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A Review on the Role of Artificial Intelligence in Livestock Health Management

Lalit Kumar [a++*], Kaajal Nainwal [b++], Sanjay [c++], Pooja Nitharwal [a++], Yogendra Kumar Shukla [d#], Rashmi Shukla [e†] and Pulkit Chugh [f]

[a] Department of Livestock Production and Management, School of Agricultural Sciences, Nagaland University, Medziphema Campus, Nagaland-797106, India.
[b] Department of Animal Husbandry & Dairying, Sam Higginbottom University of Agriculture Technology & Sciences, Prayagraj, Uttar Pradesh-211007, India.
[c] Department Livestock Production and Management, College of Agriculture, Bikaner, Rajasthan, 334006, India.
[d] Department of Soil Science, Krishi Vigyan Kendra, RVSKVV, Khandwa, India.
[e] Department of Home Science, Krishi Vigyan Kendra, RVSKVV, Khandwa, India.
[f] Livestock Production Management, LUVAS, Hisar, 125004, Haryana, India.

Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

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[++]Master's Scholar;
[#]Scientist;
[†]STO;
**Corresponding author: Email: lalitbhaisahab@gmail.com;*

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ABSTRACT

Artificial Intelligence (AI) is transforming livestock health management by introducing practices that are guided by data, efficient, and environmentally sustainable. This paper examines how AI technologies are being applied in animal agriculture, emphasizing their contributions to live monitoring, illness detection, behavior tracking, and improving breeding processes. Utilizing machine learning, computer vision, and Internet of Things (IoT) tools, AI supports early health issue identification, enhances animal well-being, and boosts overall productivity. The discussion includes applications like automated health evaluations and advancements in reproductive success, alongside the significant impact of AI in managing poultry. Additionally, the study considers the hurdles of implementing AI, such as substantial costs, information security, and moral implications. In spite of these challenges, AI presents valuable opportunities for the advancement of precision livestock farming by promoting informed decisions and optimized use of resources. The paper finishes by projecting how AI could influence the future of livestock oversight through ongoing research, technological innovation, and supportive policies, all while maintaining ethical and sustainable practices in farming.

Keywords: Artificial intelligence; livestock; health management; environment; IoT; animal agriculture.

1. INTRODUCTION

Livestock farming is an essential component of global agriculture, supplying food, raw resources, and economic security to millions of individuals across the globe. Nevertheless, effective livestock management demands detailed observation of animal health, feed conversion, breeding routines, and disease prevention. In earlier times, these tasks largely depended on manual checks, knowledge-based judgments, and veterinary support. Artificial Intelligence (AI) is transforming livestock health management by allowing real-time surveillance, prompt disease recognition, and analytical decision-making. These advancements improve animal welfare, cut financial losses, and encourage environmentally sustainable livestock farming operations.

With the emergence of Artificial Intelligence (AI), livestock management has undergone a significant transformation. AI-powered systems are changing the landscape of animal health tracking, refining feeding methods, and enhancing overall output. Utilizing machine learning, computer vision, Internet of Things (IoT) sensors, and big data analytics, AI helps farmers make informed decisions that boost both efficiency and sustainability (Deepika et al*.,* 2024). AI-based technologies have been applied in areas like farm design, animal oversight, sustainable resource management, and disease control (Viejo C et al*.,* 2022). Through the use of drones, robotic systems, and smart monitoring tools, AI has been embraced in multiple sectors and is set to transform agriculture (Smith et al*.,* 2006). Researchers have found that smart farming requires AI-enabled robots and software tools equipped with AI modules. These innovations can reduce farming costs while improving product quality. A study led to the creation of a smart cow shed with sensors to track movement, weight, and health using AI (Blanes et al*.,* 2010).

The AI-Driven Animal Farming and Livestock Management System marks a significant step forward in agricultural innovation, aiming to transform conventional farming methods by embedding Artificial Intelligence (AI) into livestock oversight. This abstract outlines the system's broad capabilities, highlighting its importance in assisting farmers with superior livestock management, improving marketing approaches, and delivering a range of advanced features. The foundation of this system lies in its use of advanced AI techniques such as Natural Language Processing (NLP) and Convolutional Neural Networks (CNNs), offering tailored support to farmers to ensure adherence to optimal livestock care standards. With real-time surveillance and analytical tools, it generates practical insights related to animal nutrition, health, and reproductive processes, thus enhancing both livestock well-being and productivity (Kazembe and Mkandawire, 2024). Early detection and tracking functions can identify diseases at initial stages, allowing for timely treatment and helping farmers avoid major financial losses. Numerous AI technologies—like machine learning, deep learning, precision learning, robotics, and computer vision—are increasingly utilized to boost reproductive

performance in farm animals. These AI-driven solutions assist with oestrus recognition, fertility monitoring, and determining the embryonic sex of animals (e.g., chicks). With the rising need for increased livestock output, AI applications in this domain have expanded considerably.

