AI Applications in Aquaculture and Fisheries Production in Nigeria: Potentials and Challenges

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Abstract
The need to increase fish supply for consumption is driving the aquaculture sector to seek for practices that will improve and increase production. In recent time, modern technology such as the use of Artificial Intelligence (AI) is being considered. Artificial Intelligence (AI) is "the theory and development of computer systems that enables the performance of tasks that normally require human intelligence, such as visual perception, speech recognition, decision-making, and translation between languages". Application and programming for artificial intelligence (AI) enables the recognition of objects, languages, sounds, and images and decision-making without requiring human oversight. Artificial Intelligence (AI) is an all-encompassing tool that is now being used to revolutionizing various fields by allowing individuals to reconsider how we integrate information, analyze data, and apply the ensuing insights for better decision-making. In some of developing countries, aquaculture is now evaluating and implementing AI as a means of increasing fish production through efficient and effective use of resources. This paper reviews the application of AI in enhancing the roles and operation of aquaculture and fisheries in Nigeria. Its emergence has led to significant advancements in automation, data analyses, and decision-making processes. This paper highlights the recent application of AI in developed countries and elaborates on the potential applications of AI in aquaculture and fisheries in Nigeria, most especially in areas like smart feeding systems, water quality management, fish disease control and prevention, market analysis, supply chain optimizations and aquaculture system management. It shows that integrating AI technologies in aquaculture and fisheries offers immense potential for improving production efficiency, reducing environmental impacts, and ensuring sustainable growth in the sector. However, the paper identifies several challenges and difficulties that must be addressed for its successful implementation in Nigeria. These include challenges such as limited data availability, cost and affordability, technical expertise and training, and adoption barriers, among others. The paper concludes by suggesting the way forward, such as comprehensive data collection and integration, adequate collaboration and research work, remote sensing and monitoring, capacity building and awareness, and sound policy framework and regulation.

Keywords: Artificial intelligence, aquaculture, fisheries, technology, Nigeria

Introduction

The global community is currently grappling with a critical challenge that directly impacts human well-being and sustainable development for food security. In particular, the African continent has long experienced persistent malnutrition and periodic food shortages, largely due to inadequate infrastructure supporting food production systems. Widespread poverty continues to dominate the African landscape, manifesting in chronic hunger and nutritional deficiencies among its population. Despite these challenges, Africa possesses immense agricultural potential, including a favourable climate, fertile soils, and a capable human workforce suited to both crop and livestock production. Among the various sources of animal protein essential for human nutrition, fish stands out as a vital component. Fish can be sourced from both inland and marine environments. Inland water bodies such as lakes, rivers, dams, and streams offer considerable opportunities for freshwater fish farming, while marine ecosystems including oceans and seas, present vast untapped resources that can be sustainably exploited through modern aquaculture and fisheries management practices. Simply put, aquaculture and fisheries production could play a major contributory role in improving food security in Africa. This paper is a review of the place and role of AI in aquaculture and fisheries in Nigeria. It examines the emergence of AI in world economy and its current success story in various sectors of the world economy.

Meaning of Aquaculture and Fisheries?

Numerous definitions of aquaculture exist, put forth by various scholars and practitioners in fisheries. Nonetheless, grasping the operational principles of both capture fisheries and culture fisheries lays a strong groundwork for defining aquaculture. The distinction between these two systems is clear: capture fisheries involve harvesting aquatic organisms directly from natural water bodies without any prior cultivation, whereas culture fisheries (aquaculture) entail the deliberate breeding, nurturing, and raising of aquatic organisms in controlled settings until they reach a size suitable for harvest or sale.

Jhingran (1987) defines aquaculture as an industrialized process involving the cultivation of aquatic organisms up to their final stage of commercial production within designated aquatic environments. This process includes the deliberate control of environmental conditions and active management of the organism's life cycle. He further characterized aquaculture as the structured cultivation of

biological "crops", whether plant or animal, within aquatic ecosystems. Expanding on this, Beveridge and Phillips (1993) emphasized that aquaculture is practiced across marine, brackish, and freshwater environments, with the bulk of global aquaculture production occurring in freshwater systems. These systems may include cages located in natural and semi-natural water bodies such as lakes, rivers, estuaries, and reservoirs, as well as land-based ponds specifically designed for aquaculture activities. Complementing these views, the Food and Agriculture Organization (FAO, 2018) broadly defines aquaculture as the systematic cultivation, feeding, breeding, and management of aquatic organisms for purposes that may be commercial, recreational, or serve the public interest.

