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Review Article

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Impact of climate change on ecology and biodiversity of Africa- *a review*

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ABSTRACT
The most diverse among all the eco-biosphere entities is the aquatic ecosystem. With their dynamic biodiversity, energy cycles, prey-predator interactions and seasonal patterns aquatic ecosystems are unique in the nature. They are the most influenced of all the others due to their gradual sensitivity by a small change in the climatic condition. The sensitivity can be linked with their response towards temperature and light influencing several abiotic parameters including water, rainfall, pH, dissolved oxygen. The behavior and ecology of biotic components largely depend upon these abiotic parameters; a slight change in which can alter the community dynamics, species composition and diversity of the entire system. Compared to natural causes of climate change, anthropogenic activities are more influential and long standing. Excess use of fossil fuels, use of plastic, confluence of industrial gases and effluents, deforestation are few such examples for the detioriating situation. Both lentic, and lotic among fresh water, the marine with all its components, the estuarine diversity and distribution of species are facing challenges to cope up large-scale stress due to convergence of landmass, destruction of forests including mangroves, over usage of pesticides and fertilizers, exploitation of aquatic products including fish and corals. Not only the aquatic ecology and species in but also the human population and the community which largely depends upon them, disturbed leading to poverty, unemployment, population displacement and conflicts for water and cultivation land. Africa with all its floral and faunal biodiversity, extended lakes with vivid climatic zones is not away from the impacts of climate change. Africa is facing many challenges despite all efforts although a less-contributor of greenhouse gases. To understand all these aspects at the global level especially in Africa, this review paper is prepared accumulating from various sources to apprehend the causes, dimensions and challenges faced by various aquatic ecosystems because of climate change.
Keywords: Africa, Aquaculture, Aquatic, Climate change, Fish, Fisheries, Impact.

INTRODUCTION

Mother Earth is called as “blue planet” due to the existence of water on it, can also be called “green planet” because of plants and vegetation and also as “brown planet” for having faunal life. But with the emergence of industrial revolution and technological advancements, along with careless behavior of human population towards nature; the climate of our living planet is fast changing towards a negative side causing distress to the entire living system. The decade 2011-2020 was the warmest decade ever recorded, with average temperature reaching 1.1°C as compared to the previous decades. Global warming due to anthropogenic activities is increasing at 0.2°C per decade compared to the temperature in pre-industrial era, associated with grave negative impacts to the natural environment and biodiversity that although do not result positively for gradual evolution of existing species rather for origin of new species. Several efforts were made to minimize the rate of global warming below 1.5°C instead of 2°C but all remained in the record without practical implementation (Dupont and Thorndyke, 2009).

The Climate change is not simply warming of the globe due to the gases alone but is a conglomeration of several other aspects including anthropogenic interference in all natural components. To name few, destruction of forests, use of plastic materials, use of petroleum products, industrial gases and effluents is few such examples besides the explosion of human population. One of the main components for climate change is the greenhouse effect in which the Earth's atmosphere behaves like a glass in a greenhouse, trapping the heat due to growing temperature preventing it from seeping back to space causing global warming. Many of these greenhouse gases released due to human activities such as carbon dioxide (CO_2), methane, nitrous oxide, fluorinated gases etc. By 2020, the carbon dioxide (CO_2) concentration in the atmosphere had risen to 48% above is the largest contributor to global warming (Susane *et al.*,2019). Methane is a more powerful greenhouse gas than CO_2,

but has a shorter atmospheric lifetime. Nitrous oxide, like CO_2, is a long-lived greenhouse gas that accumulates in the atmosphere over decades to centuries. Non-greenhouse gas pollutants, including aerosols like soot, have different warming and cooling effects and are also associated with other issues such as poor air quality.

Causes of climate change

Carbon dioxide and Nitrous oxide are emitted by burning coal, oil and gas products.

Due to deforestation absorption of CO_2 from the atmosphere decreasing also the emission of O_2.

Improper handling of byproducts from livestock and cattle farming such as fecal maters that cause methane growth

Artificial fertilizers those contain nitrogen can produce nitrous oxide emissions also pollute the water bodies to which they are released as effluents from agricultural lands.

