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Invited Review Article

Artificial Intelligence (AI): A prospective frontier area in the field of livestock and aquaculture

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Abstract

Artificial Intelligence (AI) is going to give a shape of future livestock and aquatic farming systems not only in India but throughout the Globe in the very near future. The tools of AI are set to revolutionize farming avocation by incorporating different systems through drones, robots, and intelligent monitoring technology. With rising demand for higher yields from farm and aquatic animals, AI is becoming an indispensable tool in modern farming practices. Considering its tremendous potentiality, various prospects of AI in different animal husbandry sectors, such as as-Automated Milking, Smart Farming for Cows, AI for Health Check-ups, Spotting Reproductive Signs, Rob shots for Cows, Safe Food Journey, Clever Data Collection, Super Food for Dairy animals, Faces that Tell Stories, Cameras that Watch Over Meals were reviewed with various available literature and resources. Simultaneously, prospects and possible applications of AI in various aquaculture sectors like- AI based Aquatic Feeding Devices, Fish Seed Screening, Routine Check-ups of fish seed Stocks, Prevention of Fish Diseases, Processing of Fish, Shrimp Culture and supply Chain, Smartphone Applications, Drones in Aquaculture, Open Sea Fisheries, Endangered Fish Conservation were also explored and reviewed. The study signifies that, with judicious application, AI has the capacity to spur a rapid upsurge in aquaculture and livestock development. So, with the continuous advancement and intensification of the livestock and aquaculture sector, the incorporation of AI appears to be an inevitable and pivotal step. It can be a potential tool to mitigate the ever-increasing protein hunger of the thriving population of the world, there to save them from malnutrition.

Keywords: Aquaculture, Artificial Intelligence, Frontier, Livestock, Prospects

Highlights

- This article is a collective source of information on the present application and status of artificial intelligence in the animal husbandry sector.
- It provides a detailed overview of Artificial Intelligence on frontiers prospects in the livestock sector.
- It enlightens about AI-improved procedures or methods of alled animal husbandry practices for better profitability.
- This explores the prospects and potentiality of AI in the modern fishery sector.
- The facts about the application of AI technology for its general implementation and acceptability in standard livestock and aquaculture Practices.

INTRODUCTION

Artificial Intelligence (AI) by definition means 'the future made from the pieces of past'. These are programs that learn new solutions through experience (Chrispin *et al*., 2020). Artificial Intelligence (AI) is shaping the future of livestock and aquatic farming systems in India. By using AI in animal husbandry and aquaculture, we can smartly identify animals& fishes of different weights and stages, providing tailored feeding methods for better results. This is crucial as the world's population continues to grow and farmers seek smarter techniques to efficiently use land, water, and energy to feed everyone and prevent global food shortages (Kumari and Dhawal, 2021). Experts believe that the key lies in employing sensors, robots, and AI technology. These tools are set to revolutionize farming by incorporating drones, robots, and intelligent monitoring systems. One promising development is a technique that uses a camera and AI to create a "smart" animal house, allowing for precise monitoring of the health of farm and aquatic animals and other animal & aquatic farming systems. This advanced system can detect injuries and illnesses early on, ensuring both the quantity and quality of milk, meat, egg and fish production (Neethirajan, 2020). With the

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rising demand for higher yields from farm and aquatic animals, AI technology is becoming an indispensable tool in modern Husbandry and farming. AI can be an indispensable tool for assessing water quality parameters, controlling stock density, feeding, breeding, disease diagnosis, and farmers' assistance in modern aquatic farm management in future. It's poised to play a pivotal role in ensuring a sustainable and efficient future for animal as well as aquatic farming in Pan India. The present article will study and review various literature systematically to reveal the prospects and potentialities in frontier animal husbandry and aquatic farming practices for its better adoption and strategic application in the near future.

prospects of AI in livestock farming

Automated milking with AI: In modern animal husbandry, artificial intelligence is playing a crucial role in the milking process. Specifically, AI-powered smart sensors are integrated into automated milking units. These sensors have the capability to assess the quality of milk and promptly identify any irregularities or issues with the product (Dongre *et al*., 2017).

Smart farming for cows: The latest advancements in dairy farming have introduced a concept known as "precision livestock farming." This innovative approach incorporates sensors and artificial intelligence to closely monitor dairy animals. These sensors cover a wide range of functions, from detecting heat cycles and calving to providing health updates. For example, the Sense Time Solution sensor observes and records animals' daily activities, including their eating patterns, walking behaviour, and rumination (Singh *et al*., 2015). This data, when coupled with AI software, empowers farmers with proactive solutions tailored to individual animals. It also assists in tracking changes in animal movements, food intake, sleep patterns, and even the air quality within their shelters (Barron *et al*., 2009).