On the other hand, fisheries, as described by the FAO (2020), represent an essential economic activity centered on obtaining fish and other aquatic organisms either from natural ecosystems, referred to as capture fisheries, or through regulated cultivation methods known as culture fisheries or aquaculture. This activity operates across different scales, from traditional or small-scale fisheries (SSF), which primarily support household food security and subsistence, to large-scale or commercial fisheries, which are primarily geared toward income generation and profit.

Béné *et al*. (2007) define fisheries as encompassing both the industry or enterprise involved in harvesting aquatic organisms and the physical locations—commonly referred to as fishing grounds—where these activities take place. Expanding on this, AU-IBAR (2016) emphasizes that fisheries in the African context include not only the economic and subsistence aspects of capturing or cultivating aquatic species but also the diverse aquatic ecosystems, such as rivers, lakes, coastal zones, and marine environments, where such practices occur. Globally, the fisheries sector comprises two main components: wild capture fisheries and aquaculture. Approximately 90% of global fish catch is derived from marine sources, while the remaining 10% comes from freshwater bodies. Notably, fisheries serve as a vital livelihood source for more than 500 million people worldwide, underscoring their critical role as a global socio-economic engine.

Significance of Aquaculture and Fisheries Production in Nigeria

In Nigeria, fish production is predominantly sourced from two main systems: capture fisheries and aquaculture. Both systems play complementary roles in addressing the challenges of food and nutritional security. While capture fisheries rely on natural stocks, aquaculture provides a means of controlled and sustainable fish production. Aquaculture and fisheries in Nigeria are inherently diverse, shaped by varying environmental, economic, and social conditions. These factors influence the structure and performance of the sector across the country. According to Akegbejo-Samsons (2022), aquaculture and fisheries have transformative potential across three major dimensions. Firstly, they serve as a vital source of high-quality protein, essential for combating malnutrition and undernourishment in a country where food insecurity remains a critical issue. Secondly, the sector offers massive employment opportunities, particularly for Nigeria's burgeoning youth population, thereby serving as a strategic tool for poverty alleviation and rural development. Thirdly, it contributes significantly to increasing the national supply of fish and fishery products, reducing the country's dependency on fish imports and enhancing food sovereignty.

Nigeria ranks second in African aquaculture production, with an annual output of approximately 300,000 metric tonnes, primarily dominated by catfish farming (FAO, 2016; 2018a; Ozigbo *et al*., 2014). The dominance of catfish culture reflects both consumer preferences and the species' adaptability to local farming conditions. Uganda, by comparison, ranks third and is a major supplier of fishery inputs such as feed and fish seeds to neighbouring countries like Kenya, Congo, and Rwanda (FAO, 2004–2020; Safina et al., 2018). Beyond its nutritional and economic functions, aquaculture also plays an important recreational and social role. Recreational fishing and fish farming activities in urban and peri-urban areas provide opportunities for leisure, tourism, and education. Such initiatives also contribute to community engagement, environmental awareness, and stress reduction, while often doubling as small-scale income-generating ventures.

Economically, the fisheries and aquaculture sector makes measurable contributions to Nigeria's Gross Domestic Product (GDP). It provides millions of direct and indirect jobs along the value chain—including fish farming, processing, marketing, feed production, and logistics. It also supports livelihoods in related industries such as boat building and aquaculture equipment manufacturing. According to HLPE (2014), fish stands out not only for its high protein and micronutrient content but also for its efficiency in converting feed to edible protein, making it a more sustainable alternative to other animal protein sources.

