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Transforming Livestock with AI: Technological Breakthroughs

Rushikesh Ramchandra Kore[1], Rushikesh R. Sathe[2], D. K. Deokar[3], D. K. Kamble[4]
And **U. S. Gaikwad[5]**

[1]Ph.D. Scholar, Department of Animal Husbandry and Dairy Science, PGI,
Mahatma Phule Krishi Vidyapeeth, Rahuri.

[2]Ph.D. Scholar, Department of Animal Husbandry and Dairy Science, PGI,
Mahatma Phule Krishi Vidyapeeth, Rahuri.

[3]Associate Professor, Department of Animal Husbandry and Dairy Science, PGI, MPKV, Rahuri

[4]Head, Department of Animal Husbandry and Dairy Science, PGI, MPKV, Rahuri

[5]Associate Professor, Department of Animal Husbandry and Dairy Science, PGI, MPKV,

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Abstract

The livestock sector is under increasing pressure to meet the rising global demand for animal derived products while addressing challenges related to resource limitations, sustainability, animal welfare and economic efficiency. In this context, Artificial Intelligence (AI) has emerged as a transformative technological tool for improving productivity, resilience and decision making in livestock systems. AI involves computer-based systems capable of learning from data, recognizing patterns and supporting predictive and automated actions, driven by advances in digital connectivity, sensor technologies, big data analytics and machine learning. AI based technologies such as automated milking systems, robotic feeders, wearable sensors, rumen monitoring devices, estrus detection systems, drones and GPS–RFID tagging enable precision livestock farming through real-time monitoring of animal health, behavior, nutrition and productivity. These tools support early disease detection, optimized feeding and breeding, improved animal welfare and reduced production losses.

In India, AI adoption aligns with initiatives have some constraints such as small herd sizes, high costs and limited digital literacy, AI holds strong potential for sustainable and efficient modernization of Indian animal husbandry.

Key words: Artificial Intelligence (AI), livestock, GPS, RFID, Milking machine.

Introduction

The livestock and animal husbandry sector is currently going through an important phase of change. This shift is mainly due to rapid population growth, changing food habits and increasing pressure on natural resources. As the global population continues to rise, the demand for animal-based products like milk, meat, eggs and wool is also expected to grow significantly. In fact, it is estimated that this demand may increase by around 70% in the coming decades. This increase is especially noticeable in developing countries, where urbanization and higher income levels are influencing people's diets. However, meeting such high demand using traditional farming methods alone creates serious challenges related to sustainability, animal health, environmental protection and cost efficiency.

At the same time, the world is becoming more digitally connected than ever before. A large portion of the global population now uses smartphones and has access to the internet. This has made it easier to collect, share and use information quickly. Even rural areas and farming communities are becoming part of this digital network. As a result, livestock farmers now have access to various modern tools such as mobile apps, sensors, automated machines and cloud-based systems. These technologies are slowly changing the way farming activities are carried out (Russell & Norvig, 2021).

In this situation, Artificial Intelligence (AI) is emerging as a powerful solution for improving livestock management. AI refers to machines or computer systems that can perform tasks that usually require human thinking, such as learning, decision-making and problem-solving (Kamilaris *et al*., 2017). These systems work by collecting data from their surroundings, analyzing it using algorithms and then providing useful outputs or suggestions. In simple terms, AI acts like an intelligent assistant that helps farmers make better decisions.

In the field of animal husbandry, AI can be used to monitor animals and farm conditions continuously. It collects data through tools like cameras, sensors and wearable devices attached to animals. Based on this data, AI systems can help farmers manage feeding schedules, improve breeding practices, detect diseases early and maintain proper housing conditions (FAO, 2020). This not only improves productivity but also ensures better animal welfare.

Overall, the use of AI in livestock farming is closely linked with the goal of creating more sustainable and efficient farming systems. By combining digital technology with intelligent data analysis, AI can help overcome the gap between increasing demand and limited resources. Therefore, AI is not just a modern technology, but an important tool that can support food security, improve farmers' income and promote responsible livestock farming in the future.