AI for health check-ups: Artificial intelligence serves as a vigilant health monitor for farm animals. It sends real-time alerts to farmers if a cow's behaviour exhibits any unusual patterns. This immediate notification allows for prompt human intervention, ensuring the well-being of the animals (Awasthi *et al*., 2016).

Spotting reproductive signs: An innovative tool involves a collar equipped with motion sensors that cows wear around their necks. This collar continuously gathers a wide range of data about the cow's activities throughout the day. Through the application of artificial intelligence, this collected data is processed to provide insights into critical aspects such as heat stress levels, changes in feeding efficiency, and the identification of the cow's reproductive cycle. The release of specific hormones during the oestrus cycle influences the cow's behaviour and movements (Kuhl and Burghardt, 2013).

RoboShots for cows: In modern dairy farms aiming for sustainable practices and a high compliance rate, robots are employed to administer vaccines and reproductive medicines to domestic animals. This robotic system is seamlessly integrated with the dairy automation system. By reading RFID tags attached to the cow's ear, the robot accesses vital health-related information and vaccination records. If a cow requires an injection, the system guides it to the injection site, ensuring accurate delivery of the medication (Berry *et al*., 2003).

Safe food journey: Blockchain technology is utilized to create a transparent and secure food supply chain. This system traces the journey of food products from the producer to the consumer, guaranteeing safety and authenticity. This level of traceability is especially advantageous in dairy farming, where consumers value knowing the origin and quality of their dairy products (Mateti *et al*., 2022).

Clever data collection: Through the integration of sensors, AI, and other advanced technologies, data collection on dairy farms has become highly individualized. This means that instead of general information for the entire farm, specific data is collected for each cow. This precise data empowers farmers to make informed and accurate decisions regarding the management of their livestock (Fisher and Gould, 2017).

Superfood for dairy animals: Cutting-edge machinery equipped with AI capabilities ensures that the food provided to dairy animals is of the highest quality. These automated systems efficiently harvest crops, taking into account factors like moisture levels and overall yield (Saxena and Parasher, 2019). This significantly speeds up the harvesting process compared to traditional manual methods (Coldewey, 2021).

Faces that tell stories: Facial recognition technology powered by AI holds great promise in understanding and assessing the emotional and intentional state of animals. By closely studying the movements of ears and eyes, farmers can gain insights into an animal's mood and level of excitement with a reasonable degree of accuracy. This technology may also prove instrumental

in managing pain symptoms, identifying injuries and diseases, and even detecting signs of predator attacks (Yongqiang *et al*., 2019).

Cameras that watch over meals: Special cameras equipped with RGB-D technology assist farmers in accurately measuring feed intake for individual cows. This enables farmers to optimize feed expenses based on the specific needs of each animal. Additionally, this technology aids in accurately estimating the performance of farm animals, including their energy expenditure during lactation, taking into account factors such as parity, milk yield component, and body condition score. This precise monitoring helps ensure the well-being and productivity of the livestock (Lim, 2023a and 2023b).

Prospects of AI in aquaculture

AI based aquatic feeding devices: AI-based aquatic feeding devices revolutionize aquaculture by addressing the significant cost of feed, which constitutes around 60% of total expenses. Balancing feeding is crucial; underfeeding can lead to growth issues and aggression, while overfeeding results in wastage and water quality degradation. By employing vibration-based sensors and acoustic signals, AI technology accurately gauges fish appetite, distinguishing between hunger and satiety. This information is then utilized by a precision feed dispenser, releasing the appropriate amount of feed at optimal times. This innovative device slashes feed expenses by approximately 21%, offering precise, data-driven feeding recommendations for farmers. Ultimately, it enhances cost-efficiency while maintaining water quality in aquaculture systems (Huzaifah, 2023).

AI based fish seed screening: The process of identifying and selecting robust fish seed is crucial in fish farming, yet it can be labour-intensive and often requires a substantial workforce. Kindai University's Aquaculture Research Institute in Japan has innovatively employed Microsoft Azure's machine learning studio to automate the identification and removal of irregularly shaped fish seeds directly from the rearing cage (Chiu *et al*., 2022).