However, despite its potential, the fisheries sector in Nigeria remains underrepresented in national food security and development strategies. Many policy discussions tend to give limited attention to fish and aquaculture when addressing hunger and malnutrition. Yet, the importance of the sector is undeniable across three key dimensions: (i) the nutritional value of fish, rich in essential fatty acids, vitamins, and minerals; (ii) the role of fisheries in generating income and supporting livelihoods; and (iii) the efficiency and environmental sustainability of fish production, especially through well-managed aquaculture systems (HLPE, 2014).

Meaning of Artificial Intelligence?

Artificial Intelligence (AI), a term coined by emeritus Stanford Professor John McCarthy in 1955, was defined by him as "the science and engineering of making intelligent machines". Extensive research has focused on programming machines to perform intelligent tasks, such as playing chess; however, today the emphasis is on developing machines that can learn, at least to some extent, like humans (Manning, 2020). Although the term AI, is commonly used to describe a range of different

technologies in use today, many disagree their function constitutes artificial intelligence. Instead, some argue that much of the technology used in the real world today constitutes highly advanced machine that is simply a first step towards true artificial intelligence, or "general artificial intelligence" (Moran-Jackson, and Papa, 2024).

Legg and Hutter (2007) *defines* AI as "in its broadest sense, intelligence exhibited by machines, particularly computer systems, as opposed to the natural intelligence of living beings. It is a field of research in computer science that develops and studies methods and software that enable machines to perceive their environment and use learning and intelligence to take actions that maximize their chances of achieving defined goals. Implicitly, such machines may be called AIs.

Another definition puts Artificial intelligence as the development and implementation of computer systems that can perform tasks that typically require human intelligence. These tasks include speech recognition, natural language processing, problem-solving, pattern recognition, and decision-making, among others" (Anon, 2024). It further explains that-AI systems learn from data and experience, allowing them to adapt and improve over time.

AI is a concept that has been around formally since the 1950s when it was defined as a machine's ability to perform a task that would have previously required human intelligence. This is quite a broad definition that has been modified over decades of research and technological advancements. They utilize various techniques such as machine learning, deep learning, and neural networks to process and analyze information, make predictions, and solve complex problems. AI has numerous applications across different fields, including healthcare, finance, transportation, and robotics.

In essence, AI aims to replicate human cognitive abilities in machines, enabling them to perform tasks that would otherwise require human intelligence. To put it simply, artificial intelligence is the quest to create machines that can think, learn, and reason like humans, even if they do not quite match our full range of capabilities. In other words, AI refers to computer systems capable of performing complex tasks that historically only a human could do, such as reasoning, making decisions, or solving problems. However, today, the term "AI" describes a wide range of technologies that power many of the services and goods we use every day.

It is important to know that John McCarthy coined the term 'artificial intelligence' and founded the first AI laboratory at MIT in 1959. He also developed the programming language Lisp, which became widely used in AI research.

Emergence of AI in the World Economy

AI has been making its way into our daily lives in a plethora of ways, even though we have not always noticed it. In today's rapidly evolving technological landscape, it is crucial to understand that Artificial Intelligence is no longer just an option—it's a necessity (Brevetti, 2024).

AI has been a transformative force in the world economy, impacting various sectors and industries. Its emergence has led to significant advancements in automation, data analytics, and decision-making processes.

The field of artificial intelligence arose from the idea that machines might be able to think like humans do. It required an analysis of how our brains process information and use it to perform new tasks and adapt to novel situations. Continuing exploration of these concepts has fueled technological innovation and led to the development of AI applications that use data to identify patterns, carry out predictions, and make decisions. Often these applications are more efficient and precise than humans are—sometimes replacing people to perform repetitive or tedious tasks and calculations. Today, rapid advances in the field have opened new avenues for research and discovery but also raise ethical and safety questions (Caltech, California Institute of Technology. 2024)

Some benefits of the utilization of AI to production includes;

