumer or demand of the society in the Logiya Town. All species in the reservoir were damaged except few Cat fish species were tolerate lower water quality in the main channel of the Awash River course.

It is known as all biotic and abiotic components of the reservoir were damaged when the reservoir dried totally. Based on the field observation and personal communication this type of drought
is very serious and unique because the reservoir dried in unexpected way within very few days as shown (picture, 4).

2.5. The effect of drought on physical and chemical properties of reservoir water

Awash River is major water sources of Tendaho reservoir. The river flows from central highlands through Ethiopia's major industrial and agro-industrial belt. Pollutants point and non-point source from suburb of Addis Ababa and other cities enter Awash River carrying the whole burden of all types of raw effluents from industrial and agricultural sources which are the main causes for distract river and reservoir water quality. The reservoir is located in very hot area with average temperature ranging from above 28.5°C where evapotranspiration greatly exceeds mean annual rainfall that leads to the accumulation of salts on surface soil from the ground water and closeness to Ethiopia-Djibouti rides of highway also increases concentration of salt and toxic elements (Wondimagegne Asefa and Tarekegn Beranu, 2015).

Fortunately, during dried reservoir, physic-chemical parameters were measured at field and some parameters measured at Samara University Laboratory center. The impact of drought particularly create high evaporation and ground percolation which might be increase the remaining water salinity and also other conductivity and TDS parameters. The recent status of the reservoir water physico-chemical parameters were showed significance difference as compare the report of previous report (Table,2) (Hussien Abegaz et al., 2010).

<table>
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<tr>
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<tbody>
<tr>
<td>pH</td>
<td>8.4</td>
<td>7.8</td>
</tr>
<tr>
<td>Temperature (°C)</td>
<td>25.1</td>
<td>29.25</td>
</tr>
<tr>
<td>Conductivity (µS/cm)</td>
<td>569</td>
<td>833</td>
</tr>
<tr>
<td>DO (ppm)</td>
<td>7.82</td>
<td>4.6</td>
</tr>
<tr>
<td>Sechi-disk (cm)</td>
<td>65</td>
<td>36</td>
</tr>
<tr>
<td>Area (km2)</td>
<td>170</td>
<td>-</td>
</tr>
<tr>
<td>Max Depth (m)</td>
<td>53</td>
<td>-</td>
</tr>
</tbody>
</table>

According Ha et al., 1999 and Colley, 2004 high temperature that accompanied by stratification and increase conductivity (salinity) might be decreasing oxygen levels and severely stress on aquatic fauna. The combination of high temperature and low oxygen levels may eliminate some fish species.
3. Conclusion and recommendation

3.1. Conclusion

Drought affects Ethiopia by affecting its economy, agriculture, environment and biodiversity, population dynamics, human nutrition and health, animal population and water resources. Fish provides nutritious food, fishing and fish farming generate income and employment to millions of poor people, and trade in fishery products contributes to poverty reduction and national economic growth in many developing nations like Ethiopia. Global warming affects aquatic ecosystems and their fishery productivity. Fisheries directly affected by low precipitation which affects reservoir levels and river flows, and increasing seepage and evaporation of standing water bodies. Greater climate variability and uncertainty complicate the sustainability of fisheries in reservoir and rives. Fisheries management must consider drought mitigation measures not only seeking to maximize yield rather to increasing adaptive capacity related to climate change. Research is needed to find innovative ways to solve the vulnerability of drought on reservoir aquatic resource as well as the adaptability and sustainability of fisheries and aquaculture in semi-arid environment like Afar Region. As we observed Tendaho Reservoir fish production capacity, the area indicates to have moderate and suitability for Aquaculture which has drought as a limited factor. This review concluded that “the effect of drought on reservoir resource and development activities has a very limited information or research in the country at whole”. However, it would be important for wisely utilize and protect aquatic resource in reservoir.

3.2 Recommendation

- The recent drought (El Niño) is a critical problem in Ethiopia which affects the development project; therefore natural and human factors which influence the growth of development activities in the aquatic environment should be analyzed their level of effect and develop measurement guideline framework.
- El Niño is unseasonal and unexpected disaster which affect terrestrial and aquatic environment; therefore prevention techniques should be designed before incidence of this type of drought.
- Fresh water ecosystem especially reservoir is the most sensitive and vulnerable for easily depleted by drought. Therefore, conservation of endemic and critical endanger species should be mandatory for sake of sustainable development.
- Each development projects EIA framework should be prepared by considering natural disaster and prevention mechanisms
- Problem solving and innovative type of deep research should be conducted on the following thematic areas:-
  - The impact of El Niño on riverine and reservoir fisheries and biodiversity.
  - The suitability and productivity rate of fish production in reservoir ecology at lowland part of Ethiopia
  - Cause and rate of reoccurrence and mitigation models of El Niño in Ethiopia
  - Determine water quality and quantity for establish Aquaculture or hatcheries site at semi-arid environment and re-stock decline stock reservoir.
  - Why Ethiopia is the most and first country redundantly affected by El Niño drought?
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