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APPLICATION OF ARTIFICIAL INTELLIGENCE (AI) IN AQUACULTURE

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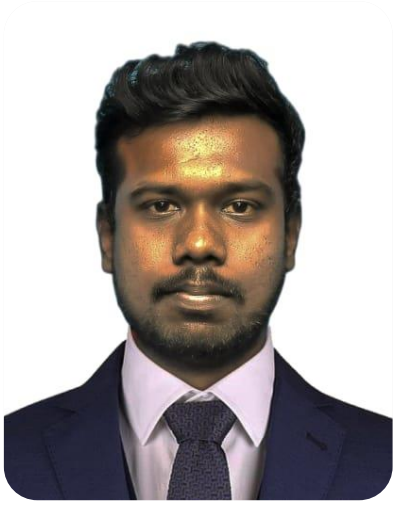
ABSTRACT

Aquaculture in India has evolved with increasing production demands, yet faces obstacles in efficiency, labor, and quality. Artificial Intelligence (AI) offers transformative solutions across the aquaculture cycle, from site selection and pond design to stocking, feeding, and disease management. AI applications improve resource use and operational accuracy, fostering automation and enhancing sustainability. This review examines AI-driven tools like AQUASIGHT and Eruvaka, which optimize practices in pre-stocking, stocking, and post-stocking phases. AI's integration is crucial for advancing the future of sustainable aquaculture.



KEYWORDS: Artificial Intelligence, Aquaculture, Disease Management, Harvesting, Site Selection

INTRODUCTION

The production of India's aquaculture has developed from an extensive culture to an intensive one, and it has consistently increased along with ongoing structural upgrades. However, as an important part of India's agricultural production, aquaculture plays an important role in promoting the development of agricultural economy. The rapid expansion of India's aquaculture sector has been severely hampered by lack of labour, production efficiency and resource use, low-quality aquatic goods, and a lack of safety assurances. The key to resolve these problems is using information technology and intelligent devices to accomplish accurate, automated, and intelligent aquaculture practices to increase farming output and optimize resource usage. Artificial intelligence technology and aquaculture development are inextricably linked, and this evaluation can offer resources to accelerate the growth of digitalization, accuracy, and intelligent aquaculture. This article is mainly focus on the application of artificial intelligence to know how it's used and how they work in pre-stocking (site selection, pond formation, pond preparation, etc), stocking, post- stocking and harvesting practices in aquaculture.

ARTIFICIAL INTELLIGENCE (AI)

Artificial intelligence (AI) is the term used to describe the recreation of human intelligence in automated machines to think and mimic their action like humans. The term may also be applied to any machine that implies traits comparable to a human mind such as learning and problem-solving.

ARTIFICIAL INTELLIGENCE (AI) IN AQUACULTURE

1. PRE-STOCKING MANAGEMENT

AI IN SITE SELECTION

In aquaculture, a significant number of commercial ventures fail due to inadequate site selection. It is essential to consider the site's economic factors, such as its potential for pollution, access to marketing channels, and existing infrastructures. Additionally, evaluating the regulatory environment at both local and regional levels and identifying potential conflicts of interest is crucial. Leveraging AI can help to address these challenges, allowing for more informed decision-making, minimizing risks, and ultimately improve the sustainability and success of aquaculture operations.

AI revolutionizes the selection of aquaculture sites by leveraging data analysis, remote sensing, GIS (Geographic Information System), predictive modelling, and decision support systems. By processing diverse datasets, including water quality, environmental conditions, and historical aquaculture data, AI pinpoint's ideal sites. It also analyzes satellite images to identify areas which are conducive for aquaculture (Anand *et al*., 2021). Through predictive modelling, AI evaluates growth potential and risk factors, integrating multiple criteria to recommend the best sites. This automation of complex analyses enhances decision-making, promoting the sustainability and success of aquaculture operations. AQUASIGHT (for coastal aquaculture), DESTA (Decision Support Tool for Aquaculture), ADDSS (Aquacultural Development Decision Support System) and CADS_TOOL (Cage Aquaculture Decision Support Tool) are some of the AI models used in aquaculture site selection.

AI IN POND CONSTRUCTION

Pond construction is a crucial aspect in aquaculture, providing a controlled environment for the cultivation of aquatic species. Proper design and construction are essential for maintaining water quality, ensuring adequate fish health, and optimizing production. However, several challenges can arise during and after the construction of ponds in aquaculture such as water supply, incorrect slope design, poor drainage, etc. Effective planning, appropriate construction techniques, and ongoing maintenance are essential to overcoming these challenges.