1. ***Automation of tasks****:* AI has facilitated the automation of both manual and cognitive processes, enabling businesses to optimize operations, lower expenses, and boost efficiency. By interpreting and analyzing vast amounts of data, AI-driven systems are capable of managing repetitive or intricate tasks, resulting in enhanced productivity. (Soori *et al*. 2023)
2. ***Enhanced productivity and innovation****:* AI technologies hold significant potential to enhance productivity and stimulate innovation. By automating repetitive and routine tasks, employees are freed to concentrate on higher-value activities such as creative problem-solving and innovative thinking. Consequently, this shift can foster the creation of new products, services, and business models.
3. ***Data-driven decision-making****:* With the ability to process and analyze vast amounts of data rapidly, AI systems facilitate data-driven decision-making, extracting valuable insights and patterns from large datasets. Businesses can identify trends, forecast outcomes, and make more informed strategic decisions. (Badmus *et al*., 2024).
4. ***Improved customer experiences***: AI-powered applications including chatbots, virtual assistants, and personalized recommendation systems have significantly improved customer experiences. Natural Language Processing (NLP) enables chatbots to understand and respond to customer inquiries, while machine learning-based recommendation systems deliver tailored suggestions. These intelligent systems reduce response times and enhance interaction quality, leading to higher customer satisfaction. (Balanm 2023)
5. ***Economic impact across sectors****:* AI's emergence has produced a profound economic impact across key industries—including healthcare, finance, logistics, and manufacturing—by boosting productivity, optimizing supply chains, improving diagnostics, and accelerating scientific research. These innovations collectively drive economic growth and efficiency across sectors (Comunale & Manera, 2024).

Potentials of AI application in Agriculture in Nigeria

Agriculture plays a vital role in Nigeria's economy. AI can contribute by providing advanced analytics and predictive models to optimize farming practices, improve crop yield, and manage resources efficiently. AI-powered systems can monitor soil conditions, weather patterns, crop diseases, and pests, enabling farmers to make informed decisions and maximize productivity. Application of AI to Agriculture will assists to achieve the following;

1. ***Agricultural Productivity****:* AI has the capacity to revolutionize agricultural practices by enhancing decision-making in areas such as crop selection, planting methods, and irrigation planning. Through the analysis of data on soil composition, climate trends, and crop behavior, AI-powered systems can offer customized guidance to farmers aimed at maximizing yields and reducing losses. These advancements in agricultural efficiency play a crucial role in supporting food security for Nigeria's rapidly growing population (Yakubu *et al*, 2024).

2. ***Pest and Disease Management:*** AI can aid in the early detection and management of pests and diseases that affect crops and livestock. By using image recognition and data analysis techniques, AI systems can identify patterns and symptoms associated with specific pests or diseases. This will allow farmers to take timely preventive measures and reduce the risk of crop or livestock losses, thus safeguarding food production (Akinyemi *et al*., 2023).

3. ***Climate Resilience:*** Climate change poses challenges to agricultural productivity and food security. AI can assist in predicting climate patterns, weather-related risks, and extreme events that may affect crop growth and livestock health. With this information, farmers can make informed decisions on planting, irrigation, and other adaptive strategies to mitigate climate risks and maintain food production. (Nawaz and Babar, 2024).

4. ***Supply Chain Optimization:*** AI can enhance efficiency in the food supply chain, from farm to consumer. By analyzing data on transportation logistics, demand patterns, and market trends, AI systems can optimize routes, reduce waste, and ensure the timely delivery of fresh produce. This helps minimize post-harvest losses and ensures that food reaches consumers promptly (Onyeaka *et al*.,2023)

5. ***Data-Driven Decision Making:*** AI can analyze large volumes of data from diverse sources, including weather data, market trends, and socio-economic factors. This data-driven approach can inform policy decisions related to agriculture, food distribution, and investment in rural infrastructure. By utilizing AI-generated insights, stakeholders can make informed decisions to improve food security strategies in Nigeria. (Asolo *et al*., 2024).

6. ***Aquaculture and Fisheries****:* AI can play a significant role in optimizing aquaculture and fisheries production. By enhancing monitoring, disease detection, and feeding strategies, AI applications can increase productivity, reduce losses, and contribute to the availability of nutritious fish products, supporting food security efforts in coastal communities and beyond.

It is important to note that while AI can offer significant benefits, its successful implementation requires a supportive policy environment, access to quality data, technological infrastructure, and appropriate training for farmers and stakeholders. By leveraging AI applications thoughtfully and collaboratively, Nigeria can enhance its food security initiatives and work towards a more sustainable and resilient food system (Salako *et al*., 2024).

