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Climate Smart Aquaculture for Poverty Alleviation

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Abstract **Review Article**

Climate change is one of the main obstacles to ensuring food security and it is crucial to know how the effects of climate change will affect the world's agricultural industry. Climate may change as a result of biological, geographical, and human forces (anthropogenic), Astronomical phenomena, alien influences, and volcanic eruptions are examples of nature activities. Aquaculture system ensure continuous yield of seafood product. For aquacultures to achieve success, aquaculture practice must be supported by climate smart innovation to achieve sustainable production, alleviate poverty, achieve climate resilience and food security, the government and other stakeholders should adopt climate smart fish farming and strictly adapt to the measures to mitigate climate change effects. This Review highlight the importance of climate smart aquaculture as solution to ensure food security and eradicate poverty.

Keywords: Climate change, Climate smart-aquaculture, Adaptation, Mitigation, poverty alleviation.

INTRODUCTION

One of the main obstacles to ensuring food security is to know how the effects of climate change will affect the world's agricultural industry (Spradlin, & Saha, 2022). Aquaculture system ensure continuous yield of seafood product. Meanwhile, due to the unsuitable methods of harvesting of seafoods from the wild, aquaculture is regarded as the best approach to catch on with the high quest for aquaculture produce in the world. Based on the report of Maulu, *et al*., (2021) the percentage contributed from aquaculture to the world fisheries produce keep rising and attaining 82, 1 million tons (46%) from the forecasted 179 million tons of the world yield. Additionally, the culture of fish and shellfish quota in the world fish yield is predicted to increase from 46 to 53% in the year 2030(Maula, *et al*., 2021). Climate change is described as disparity that takes place in data division of temperature across prolonged time, commonly differs by period to numerous of years (Maula, *et al*., 2021). The occurrence of climate change leads to rise in unfavorable consequences with increased dimension due to outcome of deliberate and accidental effects of abiotic pressure that took place from continuous logging and depletion of natural gas, Carbon-dioxide rate increased from 280 µmol−1 to 400 µmol−1 in the atmosphere. Prediction of carbon-dioxide continuously increased till the figure is duplicated, that is up to 800 µmol−1 close to the end of century (Ogunkalu, O. 2021). The effects of GHG buildup in the airspace and water connected in climatic variables, such as slow changes ocean temperature, acidified ocean environment, modification of ocean tides, and high tides in sea levels. This natural modifications have impacts on the prevalence, severity, and position of utmost temperature incidents likewise as biological processes within marine structure (Ahmed, & Solomon, 2016). Climate may change as a result of biological, geographical, and human forces (anthropogenic). Astronomical phenomena, alien influences, and volcanic eruptions are examples of nature activities. The continental structures, modification in the obliquity of the ecliptic plane, changes in orbital cycle, and changes in the eccentricity of the earth's orbit are all examples of astronomical factors. Solar radiation volume and standard are examples of extraterrestrial factors. Meanwhile, the anthropogenic factor in climatic alterations refers to people inter-reaction that either reduce the amount of carbons absorbed from the atmosphere or discharge larger quantity of greenhouse gases (GHG), such as carbon (IV) oxide (CO2), methane (CH4), chlorofluorocarbons (CFCs), and nitrous oxide (N_2O), into the atmosphere (Ahmed & Solomon 2016).

Effects of Climate Change on Aquaculture and Fisheries

Aquatic habitats are being drastically impacted by increased ocean temperature and ocean acidification. Fish disbursement and maritime capacity are changing due to climate change. Aquatic organisms in freshwater,

likewise. This has an effect on the ability of the seas to trap and store carbon, the viability of seafood and aquaculture, the lives of populations that relied on fisheries, and (biological pump). Coastal fishing communities are on the front lines of climate change due to sea level increased, while inland (freshwater) fisheries and aquaculture are impacted by shifting rainfall patterns and water use. Fisheries and aquaculture solely relied on healthy aquatic ecosystems and provide a substantial contribution to food security and livelihoods, yet these realities are frequently overlooked and underestimated (khoshnevis & Shakouri, 2010). Also, Increased ocean acidic level affected the calcification process which gives marine animals like corals, shrimp, and oysters their shells—more challenging. Many significant creatures have calcium shells, including zooplankton, which forms the basis of the marine food chain. As a result, there are "cracks in the food chain" and this resulted in alteration in the whole marine food web (khoshnevis & Shakouri, 2010). Also, Diseases like bacterial, parasite infection, viral and fungal infection, all these together could occur as a result of rise in water temperature, when thermal fluctuation occurs in water body the aquatic organisms are vulnerable to diseases and the condition of water body could later advance to exotic diseases (Collins, *et al*., 2020). Climate change, like many other concurrent stressors such as overfishing, habitat degradation, pollution, the introduction of new species, and so on, poses serious dangers to fisheries. It has both direct and indirect effects on fish stocks because they are very vulnerable to biotic and abiotic stress, which directly alter swimming behavior, physiology, and growth, reproductive capability, mortality, and distribution pattern. The indirect impacts are also negative, since the structure, productivity, and composition of the aquaculture ecosystems on which fish rely for food are altered. The spawning season is linked to the rainfall pattern, and climate change has affected the breeding seasons of fish such as Indian big carp (Rasal, *et al*., 2023).

