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Review of the progress, limitations and future expectations of climate smart agriculture (CSA) of the fishery sector in Nigeria

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Abstract

The incessant pollution and release of greenhouse gases (GHGs) into the atmosphere is the main contributor to the changing climate due to their ozone depleting activities, thus allowing the passage of harmful infra-red rays to warm up the earth's surface. Records show an increasing rise in global warming of the earth of roughly 1°C which thus affects all and sundry. Many agricultural activities have been affected by this warming up and not excluded is the fishery sector. The fishery sector is one of the booming industries in Nigeria with a contributing annual GDP of 624,791.738 NGN mn in 2017^[13]. It provides a source of high quality protein as well as employment and income to fish farmers and processors. However, with the increasing warming of the earth, this sector has been greatly affected, not only in Nigeria but the whole world, as oceans, inland bodies and their aquatic inhabitants are being affected by the ozone depleting activities of man. Thus, the need for improved and modern fishery/aquaculture techniques to adapt to the changing climate as well as reduce the release of GHGs from processing activities, into the atmosphere is on the rise; with farmers and scientists alike working around the clock to ensure cleaner and more efficient methods of processing fish in Nigeria.

Keywords: climate smart agriculture, fishery; climate change, Nigeria's fishery sector; aquaculture

1. Introduction

The increasing supply of greenhouse gases (GHGs) to the ecosystem over the past decades, has led to the consequent warming of the Earth, as these greenhouse gases have helped in puncturing/displacing the Earth's ozone layer. This led to the entry of harmful infra-red radiations from the sun into the Earth which thus resulted in the well-known global warming. The subsequent warming of the Earth led to the unfavourable climatic changes predominant everywhere today. According to the Intergovernmental Panel on Climate Change^[8], there are three major ways global warming has been accredited to make changes on the climate. They include the melting or forming of ice; change in the hydrological cycle; deviation in the ocean currents and air flow systems of the atmosphere. The coastal regions are also severely affected due to rise in sea level.

The National Oceanographic and Atmospheric Administration (NOAA) alongside the National Aeronautics and Space Administration (NASA) recorded 2018 as the fourth hottest year ever documented. The temperatures are speculated to increase in the coming years and according to NASA, temperature will increase up to 5.8°C in the year 2100^[10] if this problem is not curbed on time.

There are numerous causes of this global warming and thus the decisive changes in climate. Majority of these causes are man-made. They range from fossil burning and production of carbon monoxide from engine exhausts to deforestation and bush burning. Climate change maybe defined however, as the significant and lasting change in the statistical patterns of weather (precipitation, temperature, wind, humidity) and seasons over a periodical range of decades to millennia^[14].

These climatic conditions are closely linked to the growth and yield of agriculture and the undesirable impacts in climate change has shown negative effects and limitations on agriculture. High temperatures scorch up crops, leading to low yields, proliferation of weeds and pests while making breeding difficult in animals^[14]. This invariably has led to the high levels of food insecurity in many countries most especially the developing and underdeveloped

regions which are unable to control these climatic factors to suit their agricultural requirements.

Thus, 2010 witnessed the introduction of the Climate Smart Agriculture Scheme by the Food and Agriculture Organization as one of its 14 themes in support of global sustainable development [14]. It was developed as a unified approach in addressing climate change challenges in the ways it affects agriculture and other human activities. The CSA program was launched in a background paper specially designed for the Hague Conference on Agriculture, Food Security and Climate Change.

Since then, CSA has gained expansive grounds globally. It has three major objectives which frame its whole activities:

1. to sustainably increase food security by increasing agricultural productivity and income;
2. to build resistance and adapt to climate change and;
3. to reduce and/or remove greenhouse gas emissions where possible [4].

Apart from the above objectives, CSA can also profit the government by helping achieve national food security goals and reducing poverty. Climate smart agricultural techniques may vary from diverse farm-level innovations to international policy and finance schemes [4].

Fishery as one of the important sectors in agriculture is also gravely affected by climate change. Thus this research write-up aims at discussing the already known and well-practiced traditional methods of fish farming and processing in Nigeria, as well as the limitations/disadvantages associated with such practices. These orthodox methods are thereafter compared with the latest climate smart techniques employed in the fishery sector. The future expectations in improvement of fishery techniques will also be discussed under this research topic.