Some Global AI Applications in Aquaculture and Fisheries

Artificial intelligence (AI) exists in various forms and has increasingly become integrated into everyday life. In aquaculture and fisheries, the adoption of AI is transforming the industry by offering advanced, technology-driven solutions that enhance efficiency and sustainability. Key areas where AI is delivering significant benefits include feeding optimization, biomass estimation, stress detection, and health monitoring.

Despite some hesitation among stakeholders and industry players regarding the future role of AI in aquaculture production, several innovators have already embraced these technologies. For instance, the Canadian company *ReelData AI* has developed a suite of tools tailored for land-based aquaculture systems. Their *ReelAppetite* platform monitors and regulates feed consumption in real time, while *ReelBiomass* provides accurate estimations of fish size and weight distributions within production facilities. The comprehensive *ReelData AI Suite*—which includes *ReelAppetite*, *ReelBiomass*, *ReelStress*, and *ReelHealth*—offers integrated data insights and automation, enabling farms to maximize profitability and sustainability within a unified platform (ReelData, 2023).

Other useful areas of AI application in aquaculture and fisheries include the following:

1. ***Monitoring and Surveillance:*** AI is being used for monitoring aquaculture and fisheries environments to gather real-time data on factors such as water quality (temperature, and dissolved oxygen levels), and fish behavior. This data helps farmers optimize conditions, detect anomalies, and prevent disease outbreaks. AI-powered cameras and sensors can also enhance surveillance efforts to detect illegal fishing activities or unauthorized entry into fisheries areas (Capetillo-Contreras *et al*. 2024).

2. ***Precision Feeding and Nutrition:*** AI technology enables precise feeding strategies by analyzing factors like fish size, growth rate, environmental conditions, and nutritional needs. Machine learning algorithms can process data and provide recommendations for optimized feeding schedules, reducing feed wastage and improving fish health (Son and Jeong, 2024).

3. ***Disease Detection and Management****:* AI-based systems can assist in the early detection of fish diseases by analyzing data patterns and identifying signs of illness or abnormalities. This enables farmers to take prompt measures, such as adjusting water quality parameters or administering appropriate treatments, to prevent disease outbreaks and minimize losses.

4. ***Water Quality Management****:* Maintaining optimal water quality is crucial for successful aquaculture operations. AI can help monitor and manage water quality parameters, alerting farmers to deviations from optimal levels. Machine learning algorithms can analyze historical data and real-time observations to provide insights into improving water quality conditions and reducing risks to fish health (Roja *et al*. 2024).

5. ***Stock Management and Harvesting****:* AI applications can assist in accurate stock assessment, size estimation, and growth prediction, enabling farmers to make informed decisions regarding optimal stocking densities and harvesting timelines. This helps maximize production efficiency and reduces unnecessary costs associated with overstocking or premature harvesting. (Mandal and Ghosh, 2024).

6. ***Decision support system****:* AI can provide decision support tools by analyzing complex datasets, market trends, weather patterns, and other relevant factors. This enables fish farmers and fisheries managers to make data-driven decisions regarding production planning, market strategies, and resource allocation (Munim *et al*., 2020).

Overall, the integration of AI technologies in aquaculture and fisheries offers immense potential for improving production efficiency, reducing environmental impacts, and ensuring sustainable growth in the sector.

Possible Challenges and Difficulties in AI application in Aquaculture and Fisheries in Nigeria

While the application of AI in aquaculture and fisheries in Nigeria holds immense potential, there are several challenges and difficulties that need to be addressed for its successful implementation. Here are some key issues:

1. Limited Data Availability: Artificial intelligence (AI) systems rely heavily on robust, diverse, and high-quality datasets for accurate training and dependable predictive performance. However, in Nigeria, comprehensive and standardized data on aquaculture and fisheries are still scarce. Mustapha *et al*. 2021 opined that data collection, analysis, and processing challenges significantly hinder research efforts throughout the sector. The concentration of aquaculture practices in rural and semi-urban regions, where data infrastructure and digital literacy are often insufficient, worsens these issues. As a result, the lack of and inconsistency in pertinent datasets can obstruct the development and adaptation of AI models tailored to Nigeria's aquaculture landscape, thereby impacting their effectiveness and usefulness. (Vijayaraghavan & Chattaraj, 2024).