Benefits of Artificial Intelligence (AI)

Artificial Intelligence (AI) is bringing many positive changes to the livestock sector, especially by making farm management more efficient and accurate. One major advantage is the use of automated feeding systems. These systems can decide the right type and quantity of feed for animals based on their age, health condition and stage of production. This helps in reducing unnecessary feed wastage and improves overall efficiency. In a country like India, where feed costs make up around 60–70% of total livestock expenses, such improvements can make a big difference for farmers.

Another important benefit of AI is precision livestock monitoring. With the help of modern tools like sensors, cameras and wearable devices, farmers can keep track of their animals at all times. These technologies provide real-time information about animal movement, behavior and productivity. This is useful not only for large commercial farms but also for small farmers, as it helps them manage their animals more effectively and with less effort.

AI also plays a key role in maintaining animal health. It can detect early signs of diseases by studying changes in animal behavior and body conditions. For example, it can identify problems like mastitis, lameness or heat stress before they become serious. Early detection allows farmers to take quick action, which reduces treatment costs and prevents major losses (World Bank, 2021). This is especially helpful in India, where veterinary services are not easily available in all areas.

In addition to this, AI-based predictive tools help farmers plan ahead. By analyzing past and current data, these systems can predict possible disease outbreaks, future milk production and even risks related to animal mortality. This kind of information supports better planning and reduces uncertainty in farming activities.

AI is also improving breeding practices. It helps in selecting better-quality animals by analyzing genetic information and identifying the best traits. It can also assist in detecting the right time for breeding, which increases the success rate. These advancements support government initiatives like the National Artificial Insemination Program (NAIP), making them more effective.

Lastly, AI helps farmers and experts make better decisions. Decision support systems provide useful suggestions based on data, which helps in improving productivity, maintaining animal welfare and using resources wisely. Overall, AI has the potential to bring major improvements in India's livestock sector and support the livelihoods of millions of farmers who depend on it.

Framework of Artificial Intelligence (AI) in Animal Husbandry in India

The use of Artificial Intelligence (AI) in animal husbandry in India can be better understood through an integrated framework where technology, institutions and people all work together. This approach focuses on creating a well-connected system that supports smart and data-based livestock management across different types of farms in the country. At the core of this framework is a strong AI ecosystem that brings together various tools and platforms. One important part of this system is the National AI Portal, which acts as a central hub for information and coordination. It provides access to research, government policies, datasets and practical examples related to AI in agriculture. This platform encourages collaboration between researchers, startups and policymakers, helping in the development of new AI-based solutions for the livestock sector.

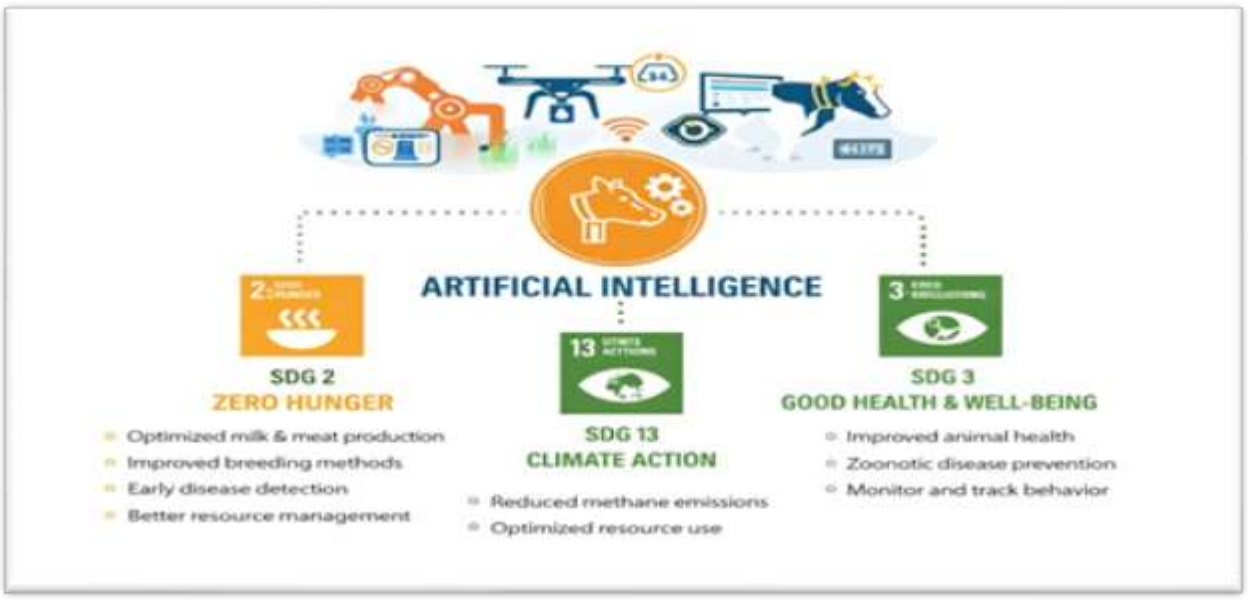
Another key element is digital infrastructure. Technologies like internet connectivity, cloud storage and livestock databases play a major role in supporting AI applications. Systems such as animal identification and tracking help in collecting and managing important data. This is especially useful in rural areas of India, where digital development is gradually improving and creating new opportunities for farmers.

