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Optimizing Climate-Smart Aquaculture for Sustainable Catfish Production in Nigeria

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Abstract
Food security is a major developmental issue in Africa; it has a huge social and economic effect on people. In Nigeria, the population explosion has contributed to food and nutritional insecurity; protein consumption is grossly insufficient in the diet of a larger percentage of the population. The availability and heightened cost of protein-rich food has been attributed to the incidence of climate change. Climate change is fast affecting the aquaculture industry in Nigeria, especially catfish production which accounts for over 70% of cultured fish. This study used Narrative Inquiry technique comprising of taking key extract from published literature as well as information from popular articled to identify and describe Climate Smart Aquaculture (CSAq) and adaptation practices to ensure sustainable production of catfish in Nigeria. The paper indicated that changing weather pattern tends to affect the biology of the catfish, leading to reduced growth, poor feed conversion, and incidence of new diseases. The adaptation measures include: the use of Best Management Practices (BMPs) in fish farming; the adjustment of pond stocking time; the use of PVC materials for rearing fish; planting of trees around pond areas for shade and increasing the fish stocking rate during the rainy season among others. Increased capacity-building efforts for fish farmers on climate change adaptation practices would play a key role. Research effort to develop catfish breed with tolerant traits to adverse pond water conditions is also important.

Keywords: Optimizing, Climate- Smart Aquaculture (CSAq), African catfish, Nigeria.

Introduction

Climate change is the long-term shift in temperature and weather patterns. (Un.org). This comes about as a result of multi-faced and decadal trend of ocean warning and the significant spike in global means sea level at such a rate that is more than double, over the last century, due to ice and glazier melting at global scale (FAO, 2020). Some of the major biophysical changes resulting from the ocean warning include: ocean currents, rising sea levels, higher river flows, changes in lake level and thermal structure. Others are storm severity and frequency, acidification, and flooding. All these come with their attendant effects on fish production, ecology and biodiversity, aquaculture, people's livelihood and, generally, people's socio-economic status. Badjeck, *et al*. (2010). The warmer temperature also affects fish physiology, which in turns, impacts on breeding, survival, growth health and fish yields.

The huge impact of the changes in various weather element and the outcome of the sector has taken the focus of research and development experts away from the increasing productivity of the sector to ensuring resilience of production as well as development of new technologies to ensure adaptation to the various changes. The need for adaptation as well as mitigation of climate change is not limited to the agricultural sector alone but also the fisheries and aquaculture sector. The contribution of the fisheries and aquaculture to the climate change is not well documented, albeit the scanty evidence rather pointed at the potentials of water bodies as mitigation materials for climate change. The sea is reported to absorb

over 90% of the excess heat generated due to climate change; same way up to 23% of the CO_2 emission is absorbed by the sea. While the water bodies are very useful instrument for trapping CO2 and heat absorptions, their native ecological functions is affected by climate change. The health of the water bodies is vital to its capacity to sustain the production of fishes and other sea foods. Recent assessment suggest a reduction in the production capacity of freshwater fisheries due to the incidence of climate change; apparently absorption of heat and subsequent drying of the rivers, pond etc could have effect on acidity, oxygen content and dissolved solids. These measures will have effect on the growth and well being of the aquaculture enterprise. It is imperative to understand the cause and effect of the changing climate on the aquaculture to devise targeted adaptation and optimize the known mitigation functions. This will necessitate the development of the Climate Smart Aquaculture (CSAq) as a specialized research and development instrument to support the important sector.
This paper used the Narrative Inquiry style to document the various information in published and popular articled on how to optimize the CSAq for catfish production in Nigeria.

Aquaculture in Nigeria
Nigeria is the world's largest producer of African Catfish; it is estimated that 1,260,000 tons was produced in 2019. In sub-Saharan Africa, it is the largest fish producer, next to Egypt on the continent. However, there has been a sharp decline of about 9.6 percent in the production since 2016. (FAO, 2022). This may not be unconnected with negative climate impacts in the industry.

