Adaptation Strategies for Climate- Resistance Aquaculture: Insight from farmed fish

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Abstract:

As global climate change threatens food security, particularly regarding the vital protein source of fish, innovative strategies such as climate smart aquaculture emerge as critical solutions. This approach emphasizes the cultivation of climate-resilient fish species capable of thriving in changing environmental conditions. By integrating air-breathing species like the Pangasius catfish and the Giant Snakehead, aquaculture industries can bolster local economies while mitigating environmental risks. However, successful implementation requires careful consideration of both positive and negative tradeoffs. Challenges such as temperature shifts, ocean acidification, and water scarcity demand adaptive techniques like bio floc technology to maintain water quality and enhance sustainability. Furthermore, indigenous species cultivation

not only supports local communities but also safeguards ecosystems. The development of sustainable aquaculture practices suited to regional needs relies heavily on the collaborative efforts of academic institutions, research organizations, and local stakeholders. Ensuring responsible and inclusive growth in the aquaculture industry requires a thorough understanding of the socio-economic impacts of climate change on aquaculture communities. Overall, climate-resilient aquaculture represents a multifaceted approach to addressing global food security challenges amidst a changing climate landscape. In addition to species diversification, the abstract calls for a comprehensive research agenda focusing on cultivation techniques for new species and the socio-economic ramifications of climate change on aquaculture communities. Collaborative initiatives such as those undertaken by Aqua Fish partners across various institutions underscore the importance of interdisciplinary cooperation in developing sustainable aquaculture practices. The adoption of resilient practices like bio floc technology not only enhances water quality but also promotes ecological balance within aquaculture systems. Moreover, the cultivation of indigenous species not only fosters food security but also preserves cultural heritage and biodiversity. By addressing these multifaceted challenges through innovative approaches and collaborative efforts, climate-resilient aquaculture can play a pivotal role in ensuring food security for the world's growing population amidst changing environmental conditions.

Introduction:

Adapting farmed fish farms to climate resilience for climate-adapted aquaculture is one way to increase food security for the world’s growing population in the changing environment [1]. Being a major source of protein and wealth for people all over the world, the aquaculture industry is growing rapidly and now accounts for almost half of the global fish market. Due to changing global climate and increasing importance of animal protein, there is a need to implement sustainable ecological practices to increase fish production Aquaculture industry can achieve benefit from the achievement of smart climate aquaculture by adopting appropriate management practices. [2].

Increasing weather-resistant crop varieties and strategies—those that can withstand extreme temperatures, impervious environments, and water scarcity—is an important part of this effort. Incorporating the culture of air breathing species like the Pangasius catfish into climate smart aquaculture not only provides the potential to grow local economies, it can also address some of the concerns about environmental threats by taking advantage of the evolutionary ecology of these species in their natural environments. Understanding the advantages and disadvantages of fisheries development is important to ensure that strategies are both environmentally and socially sustainable.

Aquaculture in the face of Climate Change:

Aquaculture will feel the effects of long-term climate change. Global warming, ocean acidification and sea level rise, among many other concerns, will affect the coastal and inland aquaculture industry worldwide, especially in developing countries. These temperature fluctuations will test the resilience of domesticated fish species. With the global distribution of freshwater resources and ecosystems, the aquaculture industry, smallholder farmers and markets will face challenges as well as new opportunities. The research project has several components: 1. Developing unique techniques for new species and refining farming methods, such as air-breathing fish. 2. Increasing local species diversity to promote biodiversity conservation and local community development. 3. Examine how aquaculture agencies and communities are impacted by climate change impacts on aquatic culture and economy [3].

Climate Resilience in farmed fish:

Diversifying the aquaculture industry through the introduction of climate-resistant species and species models for aquaculture is an important step towards the introduction of climate-selected aquaculture encouraged. Availability of climate-resistant fish for aquaculture may require assessment of social and environmental impacts, modification of currently farmed fish species, and development of alternative routes have persisted for newly discovered species. Gas-breathing fish species that are more resilient to projected climate change, such as rising water temperatures and depleting water quality, are included in the list of resilient species below [4].