AI systems also depend heavily on data collected through modern devices. Tools like sensors, cameras and IoT-based equipment are used to monitor animals in real time. These devices collect information about animal health, feeding patterns, behavior and surrounding environmental conditions. This data is then analyzed using machine learning techniques, which can identify patterns and provide useful insights. As a result, farmers can benefit from applications such as early disease detection, heat identification, prediction of milk production and better feeding management. In addition, AI-based predictive models are very helpful in handling risks. They can give early warnings about possible disease outbreaks, drops in productivity or stress caused by climate conditions. These features are very important for Indian farmers, who often face challenges due to changing weather and limited resources.

However, technology alone is not enough. Training and skill development are equally important parts of this framework. Farmers, veterinarians and extension workers need proper guidance to understand and use AI tools effectively. Providing education and training helps reduce the digital gap and ensures that even small farmers can benefit from these advancements. Overall, this integrated framework shows that the successful use of AI in animal husbandry depends on a combination of advanced technology, proper infrastructure and skilled people. When all these elements work together, they can help improve productivity, ensure animal welfare and support sustainable livestock farming in India, in line with national development goals (NITI Aayog, 2018).

Basic Tools Required for Artificial Intelligence (AI) in Livestock

To successfully use Artificial Intelligence (AI) in livestock farming, it is important to understand the basic technologies that support it. AI does not work alone; it depends on a group of tools that collect data, analyze it and help farmers take better decisions. These tools turn simple farm observations into useful and practical information. One of the most important components is the use of sensors and IoT (Internet of Things) devices. These devices continuously gather real-time data about animals, such as their body temperature, movement, eating habits and surrounding environmental conditions. According to Indian Council of Agricultural Research



(2021), such technologies form the base of AI systems in agriculture. In many Indian dairy farms, wearable devices like smart collars are now being used. These help farmers monitor important factors like heat stress and estrus in animals, especially in high-producing cows and buffaloes.

The data collected from these devices is then processed using data analytics software. This software uses machine learning techniques to study patterns in the data. It can predict diseases at an early stage, estimate milk production and suggest better feeding plans. This helps farmers improve productivity while reducing losses. Another emerging technology in this field is the use of drones and imaging tools. These are mainly used in large farms and gaushalas. Drones can capture images from above, which helps in observing herd movement, checking pasture conditions and managing farm infrastructure. This is especially useful in regions where animals are raised in open grazing systems, such as dry and semi-arid areas of India.

AI-powered cameras are also becoming important in livestock management. These cameras use computer vision to study animal behavior. They can identify problems like lameness, track individual animals and monitor their daily activities. This not only improves animal welfare but also reduces the need for constant human supervision. Finally, mobile applications play a key role in connecting farmers with AI technology. These apps act as an easy interface where farmers can receive advice, health alerts and market information. Many apps in India provide services in local languages, making them more accessible for small and marginal farmers. They also offer features like tele-veterinary support, which is very helpful in rural areas. Overall, all these technologies work together to support precision livestock farming. They help in improving efficiency, reducing risks and making farming more scientific. When properly combined, these tools can make AI adoption easier and more beneficial for different types of livestock systems across India.

AI contribute to meet SDG

Artificial Intelligence (AI) is playing an important role in helping the livestock sector contribute to major Sustainable Development Goals (SDGs), especially in a country like India where animal farming supports both food supply and rural livelihoods. AI-based technologies are not only improving productivity but also making livestock farming more sustainable and efficient.