2. ***Infrastructure and Connectivity***: Adequate technological infrastructure, including reliable internet connectivity and power supply, is crucial for the effective implementation of AI systems. In many rural areas of Nigeria, where aquaculture and fisheries are prevalent, such infrastructure are largely lacking or inconsistent, hampering the accessibility and proper functioning of AI tools and applications. Connectivity is a major problem in Nigeria, especially in rural and coastal areas of the country. Infrastructures that enhance easy and adequate AI application are prerequisites that must be guaranteed in some cases (Ono *et al*.,2024).

3. ***Cost and Affordability*****:** The implementation of artificial intelligence (AI) technologies often entails substantial financial commitments, including initial capital investment, ongoing maintenance, and specialized training requirements. As Masere and Worth (2022) observe, small-scale fish farmers and resource-limited communities may encounter significant barriers in affording and adopting these technologies. Given that a large proportion of fish farmers in Nigeria operate on a small scale with limited financial capacity, the cost of AI deployment remains a major constraint. Therefore, addressing these economic challenges and promoting affordability through subsidies, cooperative financing, or public-private partnerships is critical to ensuring broad-based adoption and equitable access to AI-driven innovations in the aquaculture sector.

4. ***Technical Expertise and Training***: For artificial intelligence (AI) applications to be effectively utilized within the aquaculture and fisheries sector, stakeholders, including fish farmers, fisheries managers, and policymakers, must possess adequate technical knowledge and skills. (Mandal & Ghosh, 2024). The successful implementation of AI requires specialized expertise, strong operational capabilities, and ongoing training to ensure optimal outcomes. Consequently, sustained investment in training and capacity-building initiatives is essential to enhance stakeholder readiness and maximize the potential benefits of AI tools. Collaboration among government agencies, industry stakeholders, and technology firms is imperative to develop and promote comprehensive training frameworks and support systems that facilitate the adoption of AI in the sector.

5. Ethical and Legal Considerations: AI applications must adhere to ethical guidelines concerning data privacy, transparency, and fairness. As it is customary in developed countries, developing and implementing regulations and frameworks specific to AI in aquaculture and fisheries is necessary to address concerns related to data ownership, potential biases, and responsible use of AI technologies in the country (Bush *et al*.. 2019). This will prevent many conflicts and controversies in the final application of AI in the country.

6. ***Adoption Barriers****:* Resistance to change, limited awareness of the potential benefits of artificial intelligence (AI), and skepticism toward emerging technologies are significant barriers that can hinder the adoption of AI in aquaculture and fisheries, particularly in developing contexts such as Nigeria (Ajayi and Ogunyinka, 2023). These challenges are expected to pose substantial obstacles to widespread implementation, especially among smallholder farmers and traditional aquaculture practitioners. Addressing these issues requires deliberate stakeholder engagement, targeted awareness campaigns, and evidence-based demonstrations of AI's advantages. Similar to the phased approaches employed by agricultural extension services in introducing new crops and farming practices, the adoption of AI technologies will likely need to follow a gradual, adaptive process tailored to the needs and perceptions of end-users.

7. ***Environmental Considerations***: While AI can support sustainable practices in aquaculture and fisheries, potential environmental impacts need to be carefully considered. This includes addressing risks associated with monitoring and surveillance technologies, ensuring habitat conservation, and mitigating potential disruption to ecosystems. Aquaculture practices are dependent upon different variables, either operated on extensive, intensive or semi-intensive. Fish production in cultured environments such as earthen ponds, concrete tanks, race ways, lakes, and reservoirs demands separate intricacies that will likely infringe on the success of AI application. (Adebayo and Adeyemi, 2022).

Addressing these challenges requires a multi-stakeholder approach, involving collaboration between government agencies, research institutions, technology providers, and local communities. By actively addressing these difficulties, Nigeria can better harness the potential of AI in aquaculture and fisheries to enhance productivity, sustainability, and food security in the country.