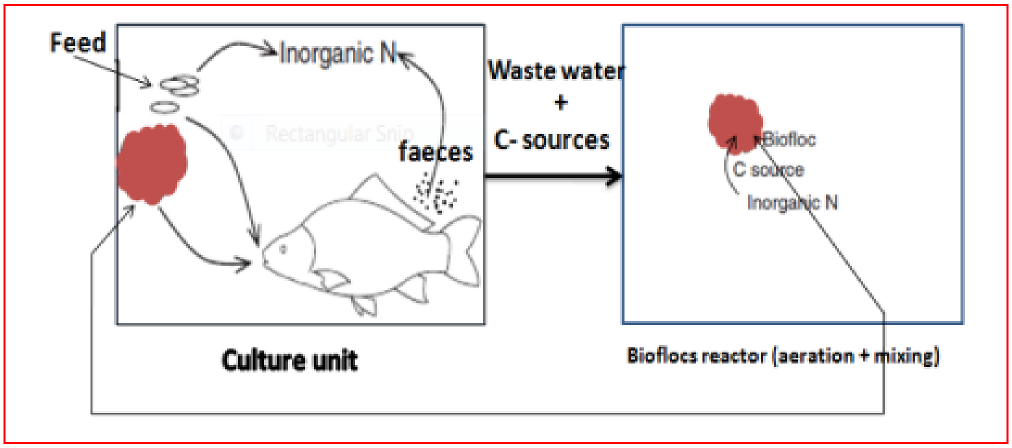
Giant Snakehead (*Channa striata*) Due to the Mekong Delta’s resilience to drought, the Mekong Delta’s most common foraging fish and classic aquatic species, the air-breathing snakehead, have been found to be weather resistant. To reduce the fish’s negative impact on the environment, researchers from the University of Rhode Island, the University of Connecticut, Oregon State University (OSU), Can Tho University in Vietnam and Inland Fisheries Research and Development Institute in Cambodia is cooperating. [5].

Pangasius Catfish (*Pangasius hypothalamus*): Pangasius, an economically important breathing fish among the many effects of climate change, makes for successful cultivation in areas filled with seawater.

African Lungfish (*Protopterus antiepics*): The African lungfish exhibits resilience to drought and water quality problems due to its ability to breathe air, making it a promising option for future aquaculture in Africa It is considered a delicacy in the area in Uganda, where over-wild catches now supply small and medium sized fish Markets depend on it. Colleagues from North Carolina State University, Auburn University, Oregon State University (OSU), and Uganda's National Fisheries Resources Research Institute are collaborating to develop sustainable and affordable breeding methods for the aquaculture industry which is developing [6].

Resilient practices in Aquaculture:

Bio floc technology (BFT): Bio Floc technology maintains the carbon-nitrogen balance in the system, thereby improving aquatic water quality. The waste is collected and converted into bio floc, which acts as a natural feedstock in culture. Algae, bacteria, protozoa, and other biological microorganisms, such as water and uneaten foods, combine to form bio flocs Microbial water forms a permeable matrix that holds each group together.



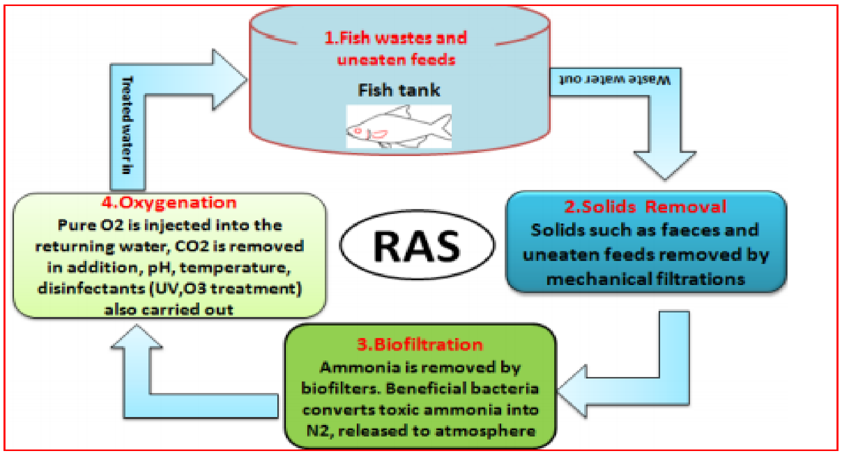
Flow diagram of Bio flocs-based aquaculture