Emission of fluorinated gases from several equipment's and domestic products those use these gases having a very strong warming effect (up to 23 000 times) greater than CO_2.

Construction of roads and buildings by concrete and asphalt covering the lower soil and preventing greensickness are increasing for more exposition and reflection of heat

More construction of dams and reservoirs freely moving aquatic species terminating inter and intra migratory behaviors.

Excess constructions near sea beaches and river side, use of mechanized boats, deposition of municipal and industrial garbage into water, over fishing, dredging and shipping activities.

Outputs of Climate Change

There are several adverse impacts of climate change on both biological and non-bioloical entities, few are given below.

The destruction of habitats for fishes and aquatic birds

Birds avoiding the urban environment due to mobile towers and getting confined to remote areas.

The habitat loss in benthic regions changing biota for fish and other aquatic species

Oil spill by gulf war caused killng millions of marine species

Global warming in Antarctica causing growth in sea levels

Bird migration got marginal change due to altered and uncertain climatic conditions

Origin of new viruses and pathogens

Destruction and displacement of many species. For example, the decrease in the number of bats (Microptera) facilitated the growth of mosquitoes, flies and insects; one of the root cause for several diseases

Excess mutation and adaptation by lead to new characteristics, much novel to existing organisms by altering gene pool, manipulation of gene flow and genomic structure.

Decrease in rainfall results in stagnation of water for longer period or drying up water bodies can lead to more adaptation emerging as sub-species. Ex. adaptation in mosquito for repellant coils

Loss of estuarine ecosystems and its diversity effecting breeding and migration in aquatic organisms.

Due to fluctuating rains and climatic conditions the diversity and habitats of several species such as reptiles, amphibians among vertebrates and mollusks and echinoderms in invertebrates.

The impact on Aquatic ecology

On faunal diversity of fish and diversity in fisheries the impact of climate change could be classified as non-biological (abiotic) and biological (biotic). Changes such as rise in sea level, water surface temperature, increasing water salinity and ocean acidification can be categorized as non-biological while biological changes include changes in primary productivity, changes in species diversity, abundance, community dynamics, and emergence of sub-species. Warming of the oceans due to climate change will mean fewer productive fish species to catch, changing predator-prey interactions keeping up with conditions where they could thrive. As temperatures raise and water warms, new organisms with fresh enrich methods of adaptation will emerge out with novel methods of food and feeding, habitat types, reproductive behavior. This was what happened millions of years back when our own origin and evolution took place. The climate change today resulted in widespread damages such as loss of several types of coral reefs and mangrove vegetation that sustained ocean life. The migration of species to higher latitudes and altitudes to have nesting and breeding from that of resting and feeding is now restricted to few species.

Climate change is primarily a crisis caused to the nature in terms of its water, air, soil and biota it's an alteration and altercation of the environment around us; just playing foul with our surroundings (Watson *et al*., 2001). Global climate change is increasingly and profoundly threatening fishes, resulting in an uncertain future for both fish diversity and fisheries sector. Understanding how fish growth responds to changing environments is essential for indicating and predicting the impacts of climate change on fish populations, communities, and even aquatic ecosystems, but the knowledge on this topic remains incomplete, and some findings are contradictory. Higher water temperatures may reduce the abundance, distribution of inland fish reserve and increase in fish mortality by reducing water quality, water chemistry, introduction of new predators and pathogens, and variation in the prey type for fish.

At a 1.1°C increase in temperature today, 60% of the world's marine ecosystems have been degraded, a warming of 1.5°C threatens to destroy 70 to 90% of coral reefs, and a 2°C increase means a nearly cent percent loss of many aquatic organisms. Changes in precipitation and outflow, alter the amount and quality of habitat for aquatic organisms they indirectly influence ecosystem productivity and diversity. With the population explosion and anthropogenic disturbances (Rosenwig *et al*, 2008), the temperature level increases alarmingly

increasing heat waves leading to tropical cyclones, extensive floods, and rise in sea level rise in massive destruction of lives, materialistic loss and population displacement.