Effects of climate change on the fishery sector of Nigeria

Nigeria is the leading consumer of fish in Africa and among the largest fish consumer worldwide with a consumption of more than 1.5million tons annually [24]. Fishery in Nigeria is a very important sector as it takes care of a huge part of the protein source available to Nigerians thus reducing malnutrition and food insecurity. It also contributes to the employment and source of income to fishermen providing an estimate of over 26million people jobs as well as a good source of protein for humans and animals [1]. Apart from the fishing activity, fishery also involves fish processing from its raw state to its finished products. In addition, it closely affects the pharmaceutical and cosmetic sectors.

According to [6], climate change is projected to affect the fishery sector in Nigeria especially in the coastal regions negatively or positively depending on the severity and level of extreme shift in the climatic elements. It could lead to the changing of the composition, production and seasonality of plankton and thus the growth and yield of fish. This is because aquatic bodies directly absorb and store solar heat and so affect the physico-chemical conditions of the cold-blooded fishes [22].

Research has shown that the geographical distribution of fish species around the Lagos lagoon has been affected by climate change resulting in change in habitat size, species diversity and the general productivity of the lagoon [22]. In addition to increased precipitation and temperature change as the inevitable causes of climate change, research has stated that changes in sea level, land-based runoff and increased

frequency of storms which hereby threaten coastal infrastructure, aquatic farms, ship ports and homes are bound to occur thereby [29].

Elevated water temperatures according to research have shown to affect the physiological processes of fish thus affecting spawning, survival of juveniles, fish population growth, production and yield. The increased flooding of freshwater bodies led to erosion which destroy fish breeding and feeding habitats and decrease general productivity. On the other hand, flooding could have positive impacts on water bodies during the dry seasons. The oceans and marine water bodies are natural carbon sinks and have removed about 25% of the CO₂ produced by human activities between 2000 and 2007. However, rising ocean temperatures and ocean acidification weakens the ocean's carbon sink abilities [28].

Thus the decrease in fish production and yield due to climate change also conclusively affects the livelihood of many people involved in this business sector as well as affect the nutrition of both humans and animals.

Progress and future expectations of climate smart agricultural production of fish in nigeria

As the earth consistently gets warmer, many countries including Nigeria are subsequently devising means of adapting to the harsh climatic conditions. In all economic sectors, techniques and infrastructure are being put in place to check-mate climate change and thus make survival and production easier.

Several international agencies such as the World Bank and the Food and Agriculture Organization (FAO), have developed programs to help countries adapt to global warming by initiating certain policies and techniques to address this issue. They achieve this by policies that improve the resilience of natural resources, increasing awareness of climate change impacts and strengthening key institutions such as the forecasting of weather and early warning systems [5].

In the fisheries sector alone, according to the Intergovernmental Panel on Climate Change (IPCC), the carbon dioxide emitted from the harvesting and shipping of fish and processing of fish products is estimated at 0.05Gt year⁻¹ with Africa producing 3.6% of the world's CO₂ emissions [9]. Though, this is not a major GHGs production sector, taking into consideration the objectives of Climate Smart Agriculture, efforts are being made to ensure aquaculture help mitigate GHG emissions.

Thus, in Nigeria, numerous agricultural techniques have been implemented to reduce the contributions fishery and aquaculture may have on the rising greenhouse gas emissions. As well as adapt to climate change impacts and ensure increased production to combat food insecurity and seasonality. Some ways these have been achieved are briefly discussed below.

Fish processing and preservation

Fish is a very perishable agricultural product and due to poor handling after harvest, 30-50% of fishes, according to research, are wasted in Nigeria [2]. Most fish farmers during and after harvest; leave the caught fish in their boats unprotected from dirt, heat and contaminated water. As soon as a fish dies, physiological and microbial activities increase on the flesh of the fish leading to deterioration and consequent spoilage [27]. Thus, fish processing and preservation is very crucial in preserving the quality of fish, from the immediate simple washing and chilling done after harvest to the other

more complicated and efficient processing/preservation methods. Various methods have been employed in Nigeria to preserve fish quality and storage life such as smoking, drying, freezing, brining and chilling. The most prominent method employed in most parts of Nigeria is the smoking of fish. The unavailability of electricity in many parts of the country for freezing/chilling of fish is a major reason why fish smoking and sun drying are primarily employed [3]. These two drying methods will be discussed in this write-up as they are major contributors to GHGs in the atmosphere as well as cause other health implications.