Food security and fish production
Food security is a burning issue in Africa, this is, majorly, so due to the ever increasing Nigerian population in the continent. With reference to Nigeria in particular, over 19.4 million, out of the more than 2.0 million people would face a food crisis by August 2022. (FAO, 2022). The country is the leading producer of farmed fish in Sub Saharan Africa (FAO, 2019) The country is projected, to produce 10,041,100 tons of fish (fisheries and aquaculture) by 2030. This represents third best in Africa next to Egypt and Morocco. Fish consumption has risen globally to about 17% of animal protein, with potentials for growth owing to awareness of healthy diet. An additional reason is its preferrence as part of local and traditional recipes (FAO, 2018). Mostly, in less developed countries, (LCD) in which African countries come under, fish consumption in 2015, accounted for about 26% percent of animal intake.

Description of African catfish, C*larias gariepinus*, (Burchell,1822) (Plate 1)
African catfish, *Clarias gariepinus,* is considered to be popular in Africa in general and specifically, the most cultured freshwater fish species in many West African basins. The fish is eel shaped having a cylindrical body with dorsal and anal fins running from head region to the caudal fin, both fins are soft rayed. The head is dorso-ventrally flattened and highly ossified, the upper side of the fish is darkly colored, while the underneath is lighter. They possess four pairs of unbranched barbels: one nasal, one maxilla on the vomer and two mandibular, the former are the longest and most mobile. The barbels are very sensitive, they help the fish in detecting prey, (Gertjan and Janseen,1996). In addition, the fish possesses accessory respiratory organ which assists it to make use of atmospheric oxygen apart from having gills. Thus, the fish can survive for many hours outside water or muddy area. The fish is omnivorous feeding on a wide variety of foods: both plants and animal sources, including insects.
The fish is the most consumed one, among many other freshwater species in the country. This is an addition to its being a substantial trade in smoked fish to neighboring countries and Nigerians in United States, Europe and Middle East. Nigerian's aquaculture production has grown from 22,000 tons in 1999 to over 300,000 in 2017 (FAO, 2017).

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The industry is worth today, ₦ 261.8 billion (FAO, FISH 4 ACP). Fish make up over 40% of Nigerian's protein consumption with per capita fish consumption at 13.3kg per year. Millions of people are gainfully employed along the fish value chain. (plate2)
However, the climate change effects post a great risk to the sustainability of this feat and the overall livelihood of Nigeria populace.

Plate 1: Cluster of African Catfish, Clarias gariepinus in Nigeria
Source: Field Survey (2019)

Plate 2: Fish oven (Value addition in African Catfish, *Clarias gariepinus)* in Nigeria.
Source: Field Survey: 2019

Climate Smart Aquaculture (CSAq)
Climate change is a global phenomenon. Variations and erratic occurrence of temperatures, precipitations, sea level and other weather element readings have, a potentially, positive, and negative

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effects on aquaculture. The negative effects outweigh the positive ones, FAO (2019). Moreover, ability to adapt to this climate induced changes is slow in developing countries. Nigeria is not excluded (Emmanuel, et al.,2009). For instance, no fewer than 200 fish farmers, reportedly lost over #500m, equivalent to over 1millon USD, to flood in Ogun State, Southwest, Nigeria. (Olatunji,2022," Flood Ravaged Ogun Fish Farmers" Significant changes in the country's climatic elements have been captured, notably, precipitation and temperature hikes (Imoleayo, et al.,2019). Extreme weather and climate patterns have been reported in many parts of Nigeria, Abatan, et al. (2016,2017) found out that a significant increase in temperature occurred during the dry period in the country. In Figure 1, the Nigerian Emergency Meteorological Agency, (NEMA), in its August 2022 Annual Flood Outlook report, indicated that 233 local government areas, in 33 out 36 states of the country were prone to flooding during the year, Njoku et al., (2020) also mapped out the flood prone locations in the country base on geospatial date into high, medium and low prone areas.