If we observe the studies conducted between 1976 to 2018 (about 1205 documents published) on fish and its ecology, less than 1% of the recorded fish species (309 out of over 32,000 species) from 30 orders have been studied to examine their growth responses to climate change. Among all the studies, most were dedicated for *Actinopterygii* belonging to orders *Cypriniformes, Perciformes and Salmoniformes*, the later studied most frequently than other orders. The effects of climate change (temporal) on fish growth and reproduction were negative both at global and local scales. Future studies covering more species of other orders such as Chondrichthyes, Cyclostomes and fishes of high-latitude areas (including cold water) should be focused for better understanding of climate change impacts on fish diversity, growth and physiology. The egg and larval stages of most fishes takes place in the tidal zone where availability of food, shelter and partner for mating is abundant. The larval phases of most species are far less tolerant of extreme temperatures than the hardy juvenile stage. With the change in the physic-chemical parameters, morpho-physiological changes were also reported in many zooplanktons and macro-invertebrates. The change in the gross body structures, outer ornamentation, appearance of spines in zooplanktons and changes in species composition and diversity indices were observed among macro-invertebrates. Besides these changes, many zooplanktons and macro-invertebrates serve as tools for bio-indicators representing the quality of water they live in (Pattnaik, 2014, 2016).

The African context

Although Africa is not at all a significant contributor of greenhouse gas emissions yet the impact of climate change is far more than expected, like burning of house at a place by the spark of smoke coming from somewhere. Only 2-3% of the total carbon dioxide emissions for the World come from Africa. A slight spatio-temporal change in climate can alter warming of water in Ocean leading to decrease in fish species, fish productivity, changing prey-predator interactions. According to the 2021 Global Climate Risk Index, impacts of climate change over last 20 years, out of the 10 countries affected most by climate change in 2019 five were from Africa, they are Mozambique, Zimbabwe, Malawi, South Sudan, and Niger (Albert.O. Amosu, 2012).

Impact on Crop varieties

According to a recent study (Ortiz-Bobea et al. 2021) climate change reduces agricultural yields by 21% worldwide over the last 60 years. During the same period, the collective impact of climate change was greatest in relatively warm regions such as sub-Saharan Africa (the sub-Saharan Africa has four climate zones namely tropical forests, savanna grasslands, semiarid or Sahel and desert) with loosing many crops and decline of yield about 33% (Essam Yassin et al). Between the years 2008 to 2018 in Africa, pests, diseases, and infestations were the second highest cause of crop and livestock production loss due to warming and changing patterns of temperature altering pests' habitats, population sizes, metabolism, and maturation rates and reproduction pattern abit faster with greater destructive impacts. Africa experienced considerable damage by two pests that have caused destruction in agriculture sector linked to climate change, were the fall armyworm and the desert locust, the former causing damage particularly to maize leading to food shortages and malnutrition in poor areas (Urama, K. C. and Ozor, N. 2010).

In Uganda the current and past trends indicate that the onset of rainy seasons shifted by 15 to 30 days (earlier or later), while the length of the rainy season changed by 20 to 40 days from year to year. There was no significant change in average annual rainfall and in average annual rainfall. This could have strong impacts on agriculture, especially regarding tree crops (e.g., coffee) and post-harvest activities such as drying and storage. An analysis of average annual temperatures between 1951-1980 and 1981-2010, shows a notable increase of approximately 0.5-1.2 °C for minimum temperatures and 0.6-0.9°C for maximum temperatures. This warming trend is projected to continue, with some models projecting an increase of over 2°C by 2030. It will likely have a strong impact on agriculture and livestock, increasing the risk of disease and pest infestations.