2. KEY APPLICATIONS OF AI IN LIVESTOCK HEALTH MANAGEMENT

2.1 Early Disease Detection

AI sends alerts to farmers when a cow's behavior shifts, allowing for timely human intervention when needed. Monitoring each cow individually in a herd would be extremely difficult without AI. Now, farmers can detect, predict, and prevent disease outbreaks before they become widespread by using advanced artificial intelligence, which is highly effective in identifying anomalies or irregular behavior (Zhou and Yamamoto, 1997). Conditions such as lameness, mastitis, and heat stress are primarily managed through animal monitoring and prevention strategies. Therefore, there is a growing potential to implement CVS systems for detecting and forecasting these conditions. A recent review by Siachos et al*.* (2024) indicated that most current research on automated lameness detection is based on CVS systems. One existing drawback of using CVS for lameness evaluation is the camera positioning, which can affect detection accuracy.

2.2 Behavioral Monitoring

Similar to how animal waste provides clues, the vocal sounds of livestock offer valuable insights into their well-being (Endale, 2011). Irregularities in animal vocalizations can be detected and classified using machine learning models trained on recorded audio data (Neethirajan, 2022). By integrating this auditory information with previously mentioned sources, a farmer can gain a comprehensive understanding of the animals' health status (Mccarthy J., 2004). Live audio feeds can also be utilized to monitor and regulate interactions among livestock (Neethirajan, 2022). This technology empowers farmers to halt the spread of abnormal behaviors and take prompt corrective actions when necessary (Zuraw A. and Aeffner F., 2022). Using AI-analyzed data, farmers can identify livestock with irregular feeding behavior, which may suggest health or behavioral concerns (Tedeschi L. O., 2022). Moreover, farmers can analyze collected data to understand the correlation between specific feed types and the health or weight outcomes of their animals (Ezanno et al*.,* 2021).

2.3 Automated Health Assessments

Monitoring heat stress is an additional method by which artificial intelligence can significantly improve animal welfare (Ezanno et al*.,* 2021). Livestock are often exposed to elevated temperatures due to the overcrowding of animals within limited spaces, which commonly results in negative effects on their physical condition and mental health (Neetson et al., 2008). In order to identify heat stress early and assess the overall health condition, livestock monitoring systems equipped with camera technology are used (Endale, 2006). The sensors integrated within these AI-powered systems are capable of collecting temperature-related data, analyzing temperature variations, and associating them with particular behaviors or physical responses (Rotaru et al*.,* 2021). The machine learning model identifies specific trends that signal an increased likelihood of heat exhaustion and issues an immediate warning when temperature levels reach the predefined danger threshold (Kumari and Dhawal, 2021). Farmers can apply targeted improvements by evaluating the collected data in relation to heat stress conditions (Wang et al., 2022).

2.4 Animal Genetics and Improvement in Breeding Management

AI plays a vital role in breeding management by tracking estrus indicators, hormonal activity, animal health, behavioral patterns, and reproductive background to estimate the most effective time for either artificial insemination or natural mating. Sophisticated algorithms process genetic data to identify animals possessing desirable traits for targeted production goals such as meat, dairy, or egg output, thereby enhancing both breeding accuracy and product quality (Jini et al*.,* 2025). The use of video cameras combined with advanced artificial vision technologies has become a powerful tool for estrus identification in cattle. Employing such visual systems has proven to be an effective strategy. These methods are particularly valued for their easy setup and integration, allowing continuous data collection without directly handling the animals. This not only reduces disturbance but may also lower the cost per animal, as a single device can observe several cows at once (P. Bruyère et al*.,* 2012). A key field where AI is rapidly advancing is genomics—

the analysis of an organism's complete genetic makeup. When DNA can be sequenced and interpreted, AI systems improve speed, cost-efficiency, and accuracy, helping scientists anticipate health risks, identify harmful mutations, and make informed choices about future care (Dias R. and Torkamani A., 2019).

2.5 AI in Poultry Industry

The poultry sector encounters several difficulties, including labor shortages, disease outbreaks, and concerns about animal welfare, all of which can reduce productivity and profits (Caldwell, 2012; Hafez et al*.,* 2020). Technological advancements, especially artificial intelligence (AI), have been suggested to help tackle these issues and meet the growing demand for poultry products (Corkery et al*.,* 2013; Mortensen et al., 2016).