In this way, carbohydrates can be added to the pool to promote the growth of heterotrophic organisms. These bacteria then make small proteins that help take up nitrogen. The naturally occurring ammonium and wastes and the nitrogen excreted by these fish are converted into living bacteria when carbon and nitrogen are in proper balance in the environment. To use this technique, one must introduce more carbon into the aquaculture system, either from an external source or through feeds with a higher carbon content. This technique accelerates the process of nitrogen removal by ammonium by enhancing the proliferation of the heterotrophic bacteria which later aids in the process where nitrogen is absorbed or immobilized as ammonium. Therefore, BFT demonstrates a novel farming practice that enables food production in an environmentally friendly way.[7].

Advantages: Bio flocs as a feed for aquaculture species, it is a bio-control measure. Bio floc system basically maintains water quality by reducing toxic ammonia, Minimum or zero water exchange. Lowers the feed conversion ratio and leads to reduced expenses on feed. Nutrients could be continuously recycled and reused, also capable of controlling pathogens in aquaculture system.

Recirculation aquaculture system (RAS): This is done in closed systems on land called recirculation aquaculture systems (RAS) where very small amounts of water are used – this is cleaned and recycled in the system to grow aquatic organisms. This method of regulating the situation on the ground enhances food security and also mitigates some of the adverse environmental impacts. These pathogenic bacteria and other accounting for 95% of suspended particles; 90% of nutrients: 99% of lipids; 98% of oils; 95% of WAO organic materials;

dissolved constituents in the wastewater are removed through RAS as shown in fig. Coarse suspended solids, floating debris, and large objects of wood, paper, rags, and some plastics are mechanically removed from the waste stream by means of the settlement tanks, sand filters, drum filters, and screens. [8].



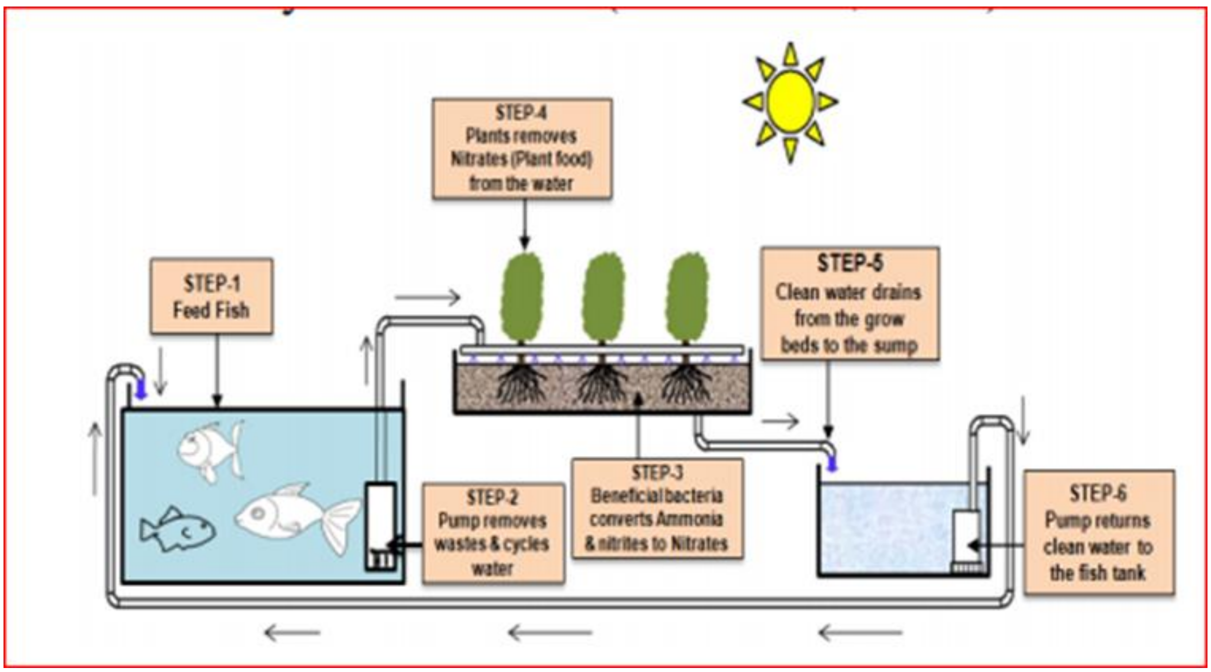
A diagram illustrating the flow of a recirculating aquaculture system.