A study on various crop varieties in Uganda revealed that many are vulnerable to the rising temperatures and decreasing rainfall. Of the crops analyzed in this assessment, Arabica coffee is the most vulnerable, while cassava is the least as per their sensitivity, with the average ranging in between rice, maize, East African Highland Banana (matooke) and sorghum. Two major rice diseases (blast and bacterial leaf blight) affect rice yields and are aggravated by weather conditions such as higher temperatures, air humidity and soil moisture. Aflatoxin contamination represents a serious threat to marketing maize and will likely worsen if dry season rainfall increases. While matooke (east African highland banana) is less vulnerable to increasing temperatures than coffee is, the potential impact of pests and diseases on the crop is significant. Erratic rain could increase post-harvest storage losses of crops typically dried in the sun (e.g., maize, beans, coffee, rice, etc.), due to increased pests and rotting. Coupled with irregular precipitation, increased temperatures could cause the proliferation of striga, a parasitic weed that affects sorghum and is prevalent in areas with degraded soils. Sweet potatoes and cassava crops grow well at temperatures much higher than ones, but are also vulnerable to pests and disease (Uganda, national report on agriculture, 2017).

In the year 2019-20, conflicts related to competition over lordship over water and grazing land due to changes in climate, push herders in western and central Nigeria over 1,700 violent deaths. Disputes among herders and farmers resulted in several hundred deaths. In one of the studies, it is estimated that, Nigeria is losing 2,000 square kilometers of crop and grazing land every year due to desertification, lack of qualitative rainfall and over dry seasons (Oladayo, 2017). According to the World Resources Institute (WRI), by 2050, climate change will diminish the areas of coffee production by half. One of the largest producers of Coffee, Ethiopia may experience significant alteration in coffee yields by 2030 with decrease in production by 30%. Along with Ethiopia, east African nations such as Kenya, Tanzania, and Uganda which contribute 80% of Africa's coffee exports are likewise susceptible to climate impacts.

Climatic impact on fishery sector and fishing community

Durational limitation in winter period under climate change may have negative implications for poiklothermic (cold-blooded) organisms. The quick *warming of water in winter season can reduce reproductive success for many species (e.g. yellow perch), resulting in distorted spawning time, lowering hatch rates, and tiny larvae. T*he climate change not only affected fish but the fishery industry too. In an estimation about 1,440 fishermen lost 590 vessels, 1,800 fishing gear, and 67 boat engines along with 58 fish tanks, 204 cages, and 257,500 fish fry in Sofala region where as in Zambézia region, fishermen lost 169 fish ponds, two cages, and 606,000 lost fry; this reveals the vulnerability of fisheries and aquaculture to extreme events particularly the cyclones in Mozambique. In Ethiopia, the studies of climate change impacts on water resources are concentrated in northern part of the country, mostly based on old climate change emission scenarios and limited number of global climate models (GCM). The study presents the fluctuation of rainfall, temperature, and humidity over the years. A 3.1°C increment was found in mean maximum temperature within 22 years in Ethiopia. Elohor Freeman (2020) in his report cited the different impacts of climate change on the physical, chemical and biological quality of water to rise in sea level, strategies for adaptations and how to cope with the impacts of changing climate on water quality, in other to sustain the industry in Nigeria.

According to the World Bank report, climate change leads to rise in sea temperatures, migration of fishes toward colder waters away from the equator, influencing the abundance, migratory patterns, and mortality rates of wild fish, also reducing fish stocks by 7.7% globally, 53% in Nigeria, 56% in Ivory coast, and 60% in Ghana in West Africa. The International Organization for Migration in its Strategic Vision for 2019-2023) stated that, *"climate change will have a strong influence over future dynamics and become part of the intricate set of factors fueling internal movement, including displacement, and the transfer of populations from rural to urban settings. Among those leaving rural areas were previously employed in agriculture: a pastoralist no longer able to rear livestock because of droughts, or a fisher who leaves a village because ocean acidification has erased fish stocks. Migration can be a climate adaptation strategy leading to better outcomes".* It is also the driving factor for displacement across Africa resulting to displacement of 2.7 million people around Lake Chad, over 425,000 were displaced in Ethiopia because of drought like condition; 36,000 across the Sahel, millions have fled towards the coastal cities amid drought and widespread crop failures raising a question mark for food security.