AI based routine check-up of fish seed stocks: Utilizing vision-based sensors, AI-powered devices enable the analysis of parameters like swimming behaviour, size, and injuries in cultured fish seed. This data is stored for future reference and comparison. A pioneering aquaculture company, 'Xpertsea,' introduced an AI device named 'Xper-count' which leverages machine learning and cameras to swiftly weigh, count, image, and measure shrimp (Xpertsea, 2023). These gathered metrics are then scrutinized to monitor the ongoing health status of the stock at regular intervals (Darapaneni *et al*., 2022)

AI based prevention of fish diseases: AI-powered programs serve as a crucial tool in averting fish diseases, detecting potential outbreaks by cross-referencing programmed data with real-time site information. A notable example is the introduction of 'Aqua-cloud' by Norway's seafood innovation cluster in April 2017. This cloud-based program has effectively assisted farmers in proactively preventing the proliferation of sea lice in their cages. As a result, it has led to reduced fish mortality rates and decreased reliance on costly treatments (Ahmed *et al*., 2022).

AI in processing of fish: In the processing of fish and shrimp, automation through AI-driven robots has significantly elevated production efficiency, ensuring precise and timely tasks such as cutting, filleting, and cleaning. These programmed robots excel in maintaining high standards of size, shape, and hygiene. Additionally, AI programs equipped with visual image sensors and cameras handle quality control and grading. Following this, the processed products can be efficiently packed and transported by AI robots, eliminating labour costs and the need for constant human supervision (Kidangoor, 2022).

AI in shrimp culture and supply chain: Shrimp Chain has emerged recently to improve the export feasibility of shrimps via a block chain-based traceable and transparent framework (Khan *et al*., 2022). This system is deemed effective in improving the engagement of shrimp farmers in the aspects of certification, quality assurance, and safety of shrimp produce and further exposes them to enhanced control over incentive and high-value markets (Khan *et al*., 2022). With installations in approximately 1,000 hectares of shrimp farms spanning Surat, Goa, Andhra Pradesh and Pondicherry, Eruvaka's an Indian Company innovative products empower farmers with AI-based tools for optimized shrimp culture practices. Walmart Inc introduced a pilot block chain initiative to establish complete traceability in the shrimp supply chain, specifically for exports from Andhra Pradesh to the United States. This endeavour was focused on fortifying the integrity of the shrimp supply chain and augmenting food traceability and transparency for consumers in the United States and other Countries.

AI based smartphone applications: AI-powered smartphone applications offer invaluable assistance to farmers by enabling water quality testing and disease prediction. For instance, Indian aquaculture technology start-up 'Aqua-connect' has developed the mobile app 'Farm MOJO' specifically designed for shrimp farmers. This app empowers farmers to analyse water quality and anticipate potential disease outbreaks, allowing for preventive measures before any issues arise. Regularly, farmers and developers upload images of shrimp diseases and parasites to the app, allowing the program to learn and store this information for future reference (Lau *et al*., 2021).

AI Drones in aquaculture practice: Drones outfitted with advanced sensors are revolutionizing aquaculture practices by efficiently gathering and analysing crucial water quality metrics like turbidity, temperature, dissolved oxygen levels, and even the heart rates of fish. This data is conveniently accessible through a smartphone linked to the drone. Taking innovation a step further, scientists have introduced 'shoal'—a robotic fish designed to detect pollution in the vicinity of the farm. These autonomous robots navigate the waters, acquire vital information on water quality, and even possess the ability to communicate with one another using low-frequency sound waves.

AI in open sea fisheries: In open sea fisheries, the surge in demand due to population growth has led to a rise in overfishing and poaching, particularly through illegal, unregulated, unreported practices. Traditional monitoring methods involve hiring costly observers to oversee fishing activities on ships. However, in challenging locations like the Arctic, observer tracking of IUU vessels becomes difficult. Here, AI steps in as a pivotal solution. By combining satellite technology with AI algorithms, fishing vessels can be effectively monitored through image recognition and automated review of video footage. This breakthrough has the potential to significantly curtail IUU fishing activities and facilitate the restoration of wild fish populations (Microsoft Asia News Centre, 2019).

AI in endangered fish conservation: The decline of aquatic species due to human intervention is a pressing concern, particularly in open sea environments where monitoring is challenging. AI-driven drones equipped with advanced vision sensors and cameras offer a swift and efficient means to track endangered fish and assess their habitats, outpacing human capabilities. Additionally, larger species such as sharks and Humpback whales can be monitored through the strategic placement of transmitters on their fins. This innovative approach streamlines the study of organism behaviour and contributes significantly to more effective conservation efforts (Koparan *et al*., 2018).