3. MAJOR ROLE OF AI IN POULTRY INDUSTRY

1. Infrared thermal imaging technology has proven to be effective in controlling the ambient temperature in poultry farms while also ensuring the welfare of the birds (Depuru et al., 2024). This non-invasive approach, known as Infrared Thermal Imaging (IRTI), can accurately measure the surface body temperature of birds and identify the early onset of fever, which is often a primary symptom of disease (Ben Sassi et al*.,* 2016).
2. In recent years, there has been growing interest in using artificial intelligence (AI) to optimize environmental conditions, including humidity levels, in poultry houses. AI systems are capable of analyzing temperature, humidity, and other environmental data to identify patterns and perform real-time adjustments to ventilation and control mechanisms (Kumar et al*.,* 2021). This helps maintain optimal humidity conditions and enhances the overall health and productivity of poultry.
3. Artificial intelligence can assist in monitoring and regulating ventilation systems to ensure their efficient functioning. Equipped with sensors, these systems measure air quality, temperature, humidity, and carbon dioxide concentrations. AI can detect and notify farmers of any malfunctions or breakdowns in the ventilation system, allowing for timely intervention. This prevents the buildup of hazardous gases, thereby improving farm safety, air quality, and animal welfare, which collectively enhance productivity (Zhuang et al*.,* 2018).
4. Artificial intelligence can also be used to detect and diagnose diseases in poultry at an early stage. By processing data from various sources—such as body temperature, movement patterns, and vocalizations—AI algorithms can recognize early signs of illness even before they become apparent to human observers. Early detection plays a crucial role in preventing disease spread and improving treatment success rates (Kumar et al*.,* 2022).
5. AI can contribute significantly to the development of new treatments and vaccines for poultry diseases. By examining genetic information and identifying consistent trends in disease progression, AI systems help researchers design targeted treatments and preventive strategies. These methods are often more effective and efficient than traditional approaches (Walsh et al., 2019).
6. The integration of robots in poultry farming offers multiple advantages, such as enhanced productivity, reduced labor requirements, and improved animal welfare. Robots automate routine tasks like egg collection and cleaning, saving time and operational costs. Their use is particularly beneficial in situations of labor scarcity, as they help minimize reliance on human workers.
7. Overall, the application of artificial intelligence and robotics in the poultry sector has proven to be a powerful tool for improving both the health status and productivity of poultry flocks.

4. CHALLENGES AND DRAWBACKS

Despite its many benefits, artificial intelligence also presents several drawbacks, including high development costs and the possibility of automation replacing human jobs (D. A. Isabelle, 2022). Nevertheless, it is essential to recognize that the AI industry could also create entirely new job opportunities that have yet to be conceived (C. G. Viejo et al., 2022). As a result, issues such as job displacement, the significant cost of advanced technologies like drones—which are expensive to manufacture, maintain, and repair—and the substantial data requirements for training

AI systems, all pose considerable challenges (M. Kumari and K. Dhawal, 2021). Additionally, there is a risk that AI tools may be exploited by cybercriminals to access confidential information (J. V. Congdon et al., 2021). In animal agriculture, ethical concerns arise about the potential mistreatment of animals and the morality of using technology to control living organisms. In the context of dairy livestock export, sensors and AI could be seen as intrusive or stress-inducing. Ensuring that sensors provide accurate and consistent data is crucial, as unreliable data may result in poor decisions and unintended consequences (Neethirajan S., 2023).

5. FUTURE PERSPECTIVES

The future of livestock technology offers immense potential to enhance productivity, promote animal welfare, and drive sustainability in agriculture. Smart monitoring tools, including sensors and IoT devices combined with sophisticated analytics, deliver real-time data on animal health and environmental factors. Precision livestock farming, utilizing AI and automation, holds promise for improving feeding systems, health tracking, and breeding efficiency. Ongoing research into nutrition and feed utilization, especially through alternative ingredients and precise feeding strategies, is vital for minimizing ecological impact while safeguarding animal well-being. Innovations in health care, such as early diagnostic tools and more effective vaccines, lead to stronger livestock populations. Sustainability continues to be a priority, with goals to reduce emissions and develop advanced waste management techniques. AI-enabled behavioral tracking and well-designed housing systems improve animal conditions and uphold ethical practices. Enhancing supply chains with blockchain and smart logistics increases both efficiency and transparency. Industry partnerships and farmer education are essential for adopting and benefiting from these technologies.

6. CONCLUSION

In summary, Artificial Intelligence is transforming livestock health management by introducing advanced tools that enhance animal well-being, boost productivity, and promote sustainable agricultural methods. Although some ethical and technical challenges remain, the advantages of AI in this field are clear. Ongoing investment and cross-sector cooperation can greatly strengthen the future of livestock farming through AI integration.

DISCLAIMER (ARTIFICIAL INTELLIGENCE)

Author(s) hereby declare that generative AI technologies such as Large Language Models, etc. have been used during the writing or editing of manuscripts. This explanation will include the name, version, model, and source of the generative AI technology and as well as all input prompts provided to the generative AI technology.

Details of the AI usage are given below:

1. Chat GPT

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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