Suggested solutions to Effective AI application in Aquaculture in Nigeria

The application of AI in aquaculture and fisheries in Nigeria has immense potential to enhance productivity, sustainability, and overall efficiency. To move forward in harnessing AI for this sector, several steps must be taken. These may include:

1. *Data Collection and Integration***:** Efforts should be made to collect and integrate high-quality data from aquaculture and fisheries operations, including factors such as water quality, feed management, disease incidence, and environmental conditions. (Uwagaba *et al*., 2023). This data can serve as the foundation for AI applications, enabling accurate analysis and decision-making.
2. *AI Modeling and Predictive Analytics*: Developing AI models and predictive analytics algorithms specific to aquaculture and fisheries can help optimize production processes (Agwu and Oftedal, 2025). These models can forecast optimal feeding schedules, monitor water quality parameters, predict disease outbreaks, and optimize growth rates. It is important to adapt these models to local conditions and species of interest in Nigeria.
3. *Remote Sensing and Monitoring:* AI can be used in remote sensing and monitoring systems to assess water quality, detect illegal fishing activities, and monitor fish health. Integrating AI-powered sensors, drones, and satellite imagery can provide real-time insights and enable proactive management strategies in aquaculture and fisheries operations (Mustapha *et al*., 2021)
4. *Disease Management:* Islam *et al,* 2024 noted that diseases pose a significant challenge to aquaculture and fisheries. AI tools, such as machine learning algorithms, can aid in disease detection, diagnosis, and management. By analyzing historical data and identifying patterns, AI can provide early warning systems, recommend appropriate treatment protocols, and assist in disease prevention measures.
5. *Smart Feeding and Nutrition Management:* AI-powered systems can optimize feeding regimes and assess nutritional requirements based on real-time data. By integrating environmental factors, growth rates, and fish behavior, AI algorithms can help reduce feed waste, maximize growth efficiency, and minimize environmental impacts. (Zang *et al*., 2023)
6. *Collaboration and Research:* Collaboration among stakeholders, including government agencies, research institutions, farmers, and AI developers, is essential for advancing AI in aquaculture and fisheries. Supporting research and funding initiatives specific to AI applications in this sector can accelerate innovation and knowledge sharing. (Rowan, 2023)
7. *Capacity Building and Awareness:* According to Gikunda (2024), organizing training programs, workshops, and capacity-building initiatives is essential for enhancing the technical competencies and awareness of aquaculture and fisheries practitioners regarding the applications of artificial intelligence. Such initiatives are pivotal in fostering the adoption and seamless integration of AI technologies into aquaculture operations, thereby enabling stakeholders to harness their full potential effectively
8. *Policy Framework and Regulation*: Developing a supportive policy framework and regulations that address ethical considerations, data privacy, and environmental sustainability is crucial. This will provide a clear roadmap for the responsible development and application of AI in aquaculture and fisheries in Nigeria. By focusing on these areas, Nigeria can unlock the full potential of AI for aquaculture and fisheries, leading to improved productivity, sustainability, and socioeconomic benefits for the sector (Rowan, 2023).

Conclusion

Artificial Intelligence (AI) presents a transformative opportunity for optimizing fish growth and overall productivity in aquaculture systems. Although challenges such as limited infrastructure, data availability, and technical expertise may currently slow down the full-scale adoption of AI in Nigeria, these barriers are not insurmountable. With strategic investment in capacity building, digital infrastructure, and stakeholder collaboration, AI can be effectively integrated into aquaculture and fisheries management.

AI-driven technologies offer significant benefits, including improved feeding strategies, enhanced water quality monitoring, early disease detection, and streamlined farm operations. Through intelligent analysis of environmental data—such as temperature, pH levels, and dissolved oxygen—AI tools can forecast fish growth patterns and automate feeding schedules, thereby reducing waste and improving yield.

In a broader context, the application of AI in fisheries and aquaculture aligns with the digital transformation goals of agriculture in Nigeria. It promotes efficiency, data-driven decision-making, and sustainable resource management. If Nigeria leverages these advancements, the nation stands a strong chance of not only meeting domestic fish demand but also emerging as a leading fish producer in Africa.

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