One of the key areas where AI is making a difference is in achieving **Zero Hunger (SDG 2)**. According to United Nations (2015), improving food production systems is essential for ensuring food security. In India, livestock products such as milk, eggs and meat are important sources of nutrition for a large population. AI helps farmers increase production by using techniques like smart feeding systems, better breeding methods and continuous health monitoring. It also reduces losses caused by diseases and poor farm management. As a result, food becomes more available and affordable, which supports both nutritional security and the income of small farmers.

AI also supports **Good Health and Well-being (SDG 3)** by improving disease management in animals. With the help of AI tools, farmers and veterinarians can detect diseases at an early stage and take quick action. These systems can monitor and predict the spread of serious diseases like brucellosis, tuberculosis and avian influenza. This is very important in India, where close contact between humans and animals is common. By controlling animal diseases, AI also helps protect human health, following the "One Health" approach that connects human, animal and environmental health.

Another important contribution of AI is towards **Climate Action (SDG 13)**. Livestock farming is often linked with environmental challenges, such as greenhouse gas emissions and high use of natural resources. AI helps reduce these impacts by improving feed efficiency and lowering methane emissions. It also helps farmers use water, land and other resources more wisely. In addition, AI-based tools can predict problems like heat stress, drought and changes in productivity caused by climate change. This helps farmers prepare in advance and reduce risks, which is very important in a country like India where climate conditions are becoming more unpredictable.

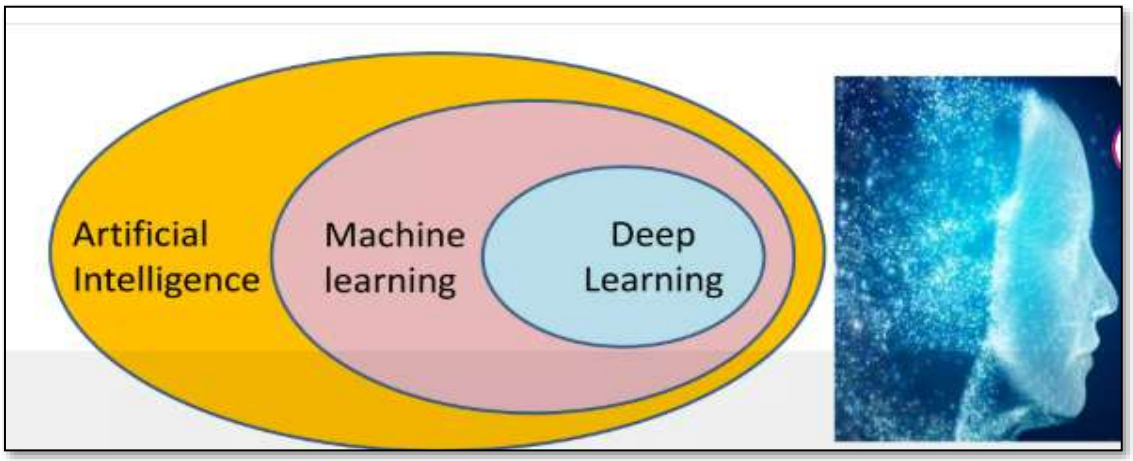
Indian government schemes of Artificial Intelligence in Animal Husbandry

India has introduced several important schemes to improve and modernize its livestock sector. According to the Department of Animal Husbandry & Dairying (2021), these initiatives show the country's long-term plan to strengthen animal husbandry, which is a major source of income for rural families and an important part of the agricultural economy. One of the key programmes is the Nationwide Artificial Insemination Programme (NAIP). This scheme focuses on improving the quality and productivity of cattle and buffaloes through better breeding practices. When modern AI tools are used along with this programme, such as heat detection systems and data-based performance tracking, the success rate of breeding improves. It also helps reduce problems like failed conception, which is a common issue in traditional methods.

Another important scheme is the Rashtriya Gokul Mission, which aims to protect and improve native breeds of cattle. AI technologies can support this mission by helping in better identification of breed characteristics and selecting high-quality animals based on scientific data. This makes the process more accurate and helps in preserving valuable indigenous breeds. The National Digital Livestock Mission (NDLM) plays a major role in building a digital system for livestock management. It includes creating unique identification for animals and maintaining large databases. These records are very useful for applying AI tools, as they provide the data needed for tracking diseases, predicting production and planning policies at a national level.