Smoking method: Fish are smoked after harvest to reduce the moisture content and water available in the fish for microbial activity and spoilage. This helps in increasing the shelf life and quality of fish. Smoking of fish is the most common method of reducing water activity in fish and is the most popular method of preserving fish in Nigeria. According to studies [2], over 70% of harvested fish are smoked as a way of preservation. It is usually performed by the rural fisher women making it a gender selective post-harvest activity [6]. It is carried out in smoking kilns of different makes and sizes, which range from those of small capacities to larger ones. The fish after harvest, are washed, degutted, salted and spiced, then smoked in kilns or open smoking racks. Plate 1 shows a traditional smoking kiln.



Plate 1: A typical traditional smoking kiln used in Nigeria (sourced from internet)

Although, smoking increases the value of fish because of the desirable taste smoke adds to the fish, it is a major contributor to GHG emission [21]. This is because the wood burnt during this process, releases carbon gases to the atmosphere. Research have also shown that smoked fish contain some polycyclic aromatic hydrocarbons which exceed the EU recommended maximum permissible level of 5.0µg/kg for benzol(α)pyrene as well as microbial contaminations due to poor handling and processing techniques [11]. Many of these PAHs and their alkylated derivatives are carcinogenic and thus pose health issues when consumed [26]. Smoking also involves felling of trees which are major carbon sinks, for use as fuel. This is a major cause of desertification.

Traditional Sun Drying method: On the other hand, sun drying of fish involves gutting and salting of fish then spreading on roofs, exposed mats or tables made for this purpose to dry under the sun. This traditional method is the

most simple, cheapest and most convenient method of preserving fish and thus widely practiced in many fishing villages [18]. The heat radiation from the sun is transferred to the fish which shrinks the fish removing excessive moisture and making it undergo irreversible changes [2]. Although traditional sun drying method is not a major contributor to the atmospheric GHGs emitted, it is not a hygienic process either as fish are exposed to blowflies, dirt and other contaminants which are harmful to human health [21].

To combat the limitations characterized with traditional smoking and sun drying process, improvements have been made to reduce the amounts of GHGs produced during smoking as well as reduce exposure of fish to contaminants, carcinogenic substances and increase yields of dried fish produced. Some of the improved techniques are enumerated below:

- **The Mechanical Smoking Method:** as smoke fish and meat products are highly cherished and valued, eradicating smoking of fish completely will be difficult. Smoked fish are necessary for many delicacies around the world. Thus, the introduction of the mechanical smoking method. This smoking technique involves the use of computerized programs in regulating the amount of smoke infused into the fish. The smoke is generated with the use of smoke condensates which are produced by industrially converting smoke into solid or liquid forms [25]. This method makes use of a laminar air-flow technology and micro-processors thus increasing production rates and sensor coverage in the smoking kiln respectively [25]. Thus, fish are not exposed long to the smoke unlike in the traditional method and greenhouse gas emissions into the environment are reduced. However, this method has not been introduced into Nigeria, it is a modern technology Nigerian government and fishing industries should look into.
- **Solar Tent Dryer:** the traditional sun drying method was improved upon to address the limitations involved with traditional solar drying in Nigeria by Olorok [20]. It involves the use of greenhouse energy to remove moisture from fish under hygienic processing conditions. Plate 2 shows a solar tent dryer and the technique involved in the drying process. This method has greatly contributed to the improvements of fish processing in Nigeria as well as mitigating against GHGs emission from burning of wood during fish smoking [21].

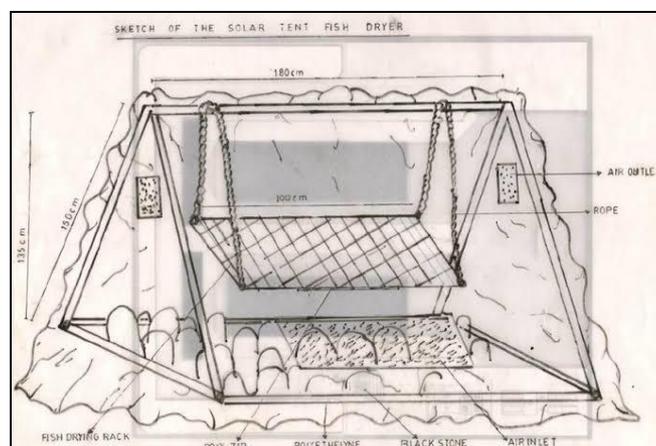


Plate 2: Solar tent dryer developed by Olorok [20]

Fish Cultivation

Artisanal fisheries accounts for more than 80% of fish

production in Nigeria and makes up about 30% of the Nation's and many other developing country's GDP ^[12]. However, artisanal fishery is very prone to the negative effects climate changes pose to this sector. The growth, reproduction and hatching of fish in the wild cannot be controlled, thus the yields of wild fish harvested annually is on the decline. To combat this problem, more effort has been directed at the improvement of aquaculture in Nigeria, thus giving fish farmers the opportunity to influence the environmental conditions of fish ponds and habitats. Aquaculture which is the science of controlling the rearing and production of fish in ponds and farms under controlled environment till maturity and harvest, has been greatly improved since its introduction over 50 years ago to negate the effects climate change in Nigeria ^[19].