In **Kenya** between 1999 and 2002, the droughts enormously affected hydropower generation that the capacity decreased up to 25 percent (Besada & Sewankambo, 2009) similar to Akosombo dam in Ghana, in which the water level decreased to 240 feet resulted in the reduction in power generation. Similarly, Ethiopia, Kenya and Somalia experienced droughts and livestock loss which thrown almost 11 million people into a critical condition prompted mass displacement (Besada & Sewankambo, 2009). Unseasoned rains causing flooding and landslides in 2010, resulted in displacement of 48,000 people in Uganda and 55,000 in Kenya, Namibia, Rwanda and Zambia (Abebe, 2014). Comparing the correlation between environmental factors and inter-provincial migration using demographic data from the population census survey, Henry et al., (2003) reported that in Burkina Faso, the mass migration is influenced by biophysical changes in the environment. In Mali, decreasing rainfalls led to poor harvesting which compelled farmers from the affected regions to migrate urban areas in search of employment (Christian Aid, 2007). All these resulting in to new environmental problems in urban areas, in terms of municipal garbage, pollution, Sox, Nox, SPM, density, transportation and finally urban crimes.

The **Ethiopian Rift Valley** is one of the potential sources for fisheries and aquaculture sector in Ethiopia. Climate changes and environmental pollutions damaged the fisheries and aquaculture sector directly by manipulating the fish stocks and the fish for consumption. 92.8% of the sewages wastes released from Addis Ababa city and agricultural fertilizers including pesticides were released into the rivers and rain-water channels having more than the permissible levels of BOD and COD levels. Heavy metals and toxic elements coming out of industrial infrastructures are another source of contamination in soil and food chain. In Lake Awassa and Lake Koka of Ethiopia, different industrial discharges induce mercury level high in different fish body parts, especially the fish liver (Mesfin M.T. et al., 2012). 90% of industries in Addis Ababa simply discharged their wastes into the streams with no treatments, and 92.8% of the liquid waste is mixed with river and rainwater channels, and this affected the water quality and indirectly it affected the fishery sector. Organic pollutants which reduced the level of oxygen cause of the death animals' species such as fish in water

bodies (Hayelom Berhe. 2021). Jansen and Harmsen, 2011 had reported that 30 pesticides having the concentration of 0.1µg/L were found near Lake Ziway (Ethiopia) out of which five are categorized as having high human risk and these pesticides are banned chemicals in European societies.

The aquaculture industry in **South Africa** is likely to be negatively affected by temperature change, increased harmful algal blooms (HABs) and ocean acidification causing considerable damage to fish and aquaculture because of their sensitivity to climate change and low capacity for adaptation (Clarck, 2006). Unlike culture fishery, the capture fishery is largely driven by fossil fuels that contribute to greenhouse effect. Transportation of catches is the other source of emissions, depending upon modes and distances of transportation. Besides having ocean acidification, habitat damage, changes in oceanography, disruption to precipitation and freshwater availability, fish ecology; fisheries sector can have diverse range of direct and indirect climate impacts namely displacement and migration of human populations; impacts on coastal population and infrastructure damage due to oceanic levels etc. Normally, economically backward, financially weak nations and their citizens are more vulnerable to climate impacts in terms of fish and aquaculture sector. Failing of fishing sector can lead to alternative occupations, unemployment, raise in poverty and a uncertainty in the fishing community.

Adaptation in Fish and Aquatic species for climate change

Fish being poiklothermic (ectothermic) is least affected due to change in the ecological conditions it takes time for adaptation and growth. Many fish have the color patterns which facilitate them to intermingle with their surroundings to avoid also to the predator. Modification in the body size and length, extension of lateral line sense organs, modification in scales and their arrangement, pigmentation on skin, working of gills, adaptive coloration, spindle body shape, light production due to biochemical reactions, and production of toxic materials are a few changes those may occur as a result of climate change. While marine mammals have rather flexible to changing ocean conditions, the foodstuff that sea lions, seals, whales and dolphins depend can change due to warming water.