In addition, the Digital Agriculture Mission supports the use of digital technology across farming sectors. It encourages the use of AI, data sharing and digital platforms to improve farming services and help farmers make better decisions. At the village level, schemes like MAITRI help bring these technologies directly to farmers. These trained workers assist in providing breeding services and spreading awareness about modern tools. Similarly, digital platforms such as e-Pashu offer services like online advice, veterinary support and market information, making it easier for farmers to access important resources.

Concept and Techniques of Artificial Intelligence



In animal husbandry, Artificial Intelligence (AI) helps farmers and experts understand large and complex data in a more scientific way. It supports better decision-making in important areas such as animal health, feeding practices, breeding and overall productivity. AI works as a broad field, and within it there are smaller areas like Machine Learning (ML) and Deep Learning (DL), which perform more specific tasks (Russell & Norvig, 2021).

Machine Learning is a part of AI that allows computer systems to learn from data and improve over time without being directly programmed for every task. It uses past records as well as current data to find patterns and make predictions. In livestock farming, ML can analyze information such as milk production, breeding history, feed consumption and weather conditions. This is especially useful in India, where farming systems are very diverse and many farmers manage small herds. With the help of ML, farmers can predict productivity based on breed, identify early signs of diseases and get useful suggestions for improving dairy and poultry farming.

Deep Learning is a more advanced part of Machine Learning. It uses artificial neural networks, which are designed to work somewhat like the human brain. These systems are very effective when working with images, videos and sensor-based data. In the livestock sector, Deep Learning can be used for tasks like identifying animals, detecting diseases through images and studying animal behavior. For example, camera-based systems can monitor animals and quickly identify signs of illness or stress. In India, such tools can be very helpful, especially in areas where resources are limited, as they reduce the need for constant manual supervision while still improving animal care and farm productivity. Overall, AI, along with its subfields ML and DL, provides a strong technological base for modern livestock farming. It helps convert raw data into useful knowledge, making farming more efficient, accurate and sustainable.

Different Types of Artificial Intelligence

Artificial Intelligence (AI) can be divided into different types based on how advanced and independent the systems are. This classification helps us understand how AI is used today and what it might do in the future, especially in areas like livestock and animal husbandry (Russell & Norvig, 2021).

The first type is **Artificial Narrow Intelligence (ANI)**, which is also called weak AI. These systems are designed to perform only specific tasks and cannot think beyond their given functions. They do not have human-like understanding but are very efficient in the work they are trained for. Most of the AI tools used in livestock farming today fall under this category. For example, machines used for automatic milking, smart feeding systems and sensors that detect heat in animals are all ANI-based. Even voice assistants like Amazon Alexa can be connected with farm systems to help manage tasks. In India, such technologies are slowly becoming popular, especially in organized dairy farms, where they help in predicting milk production, identifying diseases like mastitis and improving feeding practices.

The second type is **Artificial General Intelligence (AGI)**, also known as strong AI. This type of AI is expected to have the ability to learn and perform any intellectual task that a human can do. Unlike ANI, it can apply knowledge to different situations and adapt to new problems. However, AGI is still under development and has not yet been fully achieved. If developed in the future, it could completely change livestock farming. For example, it might be able to manage an entire farm by combining information about animal health, nutrition, breeding, weather conditions and market trends, similar to how an experienced farmer or veterinarian works.

The third type is **Artificial Super Intelligence (ASI)**, which is a theoretical concept. It refers to machines that would be more intelligent than humans in every aspect, including thinking, creativity and decision-making. At present, ASI does not exist, but it is often discussed in research and future studies. In the context of animal husbandry in India, ASI raises important questions about ethics and responsibility. It is important to ensure that such advanced technologies, if developed, are used to support farmers and improve animal welfare rather than replace human involvement completely.

Overall, these three types of AI show how technology is evolving from simple task-based systems to more advanced and intelligent ones. Understanding this helps in planning how AI can be safely and effectively used in the livestock sector.