Artificial Intelligence (AI) plays a crucial role in pond construction by analysing extensive datasets that encompass environmental, hydrological, and geological features to evaluate the best site conditions.

To optimize water retention and flow dynamics, AI adjusts design parameters such as pond size, shape, and depth. Through machine learning, AI continually refines these design aspects to ensure optimal outcomes while minimizing environmental impacts. Additionally, real-time monitoring, using sensors and IoT devices, provides continuous data to AI systems, enabling proactive management of construction quality and timeline adherence. AI-driven predictive analytics also forecasts potential risks and assists in developing mitigation strategies for sustainable project implementation. The AI models used in aquaculture pond construction are POND (provides the pond dynamics and fish growth models for warm water pond aquaculture facilities and benefit cost-returns details) and BIM (Building Information Modelling, an Intelligent 3D model-based processor which gives details about architecture, engineering, and construction professionals and tools to plan, design, construct, and manage buildings and infrastructure).

AI USED IN SOIL QUALITY

Soil quality is a critical factor in aquaculture. Effective soil management is essential for ensuring fish health, maintaining water quality, and supporting the long-term sustainability of the aquaculture system. Understanding how to manage soil characteristics, coupled with regular soil testing,is vital for optimizing productivity and preventing issues related to suboptimal soil conditions.

Based on the soil quality and application and nutrient uptake, the Brazilian agricultural company InCeres has created an app that can forecast soil fertility and quality. The study's foundation includes information on the soil's chemical composition, the condition of the weather, and satellite photos that display the rates of growth of plants (Ali,2022).

For other soil quality analysis strategies, Varatharajalu and Ramprabu (2018) has presented an automated watering system that employs a soil moisture sensor, temperature sensor, pressure regulator sensor, and molecular sensor for enhancing soil productivity.

Ali and Chahl of the University of South Australia have worked on a device that accurately measures soil quality indicators like moisture with the help of a typical RGB digital camera. It utilizes a common video camera to analyze changes in soil color to detect moisture content. The digital camera was linked to an artificial neural network (ANN) programmed to recognize different soil moisture levels under various weather situations.

2. STOCKING

Artificial intelligence (AI) is revolutionizing pond management by enhancing stocking practices. AI algorithms evaluate data on water quality, temperature, and historical stocking patterns to recommend the ideal stocking density and species mix. Predictive models forecast fish growth and behaviour based on environmental factors, aiding in the timing and quantity of stocking. Moreover, AI-powered monitoring

systems offer ongoing observation of fish populations, enabling real-time modifications to stocking strategies to achieve optimal growth and maintain ecological balance.

AI USED IN FISH SEED SCREENING

Identification and selection of healthy fish seedsare very important in fish farming. Often it become laborious and need to employ many workers for screening of healthy fish seeds. The Kindai University's Aquaculture Research Institute, Japan is using Microsoft Azure machine learning studio to identify and remove odd–shaped fish seeds from the rearing cage.

AI USED IN STOCKING DENSITY

Stocking density is a critical factor in aquaculture that directly influences the health, growth, and productivity of farmed aquatic species. It refers to the number of organisms, such as fish or shrimp, introduced into a specific volume of water or area within a farming system. Effective management of stocking density is essential for optimizing resource use, ensuring animal welfare, and maximizing yield.
The Canadian company XpertSea utilizes artificial intelligence and computer vision to count, measure, and weigh organisms. Their growth platform helps to determine daily growth rates, feed conversion ratios (FCR), stocking densities, and survival rates.

3. POST-STOCKING MANAGEMENT

AI USED IN FEEDING

Feeding is one of the most crucial aspects of aquaculture, significantly impacting the health, growth, and overall productivity of farmed aquatic species. Adequate and balanced feeding is essential for the rapid and healthy growth of aquatic species. The right feed provides the necessary proteins, fats, vitamins, and minerals that contribute to the development of muscles, bones, and other tissues.

- ✓ *eFishery* is an Indonesian aquaculture intelligence firm which introduced an AI-powered feed dispenser that provides the precise amount of feed at optimal times. Equipped with sensors to gauge the animals' appetite, this device can cut the feed costs by approximately 21%.
- ✓ *Umitron cell* is the Singapore and Japan based aquaculture technology firm which has developed this smart fish feeder that can be remotely controlled. It is the first system globally to detect fish appetite in real time in ocean environments. This data-driven device helps the farmers to optimize their feeding schedules.