Study on the threats for the Fisheries around Lake Tana, Ethiopia covering over 30 Years have shown that, the mean annual rainfall fluctuated from 74.6 mm in 1982 to 163.3 mm in 1991 then gradually decreased to 89.7 mm in 1994 and increased to 142.6 mm in 2014 (Erkie Asmare, 2016). Among the anthropogenic disturbances, encroachment of the wetlands for cultivation, demolition of fish breeding and nursery grounds, illegal fishing gear, agricultural influents; animal trampling and growth of recreational area around the lake by which untreated sewage wastes directly deposited in to the lake. The mean maximum annual temperature also in a raising trend after 2009, it was 26.9^{o}c in 1984, 25.7°C in 1991 and reached to 28.8°C with a rate of 1.9°C increment in 2013 (National meteorological Agency, Ethiopia; NMA, 2015). This shows there is a 3.1°C increment in mean maximum temperature within 22 years and variability in the rainfall, temperature, and humidity directly and indirectly having impact of fish and aquatic life. Several phytoplanktons, zooplanktons, maro-invertebrates, nektons and neustons have disappeared is not known because of their minute morphology and limited diversity but much significant in ecological aspects. Emergence of new microscopic species is also undergoing so quickly that it may create havoc in our taxonomy in coming years.

It is essential to know the difference between climate and weather; there is a common misunderstanding between these two. Weather is only a day-to-day status of the atmosphere; whereas climate is beyond such aspects reflecting long term consequences (say for over 30-40 years) for a particular geographical location. Oceanic air circulation affects atmospheric in terms of air temperature and precipitation at a particular area. For example, India is in the northern hemisphere but the annual monsoon rains are sparked by the waves of air coming through south Pacific and Indian Ocean. In temperate regions, the dominant annual climate cycle that drives changes in freshwater ecosystems is air temperature, while in the tropics, air temperatures remain relatively constant (and high), but the principal cycle affecting freshwater ecosystems is precipitation, besides variation in wind a significant contributor for a remarkable change in lentic ecosystem.

Impact by Global worming

Natural climatic variation results from a range of natural drivers including volcanic eruptions, changes in solar output and natural changes in the orbital characteristics of the earth (Hulme & Barrow, 1997). Most of the global industrial infrastructures are supported by carbon-based fuels raised significant alteration of the components of the earth's atmosphere, with amplified concentrations of atmospheric gases, e.g. carbon dioxide (CO_2), methane (CH_4), nitrates and water vapour (Solomon et al., 2007). So called greenhouse gases are naturally present in the atmosphere and are vital for persistence of life on earth, without whom the temperatures would be much colder than now, since they allow short-wave radiation from the sun to pass through the atmosphere and heat the earth (Ruddiman, 2001). Anthropogenic activities have increased greenhouse gas concentrations to levels greater than in the preceding 650,000 years (Siegenthaler et al., 2005), CO_2 concentrations close to 400ppm (Blunden & Arndt, 2013). This has resulted in increase of temperatures, leading to worming causing melting of snow and ice, rooting rise in sea level immersing of many cities in coming years in Oceans.

Coral reef

The corals and coral reef are generally abundant in warm, shallow, tidal littoral zone. They are the shelters of millions of species serve as one of the biggest contributors in the ecological niche. Due to climatic

changes coral reefs of the ecosystem are in great danger. The main reasons are increasing temperature, acidity, effluents etc. Climate related impact on the corals can be categorized on three aspects.

Coral bleaching results in degradation of reefs.

Increased Acidification resulting in degeneration of carbonate structures.

Delicacy of structural integrity of the reeves.

The coral reef is one of the most resistant ecosystems and too resilient to recover from weak chronic and acute stresses. Increasing acidity causes decreasing the pH of the ocean, which can disrupt the calcification of coral.

CONCLUSION

Climate change is the determining factor in the diversity and distribution of biodiversity. Environmental factors replicate strong influences upon species richness of aquatic organisms. Ocean warming can cause change to the marine species especially in their latitudinal range and depth range in large scale. This can lead to extinction of existing species or origin of new species. A huge shift in species richness can occur which is regarded as the main cause of disruption of marine biodiversity and ecosystem. The climate in the aquatic environment can affect biodiversity, the community dynamics.