Artificial Intelligence Applications in Animal Husbandry

AI applications in animal husbandry encompass electronic sensors, electronic data processing and machine learning algorithms. These technologies enable continuous monitoring, predictive analytics and automated interventions in livestock systems.

Automatic Milking Systems:

The Automatic Milking System (AMS) is a good example of how Artificial Intelligence (AI) is being used in modern dairy farming. It is an advanced system that allows cows to be milked automatically with very little human effort. In this system, special milking cups fitted with sensors are attached carefully to each teat of the cow. AI-based control systems help in placing these cups correctly and managing the milking process smoothly. The system also keeps track of milk flow and adjusts the process according to the condition of each animal, which helps in reducing stress and keeping the cows comfortable (Berckmans, 2017).

Another important feature of AMS is its automatic cleaning process. Before and after milking, the system cleans and sanitizes the teats properly. This helps in maintaining hygiene and reduces the chances of infections. It is especially useful in preventing diseases like mastitis, which is very common in dairy animals. AMS also includes sensors and imaging tools that check the quality of milk during the milking process. These tools can detect changes in colour, the presence of dirt or any abnormal condition in the milk. If the system finds that the milk is not suitable for consumption, it automatically separates it from the good quality milk. This ensures that only safe and clean milk reaches the market.

Overall, the Automatic Milking System makes dairy farming more efficient, hygienic and animal-friendly. It not only saves time and labour but also improves milk quality and animal health, making it a valuable technology in today's dairy industry.

Automatic Robot Feeders:

Automatic robot feeders are a useful example of how Artificial Intelligence (AI) and automation are being applied in modern livestock farming. These systems are designed to provide animals with the right type and quantity of feed based on their nutritional needs. By using sensors, fixed feeding schedules and smart algorithms, the feeders can supply balanced rations at the correct time. This helps in reducing feed wastage, improving digestion and increasing overall productivity. As a result, animals stay healthier and farmers can manage feeding more efficiently (Wathes *et al*., 2008).

Another advantage of these systems is that they reduce the need for constant manual work. Farmers do not have to monitor feeding all the time, as the system works automatically and ensures that each animal gets proper nutrition. This is especially helpful in large farms where managing feeding manually can be time-consuming and less accurate. Apart from feeding, robotics is also used to maintain cleanliness in animal housing areas. Special robots, known as scraper robots, are used to clean barn floors. These robots move along passages and

remove manure by pushing and scraping it away. They are equipped with AI-based navigation systems, which allow them to move on their own, avoid obstacles and clean efficiently without human support. Overall, automatic robot feeders and cleaning robots make livestock farming more organized, hygienic and efficient. They not only save time and labour but also improve animal welfare and farm productivity, making them an important part of modern farming systems.

Walking and Motion Activity Monitoring:

Pedometer-based activity monitoring is an important example of how Artificial Intelligence (AI) is being used in modern livestock management. In this method, small devices called pedometers are attached to the legs of dairy animals. These devices continuously track the animal's daily movements, such as walking, standing, lying down, feeding and even milking activities. According to Indian Council of Agricultural Research (2019), such tools are useful for collecting detailed information about animal behavior.

In AI-supported systems, the data collected from pedometers is analyzed using algorithms. These systems compare normal and abnormal patterns in animal activity. If there is any unusual change, the system can quickly alert the farmer. One of the most important uses of this technology is the early detection of lameness. In many cases, animals show slight changes in movement before clear symptoms appear. AI can identify these small changes early, allowing farmers to take action before the condition becomes serious. This helps in improving animal health and reducing treatment costs. The use of pedometer data along with AI platforms supports precision dairy farming. It helps farmers monitor the overall health of the herd more accurately and maintain better productivity. Healthy animals tend to produce more milk, so this technology also contributes to improved milk yield.

Animal Behaviour Sensors:

Animal behaviour sensors play a very important role in the use of Artificial Intelligence (AI) in animal husbandry. These sensors help farmers observe animals continuously in a way that is not possible through manual monitoring, especially when there are many animals in a herd. They collect real-time information about animal activities and convert it into digital data. This data can then be studied using machine learning techniques to understand patterns and detect any unusual behaviour (Rutten *et al*., 2013).