Climate Smart Aquaculture (CSAq) is the aquaculture variant of the well pronounced Climate Smart Agriculture (CSA) which according to Ajayi MT, *et al* (2020), aligns with the main goal of food security and development in a climate adaptable context. Just as the CSA relies on three pillars viz., sustainable productivity increase, improved adaptation, and mitigation of the cause and effects of the climate change. The CSAq is also built on the same pillars while it produces food in water or aquatic environment. As reported by FAO (2018), CSA principles helps farmers adapt to changing climatic conditions; improve food security, enhance income and contribute to sustainable livelihood and economic growth through adaptation and mitigation methods. CSAq requires the following:

- Improving efficiency in the use of natural resources to produce fish and aquatic foods.
- Manufacturing the resilience aquatic systems and the communities that rely on them, to allow the sector to continue contributing to sustainable development goals. (Plate 4)
- Gaining an understanding the ways to reduce effectively the vulnerabilities of this likely to negatively impacted by climate change Onada and Ogunola (2016)

Plate 3: Compact water re-use system in fish breeding aquaculture in Nigeria an Adaptation method for conserving water in CSAq . Source: Field Survey.

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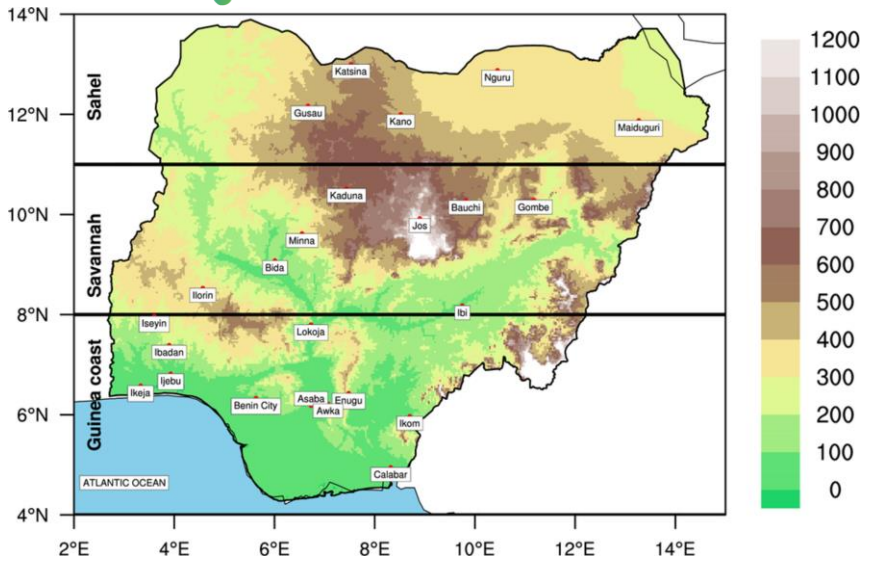

Figure 1. Climatic zones and different elevation in Nigeria (Source: Gbode et al, 2019)