The liquid waste is later treated in biofilters. Here, the waste passes through a biological film- a collaborative layer of microbes on the filtering medium which is usually about 0. 2 and 2. 0 millimeters thick)—that reproduces on the medium. A wide range of organisms including algae, bacteria, fungus, and protozoa are used in this movie.

The naturally occurring microorganisms on the films break down the organic material and purify the liquid (converts ammonia NH_4^+ and NH_3 excreted by the fish into nitrate). Since fish require oxygen for their growths and metabolism, it is therefore very important to regulate the system water oxygen content at concentrations ideal for achieving high production densities. The two most fundamental methods of DO raising are aeration and oxygenation. Through expulsion of air through an air stone, aeration creates tiny bubbles in the water column that provide a lot of surface area for oxygen break down. Any recirculating aquaculture system that would be put up must ensure that pH balance is continuously monitored and maintained. Desirable pH is typically controlled by the addition of lime ($CaCO_3$) or sodium hydroxide (NaOH) etc. Low pH levels result in elevated concentrations of dissolved carbon dioxide (CO_2), posing a toxic threat to fish. Desirable pH can also be controlled by degassing CO_2 with an aerator. Each type of fish possesses specific temperature conditions under which the fish thrive most, and beyond these conditions, the fish is subjected to unhealthy extremes, which eventually leads to death. Other factors such as temperature also bring significant impacts on DO levels, which can be regulated with the use of heat exchangers, submerged heaters, heat pumps, chillers, and so forth.. Finally it is disinfected using UV radiation or Ozone treatments before reused in the culture units[9].

Advantages: Low water and land requirements. Water quality parameters can be easily rectified. It is independent of adverse weather conditions. High stocking density of desired species can be done and proper productions. Reduce or eliminate vaccine, antibiotic and pesticide use in the aquaculture system. Consistent production can be expected. RAS is totally Eco-friendly, it also improves health and growth performance of the fish species.

Aquaponics systems: Hydroponics and aquaculture are combined in a closed-system environment known as aquaponics by using a particular setting in a contemporary farming technique. This arrangement requires the utilization of the nutrient rich water from fish tanks and is used as a liquid fertilizer to enhance development of hydroponic plants in the plant beds. This water contains nutrients that are supposed to accumulate and pose danger to the health of fishes, but such occurrence has resulted from fish waste, algae and decaying fish feed. The water is then recycled back to the fish tanks after the hydroponic beds which act as a bio filter, remove ammonia nitrates, nitrites, and phosphorus from the water. The useful nitrifying bacteria are present in the gravel and also near the roots of the plants are important to the cycle of nutrients since it helps in the converting the ammonia into the nitrate form of nitrogen which the plant may utilize. This mechanism keeps on maintaining the acceptable amounts of nitrogen in a fish. Contrary to traditional farming practices, aquaponics systems maintain a continuous water flow and consistent nutrient provision to the plants.[10-12].



Flow diagrammatic representation of Aquaponics system

Advantages: Significant reduction in the use of water. The use of fertilizers is not necessary. This technology does not require farmland with rich soil; It provides a filter for the fish production situation. It is organic**.** Reduced damage from pests and disease can be observed**.** Plants grow faster, sustainably, eco-friendly.

Conclusion

The development of climate-smart aquaculture emerges as a pivotal strategy in confronting the challenges posed by global climate change to food security. By prioritizing the cultivation of climate-resilient fish species and implementing sustainable practices such as biofloc technology, the aquaculture industry can adapt to changing environmental conditions while mitigating adverse impacts. Collaboration between academic institutions, research organizations, and local communities is crucial for driving innovation and ensuring the inclusivity and sustainability of aquaculture initiatives. Furthermore, a holistic approach that considers both ecological and socio-economic factors is essential for the long-term success of climate-resilient aquaculture. By embracing these principles and working together towards common goals, we can build a more resilient and sustainable future for aquaculture and global food security.

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