Global warming can also promote devastating cyclones causing enormous loss to man and property besides devastation of massive aquatic life. In May 2019, a cyclone named *Fani* hit Andhra Pradesh, Odisha and West Bengal that caused damage to the coastal land, boats, jetties and the shelters of the fishermen and five lakh houses were destroyed besides the damage to the sea food sector by lowering the production of shrimp by 60–70% (Krishna Kumar, 2019). Most recently, in May 2020, cyclone Amphan hit eastern India specifically West Bengal and also Bangladesh that took the life of over 9000 people (Nandi and Thakur, 2010). Cyclones also cause damage to the backwaters such as the Sundarban, which are habitats for rich faunal diversity.

The Aquaculture and fish sector is much affected by temperature increase in water and air, sea level rise, and associated factors, affected by global warming and climate change. This change in the aquatic environment or a decrease in fish production is directly affecting the economic sustainability of fish farmers. So, when we talk of climate change and its impact, it can be practically understood that they mean anthropogenic not rather natural. No natural thing is hazardous and detrimental although contribute for temporary loss but always healing; whereas all man-made emissions are hazardous and toxic not only to the atmosphere but also to all living organisms on the globe.

Climate as a whole needs a lot of study not only in one particular area but by many aspects such as agriculture, rainfall, deforestation, conversion of aquatic ecosystems to agricultural land and many. The interaction and interdependence between all these components towards contribution to global climate along with algal distribution and impact of sea grass to be studied together. The fate of glaciers, the temperature raises in the littoral zones of Oceans, drying drainage systems of rivers and Lakes, rapid downgrading of forests, release of greenhouse gases are the contribution of man himself, unless we accept this as a mistake and honestly act accordingly either to reduce or eliminate such destroyers who damage the Nature, it's difficult to imagine our future generations to lead life without facing the furious face of mother Nature!!

CONFLICT OF INTEREST

The author here declares that there is no conflict of interest in the publication of this article.

REFERENCES

Abebe, M. A. 2014. Climate change, gender inequality and migration in East Africa. *Wash. J. Envtl. L. & Pol'y,* **4**, 104.2.

Africa Action 2007. Africa Policy Outlook. Available at www.africaaction. org.

Albert O. Amosu, 2012: "Impact of climate change and anthropogenic activities on renewable coastal resources and biodiversity in Nigeria", Journal of Ecology and the Natural Environment 4(8):201 - 211:DOI: 10.5897/JENE11.104

Aschale, M., Sileshi, Y., Kelly-quinn, M., & Hailu, D. (2016). Evaluation of potentially toxic element pollution in the benthic sediments of the water bodies of the city of Addis Ababa, Ethiopia. *Biochemical Pharmacology*, **4**, 4173–4183.

Barrow,E.M. and Hulme,M. 1997. 'Describing the surface climate of the British Isles' pp.33-62 in, Climates of the British Isles: present, past and future (eds.).

Besada, H., & Sewankambo, N. 2009. CIGI Special Report: Climate Change in Africa: Adaptation, Mitigation and Governance Challenges.

Caitlin Welsh 2021: "The Effects of Climate Change in Africa."-A Testimony: Director, Global Food Security Program; Center for Strategic and International studies, CSIS USA.

Clark, B. 2006. Climate change: A looming challenge for fisheries management in southern Africa. *Marine Policy*, **30**(1): 84-95.

Christian Aid. 2007. Human Tide: The Real Migration Crisis.

Cochrane K, Young C. De, Bahri, T. 2009. Climate change implications for fisheries and aquaculture. FAO Fisheries and Aquaculture Technical Paper. 530:212.

Dupont, S. and M. C. Thorndyke. 2009. Impact of CO2 driven ocean acidification on invertebrates' early life-history – What we know, what we need to know and what we can do. *Biogeosciences Discussions*, **6**, 3109–3131.

Essam Yassin Mohammed and Zenebe Bashaw Uraguchi 2013. impacts of climate change on fisheries: Implications for food security in Sub-

Saharan Africa: Global food security ISBN: 978-1-62618-192-2.