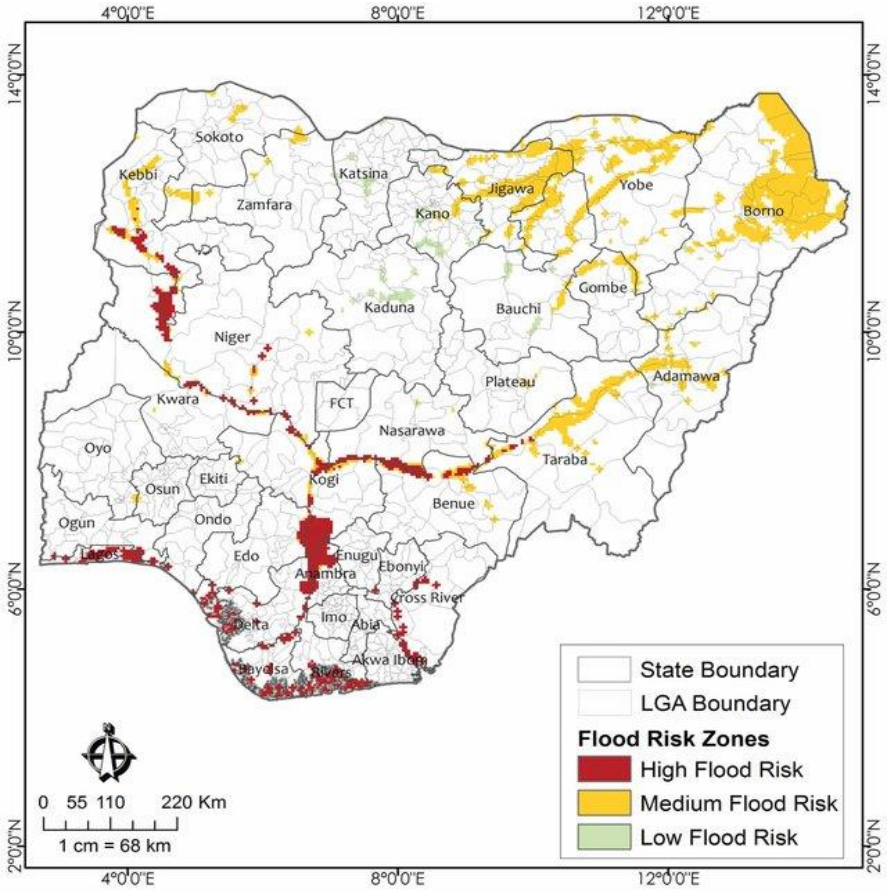

Figure 1b. Flood-risk map of Nigeria showing vulnerable States and LGAs

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Impacts of CSA on Fisheries and Aquaculture.

Basically, climate change arises from global warming, which has serious biophysical changes and its effects is felt on: production ecology and biodiversity, fishing, aquaculture and associated post-harvest operations, communities and livelihoods, and wider society and economy. (Bardjeck, et al 2010) Fig.2

There are many potential impacts of CSA on fisheries and aquaculture, these are:

- Species composition.
- Reduced production and yield.
- Increased yield variability.
- Diseases
- Coral bleaching
- Calcification

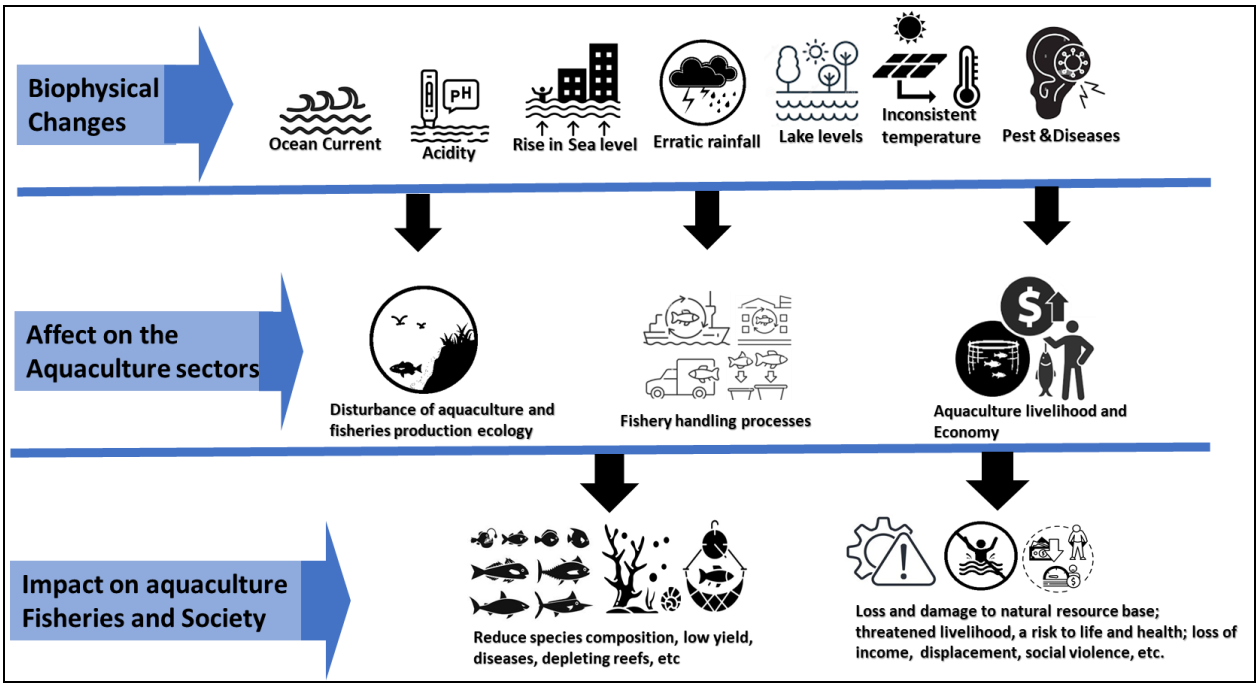

Figure 2. Graphical presentation of typical effect of change on aquaculture

Impacts of CSA on food security

Climate change has a high level of negative impacts on food security, some of them include, but not limited to, the following:

- Aquatic food availability. This is because there would be changes in habitats, stocks and species distribution.
- Fish food supply will be greatly hampered, changing the supply chain and corresponding price hikes.
- Accessibility of aquatic food will be negatively impacted, creating a shift to other substitutes, the resources are, thus stressed.

- There will be changes in utilization of aquatic products and by products. Thereby, limiting usage, purchasing and preference for a particular food item.

Adaptation strategies

Addressing drivers of vulnerability:

- Diversify sources of household income
- Participate in income stabilization programmes
- Introduce social protection initiatives
- Promote community-based risk management measures to face production failure and price of product
- Develop innovative risk financing instruments and insurance schemes to reduce climate-related risks

Building response capacity

- Conservation of genetic resources
- Implement co-management systems, managing climate risk
- Disaster risk reduction.
- Disaster risk management (Onada and Ogunola 2016)

Optimizing techniques for climate- smart aquaculture

- Provision of advanced meteorological information to fish farms via the mobile device
- Creating updates about possible risks/ dangers associated with climate change on farmers' mobile devices and media houses on an hourly basis in simple languages that the farmers understand.
- Farmers should be encouraged to have basic, simple, handy, equipment on their fish farms to monitor physico-chemical parameters of water in their farms. For instance, thermometer and Ph meters are very important.
- Weather elements readings and interpretations should be made available to fish farmers.
- Involving certified structural engineers, and environmentalist before embarking on fish farm construction. This would safeguard installations of deficient structures, and collapse of such facilities and subsequent fish losses.
- Conducting environmental impact assessments before commencing construction works on aquaculture facilities design and construction.
- Adequate insurance provision should be made by farms for their fishes in case an hazard occurs.
- Farmers should be informed/educated about the cause-and-effect phenomena associated with operation in the design of farm facilities.
- During rainy season, fish farmers should be cautious, when stocking their ponds.
- At the dry season, water budget analysis should be done by farmers before stocking their pond with fish.
- Safety measures should be put in place by farmers on their fishponds.
- Adequate funds in forms of loans, grants and credit facilities should by produced by government to fish farmers. This would serve as a shock absorber when crisis hit the farmers (FAO, 2019).
- Integrated fish farming system (IFFS) should always be adopted by fish farmers. This will guard against all fish failure in case of any climate related hazards. For instance, when fish farming cum crop production is practiced by a farmer, insufficient water for fish may be enough for crop production in irrigation farming. Another example is fish farming cum poultry production. During an acute dry season, when there is water shortage, farmers may diversify into poultry production.
- Use of water Re-use System of Aquaculture should be adopted by fish farmers during dry season. (Plate 4)

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Plate 1: Dug out pond with plastic under lay to reduce water loss during dry season in Rwanda. An adaptation technique in CSA. Source: Field survey 2016

Conclusion

Climate change has a far more deleterious effects on aquaculture, and ultimately on the people. In Nigeria, catfish, being the most preferred fish for culture and a major source of protein, is at risk. Providing an urgent solution to the lingering food crisis in the country, occasioned by myriads of challenges like recession, banditry and climate shift is a thing that requires an immediate attention. In order to achieve this, optimizing various techniques of CSA is necessary so as to achieve the needed results.

Recommendation

Sustainable catfish production in Nigeria in the face of climate vagaries entails a multifaceted approach at ensuring greater success among fish farmers when scaling up the climate resilient actions in aquaculture. This means government agencies, financial institutions, insurance brokers, telecom providers, media houses, structural engineers and ultimately, the farmers must be involved in the planning and execution of the CSA optimization techniques of catfish production in the country.

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