Different types of sensors are used to measure various behavioural and physical activities of animals. For example, sensors that track head movement and angle can help identify when an animal is eating, drinking or chewing cud. Similarly, sensors attached to the legs can record movement and step count, which is useful for detecting heat (estrus), changes in walking patterns and early signs of lameness. Monitoring activities like chewing, biting and swallowing also helps in estimating how much feed the animal is consuming and how efficiently it is digesting it. In addition to behaviour, some sensors measure physical conditions such as body weight, heart rate, body temperature and even sounds made by the animal. These indicators are helpful in identifying stress, illness or metabolic problems at an early stage. Early detection allows farmers to take quick action, which improves animal health and reduces losses.

Rumen pH and Rumen Temperature:

Rumen pH and temperature monitoring is an advanced example of how Artificial Intelligence (AI) can be used to improve the health and productivity of dairy animals. In this system, special sensors are used in the form of small boluses that animals swallow. These sensors stay inside the rumen for a long time and continuously record important information like pH level, temperature and pressure. The collected data is then sent wirelessly to a central system, where AI algorithms study it and identify any unusual changes (AlZahal *et al*., 2007).

One of the most useful features of this technology is the monitoring of rumen pH. The pH level helps in understanding the digestive condition of the animal. If the pH becomes too low, it may lead to a condition called ruminal acidosis, which is quite common in high-producing dairy animals that are fed more concentrated feed. Continuous monitoring makes it possible to detect subacute ruminal acidosis (SARA) at an early stage, which is otherwise difficult to identify using normal clinical methods. Rumen temperature is another important indicator of animal health. Changes in temperature can signal problems such as fever, reduced feed intake or

irregular drinking habits. By tracking these changes, farmers can quickly understand if an animal is facing any health issue and take necessary action in time.

Estrus Detection Systems:

Detecting estrus (heat) in dairy cows has become more challenging in recent years. This is mainly due to changes in housing systems, less time for direct observation and differences in animal behaviour under modern farming conditions. When farmers miss the correct heat period, it can lead to late insemination, lower chances of pregnancy and longer gaps between calving. All of this reduces farm productivity and causes financial losses. To solve this problem, modern farms are using 3D accelerometer-based sensors. These devices are attached to parts of the animal such as the neck, leg or ear and continuously track movement. During the estrus period, cows usually show clear behavioural changes like increased activity, restlessness, mounting other animals and changes in walking patterns (Roelofs *et al*., 2010). These sensors record such movements throughout the day without interruption.

The data collected by accelerometers is then analysed using Artificial Intelligence (AI) and machine learning techniques. These systems are trained to identify the difference between normal daily activity and behaviour related to estrus. Once the system detects signs of heat, it sends alerts to farmers or veterinarians. This helps them take timely action for insemination, which improves the chances of successful breeding.

Use of Drones:

Drones, also called unmanned aerial vehicles (UAVs), are becoming very useful in livestock farming with the support of Artificial Intelligence (AI). These devices are fitted with high-quality cameras, GPS systems and smart image analysis software. With the help of these features, drones can monitor animals over large grazing areas without the need for constant human supervision. Farmers can easily track the location of their cattle, check herd movement and even guide animals back to safer areas when needed. This saves time and reduces labour, especially in large open fields (Kamilaris *et al*., 2017).

Apart from tracking animals, drones are also helpful in managing grazing land. They can capture aerial images of pastures, which gives a clear view of grass availability, land condition and vegetation quality. When these images are analysed using AI and machine learning, farmers can understand how much fodder is available and plan grazing accordingly. This helps in avoiding overgrazing and keeps the land healthy for future use. In India, drones can be especially useful because many farmers still depend on open grazing systems. In states like Rajasthan, Gujarat and Maharashtra, livestock is often raised on common grazing lands or through migratory systems. In such conditions, managing animals can be difficult and time-consuming. Drone technology can make this work easier by improving monitoring and reducing the need for manual tracking.

For small farmers and pastoral communities, AI-based drones can improve animal safety, reduce the risk of animals getting lost and help in better use of natural resources. With growing government support for drone use in agriculture, this technology has strong potential to improve productivity, support animal welfare and make livestock farming more sustainable in India.