Aquaculture has the following benefits over capture wild fisheries:

- It provides an all year round availability of fish which do not need to be dependent on seasonality or climatic conditions
- It also reduces over dependence on the fishes grown in the wild thus reducing over fishing of natural water bodies. This gives room for increased growth of wild fishes and prevents species extinction.
- Culture fisheries or aquaculture also reduces the over dependence of fish farmers on trawlers and other fishing boats which burn fuels and produce carbon monoxide into the environment as cultivated fishes are easily harvested by draining the ponds or with the use of large nets.
- It cultivates a healthy fish environment which has little exposure to negative climatic effects.
- In algae aquaculture which involves the production of algae, it contributes to the production of fossil fuels from the processing of algae.
- Aquaculture also increases the GDP of the country as well as employment opportunities.
- With the discovery and development of silvoaquaculture which is the system of cultivating trees alongside aquatic organisms ^[15], trees have been employed directly as carbon sinks as well as aerating the soil of ponds, providing shade for aquatic organisms and providing certain nutrients for fish.
- Livestock integrated fish farming is a modern system of cultivating livestock e.g. cattle, sheep, goats, poultry, pigs or rabbits with fish. This method is designed in such a way that the wastes of livestock animals are efficiently introduced into fish ponds to fertilize the pond and thus increase growth of phytoplankton in the water ^[17]. This method efficiently uses up wastes from farm animals, reduces application of inorganic fertilizers, reduces cost of feeding fish as well as reduces the carbon emissions from the decomposition of organic waste materials as the phytoplankton uses them to grow and produce oxygen into the atmosphere.
- The integration of selective crop farming with fish cultivation is also another benefit derived from aquaculture which is not easily achievable with wild fisheries. In Nigeria, fish farmers are cultivating several crops such as rice, millet, some vegetables etc. with the waste water flushed out of fish ponds. In some instances like in the cultivation of rice which require flooded regions, farmers cultivate selected fish species (e.g. *Clarias*) in the flooded rice plains ^[16]. In this system, the

fish eat up the weeds hindering the growth of the rice plants and grains of rice which fall off during harvesting act as complimentary food for the fish.

- Aquaculture has also made it possible for fish species to breed under controlled environment instead of being dependent and under the influence of climate change and global warming which affect spawning in fish.
- Futuristic efforts are being made to cross out some weak strains in fish species so as to produce fishes with better capacity to withstand the increasing warming of the earth
- Aquaculture has also enabled fish farmers to recycle waste fish water by treatment and other cleaning processes. This also ensures that excess or wastewater expelled from fish ponds do not pose environmental threats and pollution to the environment ^[23].

It is expected that aquaculture will continue to progress in Nigeria with the support of the government in training fish scientists and farmers alike on modern fishery techniques employed in culture fisheries. This can be achieved by investing more in research as well as inviting fish scientists and farmers who have efficiently improved on their aquaculture techniques to train indigenous fish farmers.

Conclusion

Climate-smart Agriculture in the fishery sector, has been widely practiced and developed in Nigeria, cutting across all the areas associated with both capture and culture fisheries and thus achieving the major objectives of the CSA program: increasing yield, GHGs mitigation, and agriculture resilience to climate change. Nigeria has so far shown an impressive development in the area of improving her fishery sector in the face of global warming and climate change and increased efforts are being made in improving the existing fishery technologies. Although, many of the traditional fishery activities especially in the areas of fish processing and which cause harm to the ecosystem are still being practiced; the fish farming communities are quickly becoming hyper-aware of the dangers of GHGs emission to the environment and are thus improving on the orthodox techniques to better combat climate change and increase their productivity.

On the other hand, the government apart from providing trainings and research grants should help boost CSA in fishery by making the essential materials and resources required for improved fishery for farmers as well as reduce taxes on small scale fish businesses.

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