The feeding robot travels from tank to tank along a ceiling-mounted track, providing quick and efficient feeding across the entire facility. It automatically adjusts feed quantities based on registered biomass and can refill itself between feedings. With precise positioning, the robot manages feeding with

high accuracy. Operating on an overhead rail, the robot can carry up to 350 kg and moves at a maximum speed of 0.3 m/s.

eFishery

(Source: https://efishery.com/en/)

Umitron cell

(Source: https://umitron.com/en/index.html)

AI USED IN WATER QUALITY

In the aquaculture sector, monitoring various water quality parameters such as water temperature, pH, and dissolved oxygen is crucial. Traditionally, this has involved manual data collection, where individuals physically measure these parameters at set intervals. This approach is not only labour-intensive but also prone to human error. By integrating AI, aquaculture can automate the data collection process through the use of sensors that continuously monitor water quality in real-time. The data collected is then transmitted to acentralized database for processing and analysis. Automating the data collection process with AI will help to reduce human errors and increase accuracy (Capetillo-Contreras *et al*., 2024).

- ✓ Eruvaka, an Indian company, offers AI-driven solutions in shrimp farming, including real-time water quality monitoring, voice call alerts, appetite-based intelligent feeders, and automatic aerator control. Their technology is currently used across approximately 1,000 hectares of shrimp farms in Surat, Goa, Andhra Pradesh, and Pondicherry, benefiting farmers with advanced AI tools for shrimp cultivation.
- ✓ *Pond Guard* is a real-time monitoring device of dissolved oxygen (DO) and pH levels which helps farmers to assess pond conditions and take preventive actions. Notifications via voice calls for low

DO levels enable farmers to avert shrimp fatalities. Additionally, automated aerator control, which adjusts based on DO readings, can lower energy expenses by 20%.

- ✓ *FarmMOJO* is another AI device used in shrimp farming to analyze water quality.
- ✓ *Mobile Water Kit (MWK)* is a smartphone compatible low-cost water monitoring system for rapidly detecting total coliform and *E. coli*. The MWK detected the total coliform within 35 seconds, which is faster than any rapid test methods available in the market.

Pond Guard

(Source: https://eruvaka.com/)

Mobile Water Kit (MWK)

(Source: https://pubs.rsc.org)

AI USED IN DISEASE AND HEALTH MANAGEMENT

Expert system technology, commonly employed in medical diagnostics, is also being used for disease diagnosis and health management in agriculture, animal sciences, and fisheries. The advancement of expert systems in this field highlights the growing dependence on information technology to improve research and development in aquaculture information systems. These systems use a range of parameters, such as visible symptoms, water quality, images of sick fish, and microscopic images, to diagnose fish diseases. The following AI models are used to identify the fish diseases and health conditions in aquaculture. AQUADOC, Fish Doctor, Fish-Vet (all three to diagnosis various fish diseases), SALMEX (to diagnose diseases of farmed salmonid fishes in seawater), SEDIP (to diagnosis diseases in freshwater and seawater fish), FINES (to diagnosis nutritive diseases of farmed fish), HAMES (to diagnosisand treat the farmed tilapia diseases), SEDPA (exclusively for eel disease) and AWQEE-DSS and EWS-FDWQ (both for water quality evaluation and early warning in fish disease occurrence) (Alagappan and Kumaran,2013).

AI USED IN HARVESTING

Harvesting is a crucial aspect in fish farming, as it is a timing consuming and the method of harvesting significantly influence the quality and yield of the fish. AI can enhance this process by evaluating factors such as fish size, weight, water quality, and other relevant parameters. Through predictive algorithms, AI can suggest the best time and method for harvesting to optimize both the quality and yield of the fish (Panda and Baral, 2023).

XpertSea is an AI model developed to enhance the economics of harvesting, a process often based on estimates by farmers. This product employs computer vision and AI to assess shrimp growth, enabling farmers to forecast the most profitable times for harvest. By applying deep learning techniques to historical growth cycle data, the system uses continuous machine learning to accurately determine optimal harvesting periods.

XpertSea

(Source: https://www.xpertsea.com/)

CONCLUSION

Despite advancements in AI, full automation remains unavailable. Researchers are developing various technologies that aimed to operate aquaculture ventures without human intervention. AI-driven aquaculture farms can be managed with 95% operational accuracy, simplifying maintenance. Proper use of AI has the potential to boost the aquaculture production. Therefore, unlike many other industries, AI's application is becoming essential for the future growth and intensification of fisheries and aquaculture.

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