Climate-Smart Aquaculture (CSA)

Considering the potential for mitigation as well as the necessity for application of adapting techniques, climate-smart aquaculture focusses on enhancement of food security. The issues of creating synergies between the associated goals of reducing climate change impacts, adapting to them, and increasing production and income are managed by CSA, along with the possible drawbacks of doing so. Aquaculture that is climate-smart will require the factors below:

- Increasing the efficiency with which nature assets are used to generate fish and aquatic foods.
- Ensuring that aquatic ecosystems are resilient, as well as the communities who depend on them, so that the sector may continue to contribute to sustenance of development; and
- Learning how to effectively lessen the susceptibility of individuals who are possible to suffer from the effects of climate change (Ahmed & Solomon 2016).

Climate Resilience in Aquaculture

Diversifying the sector with climate resilient species and varieties that are suitable for aquaculture is an action related in focusing on climate-smart aquaculture into practice. The investigation of fish that are climate resilient for aquaculture may involve optimizing currently cultivated species, developing sustainable choices for novel species, and assessing the socio-ecological effects. A variety of air-breathing fish that are better able to endure many of the anticipated consequences of climate change, such as rising water temperatures and lower water quality, are among the climate resilient species being studied by the Aqua Fish.

Adaptation Strategies

Adaptation can be described as activities aimed at "reduction of human susceptibility or nature process to the effects of climate change and climate-linked threat by maintenance or increase in the adaptation ability and resilience of the structure". Adaptive approaches tackling drivers of susceptibility (Ahmed & Solomon 2016). Adaptive approaches are as follows:

- Diversification of household income origin
- Involvement in income stability programs

Introducing social protection initiatives

- Implementing community-based risk management measures to address production losses and product prices Facilitation
- Developing innovative risk financing instruments
- Building resilience capacity
- Conserving genetic resource
- Implementing co-management systems
- Addressing climate risk
- Reducing tragedy risk
- Tragedy risk management

In Africa, aquaculture practitioners are particularly vulnerable to climate change, which can lead to reduced production and loss of gain (Oyebola and Fada 2017; Oyebola *et al*., 2018). Adaptation measures must be taken to manage the risks of climate change if aquaculture is to maximize profits and meet the continent's burgeoning demand for fish. The concept of adaptation helps fish farmers understand how they can react to occurrence of climate change or projected climate risks while maintaining and developing capacities that enable them to take advantage of new opportunities (Solomon, *et al*., 2007). According to Rasal, *et al*., (2023). One of the ways to adapt to climate change was seen in AquaBounty Technologies, a biotechnology business located in Maynard, Massachusetts, they employed a land-based farm or

recirculating aquaculture method to raise the fish. In comparison to traditional sea-cage farming, they are rearing healthy salmon that is free of antibiotics and other toxins, resulting in a lower carbon footprint and no danger of contamination to marine habitats (https://aquabounty.com/our-farms). According to Adhikari, *et al.*, (2018) stated the report of Intergovernmental Panel on Climate Change (IPCC) and Food and Agriculture Organization (FAO), that they may result in global warming, sea level rise, changes in ocean productivity, freshwater scarcity, and more frequent extreme weather events. As a result, climate change may have varying effects on aquaculture based on climatic zones, geographical locations, rearing strategies, and species produced.

Climate change has created two key difficulties for aquaculture. First, the existing fish, which have evolved to the current environmental conditions, may be suboptimal in the future. Because fish are frequently poikilothermic, they may be particularly susceptible to temperature variations. Low temperature sensitivity will be more significant for fish than for cattle and other terrestrial animals as a result. Second, climate change may encourage existing and new epidemics. Three key adaptation techniques have been discovered to deal with the problems. First, overall 'robustness' will become an important attribute in aquaculture, as fish will be less susceptible to present and novel illnesses while living in a broader temperature range. Second, aquaculture operations including input electricity, transportation, and feed production increase greenhouse gas emissions. Aquaculture's influence on climate change will be reduced by selecting for feed efficiency and adopting a breeding aim that reduces greenhouse gas emissions.