Application of AI in livestock and aquatic

These advanced applications of AI in livestock farming are transforming the industry, enhancing the health and productivity of animals, and contributing to a more sustainable and efficient farming future. In the not-so-distant future, drones might become a common sight at our doorsteps, delivering precisely tailored milk compositions based on our health requirements (Pankaj *et al*., 2010). This illustrates how technology is reshaping everyday services. Over the years, technological advancements have made a significant impact on the aquatic and livestock industry, redefining traditional farming practices. According to UN projections, food production will need to increase by a staggering 60% to adequately feed an additional two billion people. The global population is projected to rise from 7.5 billion to 9.7 billion by 2050 (FAO, 2022). This means that farmers will need to produce more with fewer resources. Conventional farming methods alone are insufficient to meet this colossal demand. This challenge is driving livestock farmers and companies to seek innovative ways to boost production while minimizing waste. As a result, Artificial Intelligence (AI) is gradually becoming an integral part of the livestock and aquaculture industry's technological evolution (Aharwal *et al*., 2023).

AI-powered solutions are poised to empower livestock farmers not only to enhance operational efficiencies but also to improve the quantity, quality, and speed of the market of aquatic and livestock products. Machines driven by AI are capable of not just performing tasks but also understanding and analysing information, potentially revolutionizing our way of life. AI, though still in its early stages, holds immense promise. It is anticipated to bring about qualitative progress and innovation, benefiting both individuals and society as a whole. Recent developments in AI have been propelled by interdisciplinary interfaces as well as the availability of massive data sets, particularly in healthcare. India, with its vast IT talent pool, freedom from legacy constraints, high data consumption rates, and rapid digitization across industries, stands as a leading global player in the adoption of AI. A study by Salesforce ranks India third in the Asia Pacific region, after Singapore and Hong Kong, in terms of artificial intelligence readiness. Investors eyeing the Livestock and Aquatic industry have taken note of consumers'

increased spending power and their willingness to pay a premium for fresh and hygienic livestock and aquatic products. This is expected to lead to investments in the sector, driving technological advancements in logistics and farm management. AI, in particular, is a technology that requires immediate implementation in this sectoral industry (Rawat, 2022).

In recent times, as the demand for higher yields from farm animals and fisheries grows, AI has emerged as a powerful tool empowering farmers to monitor, forecast, and optimize the growth of their livestock and fishery sector. While some envision a dystopian future where machines replace humans, others see AI as a revolutionary technology with immense potential, provided it is used judiciously and ethically. There is no denying that Artificial Intelligence is poised to shape the future of future aquaculture and livestock farming practices. Farmers in animal husbandry aim to enhance animal well-being, optimize product efficiency, and implement better production monitoring. Artificial Intelligence (AI) plays a pivotal role in achieving these objectives across various domains of animal farming (Anonymous, 2020 and 2021).

In aquaculture, AI is crucial for optimizing fish farming. Free-floating aqua pods, essential for fish farming, can house thousands of fish. When repairs are required, underwater robots prove efficient, offering a safer and cost-effective solution compared to manual intervention. Drones are utilized both above and below water surfaces for monitoring offshore fish farms, inspecting nets, and providing vital data on fish stocks and environmental conditions. Sensors collect critical data such as oxygen levels, pH, salinity, and pollution levels in water (Leonard, 2023). They also gauge fish hunger levels, facilitating precise feeding strategies. Automated recirculation systems manage water circulation based on sensor data. Looking ahead to 2030, AI-driven advancements promise a highly efficient and precise future for animal and fish farming. Farmers will have real-time access to comprehensive data, revolutionizing decision-making processes. AI is a key driver in transitioning the industry from disease prevention to advanced predictive strategies. This transformative approach underscores the potential of AI and digitalization in revolutionizing the animal husbandry and fishery Sector in India and the Globe.

Conclusion

In conclusion, while AI has made significant strides, full automation remains an ongoing endeavour. Researchers are actively exploring technology capable of operating seamlessly without human intervention. The integration of AI in Livestock and aquaculture farms holds immense potential, offering a remarkable 95% accuracy in operations and substantially simplifying management. With judicious application, AI has the capacity to spur a rapid upsurge in aquaculture and animal husbandry production. Therefore, in the continuous advancement and intensification of livestock and aquaculture, the incorporation of AI appears to be an inevitable and pivotal step forward, distinguishing it from other sectors.

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