Erkie Asmare Beyene., et al.2016. "Impact of climate change and anthropogenic activities on livelihood of fishing community around Lake Tana, Ethiopia". *EC Agriculture* **3**.1: 548-557.

FAO. 2008. Climate change implications for fisheries and aquaculture. In: The State of Fisheries and Aquaculture 2008. Rome, Italy: FAO; 2008. pp. 87-91.

Hayelom Berhe Dagnaw 2021. Implications of Environmental Pollutions on Ethiopian Fisheries: Review Research on Humanities and Social Sciences,11(17).

Henry, S., Boyle, P., & Lambin, E. F. 2003. Modeling inter-provincial migration in Burkina Faso, West Africa: the role of socio-demographic and environmental factors. Applied Geography, 23(2),115–136. https://doi.org/10.1016/j.apgeog.2002.08.001

How Climate Change Threatens African Coffee Farmers. https://www.dw.com/en/how-climate-change-threatens-african-coffee-farmers/a-55648060).

Jansen HC, Harmsen J 2011. Pesticide monitoring in the Central Rift Valley 2009-2010. Report 2083. Alterra, Wageningen, http://library. wur.nl/WebQuery/clc/1966024.

Krishnakumar PK. 2019. Shrimp Production in Odisha Hit by Cyclone Fani. The Economic Times. 2019.

Mesfin M T., Carlos Eduardo V. C., Elias D., and Sindern S. 2012. Assessment of heavy metals in water samples and tissues of edible fish species from Awassa and Koka Rift Valley Lakes, Ethiopia. Environmental Monitoring and Assessment · July 2012 DOI: 10.1007/s10661-012-2777-8 ·

Meisner, J. D. and Brian J Shuter 1992. Assessing potential effects of global climate change on tropical freshwater fishes: GeoJournal 28(1):21-27: DOI: 10.1007/BF00216403

Nandi J, Thakur J. 2020. Amphan Transforming into Super Cyclone, first after Deadly 1999 Super Cyclone in Bay of Bengal. Hindustan times. 2020.

National Meteorology Agency 2007, 2015. Final Report on Evaluation Criteria for Identifying High Priority Adaptation Activities prepared by B and M Development Consultants for NMA, Addis Ababa.

Oladayo Nathaniel and Jonathan 2017. The Impacts of climate change in Africa: a review of the scientific literature: Journal of International *Academic Research for Multidisciplinary*, **5**(1).

Pattnaik, B.S.R. 2014. Species Diversity of Lake Hawasa, Ethiopia: International Journal of Scientific research: **3**(1): 33-35: November 2014 • DOI : 10.15373/22778179

Pattnaik, B.S.R. 2016. "Environmental impacts on Ecology and Species diversity of Lake Chilika -a Retrospective": Life Sciences International Research Journal : Volume 3 || Issue 2: ISSN 2347-8691|

Roessig JM, Woodley CM, Cech JJ, Hansen LJ. 2004. Effects of global climate change on marine and estuarine fishes and fisheries. *Reviews in Fish Biology and Fisheries.* 14(2):251-275.

Rosenzweig C, Karoly D, Vicarelli M, et al. 2008. Attributing physical and biological impacts to anthropogenic climate change. *Nature*. 2008;453:353-357 .

Susan Solomon susan.solomon@noaa.gov, Gian-Kasper Plattner, Reto Knutti,and Pierre Friedling stein. 2009. "Irreversible climate change due to carbon dioxide emissions": Environmental sciences: **106** (6) 1704-1709 https://doi.org/10.1073/pnas.0812721106

Urama, K. C. and Ozor, N. 2010. Impacts of climate change on water resources in Africa: the Role of Adaptation. Available at http://www.ourplanet.com/climate-adaptation

Watson RT, Zinyowera MC, Moss RH, Dokken DJ. IPCC Special Report:2021. The Regional Impacts of Climate Change: An Assessment of Vulnerability. United Nations: IPCC; 2001.

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