Mitigation Strategies

Mitigation helps in reduction of green -house gas emission which involves technological alteration reducing resource inputs and emission per unit of outputs (Ahmed & Solomon 2016). There are three main ways in mitigation of climate change:

- Reduction of emission
- Adoption of enhanced Aquaculture system
- Displacement of emission
- Reduction in post-harvest waste
- Afforestation of mangroves in aquaculture sites

Fish, Aquaculture, and the Security of Food and Nutrition

The global seafoods are increasing in demand for consumption as a result of the combination of populace expansion, industrialization, and increased affluence. Just little profit from harvested seafoods are predicted; The continuous request must be accommodated by aquaculture. The World Bank concluded that the rich countries, where aquaculture production is lucrative, will supply highest quantity in per capita fish supplies, which yielded in expansion of provincial disparity between supply and demand. Meanwhile the global Bank predicted profitable aquaculture in Latin America, consumption is expected to drop down just as demand and consumption increases across Asia. (i.e. exports will increase). The expected decreases in consumption in sub-Saharan Africa, where levels are already low (Kassam, L. 2014).

- About 3 billion populace, benefited from important nourishment of fish (including shellfish), and for 400 million of the world's impoverished, it supplies at least 50% of their animal protein and minerals.
- More than 500 million people nation undergoing development rely on fisheries and aquaculture for their livelihoods, either intentionally or unintentionally.
- With an average yearly growth rate of 7%, aquaculture is recognized as one of the fastest-developed food production structure in the world.
- Fish products account for more than 37% [by volume] of all food trade (khoshnevis & Shakouri, 2010).

Impacts of Aquaculture in Reduction of Poverty

In relation to hunger and poverty, fish and other aquatic farm-raised commodities have the potential to be significant in two main ways. Firstly, fish is nutritionally rich diet that is abundant in vital fatty acids, highly accessible quality protein, and essential amino acids, and micronutrients, which are suggested as a crucial component of a balanced nutrition. Secondly, Fishing's capture, cultivation, and trade all result in jobs and revenue. The FAO has recently estimated that there are between 27 and 57 million all day similar employment associated to aquaculture, with over 75 percent of those occupations being in creation of fish products. The worth of world fish commerce is more than the value of all other animal proteins put together, and it contributes between 0.5 and 2.5% of global gross domestic product (GDP) Because of the aforementioned factors, aquaculture is frequently regarded as an investment that may benefit development, increase food security, reduce poverty, and improve nutrient capacity. Nonetheless, aquaculture has become more widely recognized, the body of information around the direct and indirect effects of aquaculture on the security of food and nutrition and the reduction of poverty in nations undergoing development (Kassam, L. 2014). According to Edwards, P. (2000) Aquaculture improves the livelihoods of the poor by increasing food supply, employment, and income. Many small-scale farmers have modest land holdings in areas of complicated, diversified, and risky agriculture, primarily on the outskirts of lowlands or in uplands. By providing a supply of water, the construction of a pond on these typically ecologically damaged farms may also provide a focal point for agricultural diversity and enhanced sustainability. The impoverished in well-endowed lowlands are frequently landless or near

landless; fish farming in common water bodies may assist to alleviate this situation. poverty, if the poor have access to them. Inland and coastal fishermen are typically landless and among the poorest; their options are primarily limited to water-based culture systems. Although fish supply significantly less animal protein for worldwide nutrition than cattle, people in key portions of Africa and Asia rely heavily on fish as part of their daily diet: fish contribute at least 40% of dietary animal protein in 18 African and Asian countries, nine on each continent. They also supply highly digested energy and are abundant in fat- and water-soluble vitamins, minerals, and fatty acids. Aquaculture has historically contributed to poverty reduction in disadvantaged communities in the few locations of the world where it is practiced. The world Bank (2013) estimated seafood products per capital supply in Sub-Saharan African is possible to reduce by one percent per year, ranging between 6.8 kilogram in the year 2010 to 5.6kg in 2030, the lowest in the world estimated (global average = 18.2 kg). Fish are actively traded in international markets, (FAO, 2012). But given the lack of real price increases and insufficient income growth, the potential for trade to bridge the widening demand-supply gap in the region is unlikely (Béné, *et al*., 2016). Low aquaculture production techniques are being enhanced, reducing the use of increasingly unavailable and high-cost fishmeal and fish oil, (Tacon, & Metian, 2015). And increasing reliance on plant-based feeds to improve the nutritional profile and economic access to farmed seafood. The global food and beverage economy Food security (Belton, & Thilsted, 2014). Also, being a nutritious food, there is little prove that increase in availability to fish is effective or economical in enhancement of individual nutritional outcomes. Asiedu, *et al*., (2018) researched on economic impacts of change on small-scale aquaculture in Ghana and reported that climate change has the capability to drastically reduced the economic worth of aquaculture and thereby leads to poverty majorly in villages.

CONCLUSION

The impacts of climate change are becoming more influential in food production system, Aquaculture stands as a wheels to ensure high fish production for the increasing human population. Climate change is one of the main obstacles to ensuring food security and it is crucial to know how the effects of climate change will affect the world's agricultural industry. For aquacultures to achieve success, aquaculture practice must be supported by climate smart innovation to achieve sustainable production, alleviate poverty, achieve climate resilience and food security, the government and other stakeholders should adopt climate smart fish farming and strictly adapt to the measures to mitigate climate change effects.

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