GPS and RFID tagging systems:

GPS and RFID tagging systems are very important tools for collecting data in Artificial Intelligence (AI)-based livestock management. These technologies help in giving every animal a unique identity, which is necessary for managing animals in a more accurate and scientific way. RFID tags act like digital IDs that stay with the animal for a long time. With the help of these tags, farmers can record details such as milk production, feeding patterns, health condition and breeding history for each individual animal.

When GPS devices are used along with RFID, the system becomes even more powerful. GPS helps in tracking the exact location and movement of animals at all times. It can provide information about grazing habits, distance travelled, resting time and general activity levels. This movement data can also give indirect clues about the animal's health, such as stress levels or unusual behaviour. GPS tracking is especially useful in large grazing areas where animals are spread out. It helps farmers quickly locate animals, prevent theft and manage grazing

more effectively. In case of emergencies, such as illness or injury, animals can be found easily without wasting time (Trotter *et al*., 2010).

In India, many farmers still follow extensive or semi-intensive livestock systems, where animals are often kept in open areas. In such conditions, GPS and RFID technologies can greatly improve herd management and tracking. When these tools are connected with AI systems and mobile applications, farmers can receive real-time updates and useful insights about their animals. These technologies also support government efforts related to animal identification, disease control and improving productivity. Overall, GPS and RFID systems create a strong base for smart livestock farming by helping farmers make better decisions using accurate and real-time data.

Smart Precision Farming:

Smart precision farming is an advanced approach in livestock management where farmers use modern technologies to closely monitor each animal. In this system, different types of sensors and wearable devices are used to collect real-time information about animals. These include data on body temperature, eating habits, rumination, physical activity, milk production and reproductive behaviour. This information is then processed using Artificial Intelligence (AI), which helps farmers understand the condition of their animals and make better decisions.

One of the main advantages of Precision Dairy Farming (PDF) technologies is that they reduce the need for manual work. Many routine tasks, such as observing animal health or detecting heat, can be done automatically. This is very useful in India, where most livestock farming is done by small families who often face labour shortages and increasing costs. AI-based tools can quickly identify problems like diseases, low productivity or breeding issues at an early stage, which helps in reducing losses and improving farm income (Berckmans, 2017). Another important benefit of smart precision farming is that it converts complex biological data into simple and useful information. Farmers can easily understand this information and take timely action. For example, if an animal shows signs of stress, infection like mastitis or reproductive problems, the system can alert the farmer early. This helps in giving proper treatment on time, reducing veterinary expenses and improving milk production.

Farm Management:

An AI-based Farm Management System (FMS) is a modern solution that helps farmers manage their livestock more efficiently by using data from different sources. In this system, information collected from sensors and monitoring devices is brought together on a single platform. This allows farmers to continuously observe important factors like animal health, feeding patterns, behaviour, milk production and daily activity. According to Rutten *et al*. (2013), such systems help convert raw data into useful insights, making it easier to detect diseases early, manage reproduction and improve feeding and milking practices. A key feature of these systems is the use of smart animal trackers. These small devices can be attached to different parts of the animal's body, such as the ear, neck, leg or tail. They collect data on movement, rumination, body temperature and other physical conditions. AI algorithms then study this data and identify any unusual changes. For example, the system can send alerts if an animal is showing signs of illness, coming into heat, nearing calving or producing less milk than usual. Some well-known systems like Herdman, smaXtec, Moocall and Smartbow show how these technologies can improve overall farm management and animal care.

In India, where most dairy farming is done by small farmers and depends heavily on manual labour, AI-based FMS can be very helpful. These systems connect traditional farming with modern technology. Many platforms now offer mobile-based dashboards in local languages, making them easier to use for farmers. This helps farmers, dairy cooperatives and veterinarians take quick and informed decisions.

Limitations of Artificial Intelligence in Animal Husbandry

1. The key limitations affecting the adoption of Artificial Intelligence (AI) in animal husbandry, with particular relevance to developing countries such as India is mentioned here. Although AI technologies offer promising solutions for precision livestock management, their adoption rate remains low, especially at the grassroots level.
2. One major constraint is the small herd size typical of Indian dairy farms, where farmers own two to five animals. For such farmers, the high initial investment required for sensors, software and data services often outweighs the perceived benefits.
3. Another critical limitation is the lack of clearly demonstrated field level impacts, especially under diverse agro-climatic and management conditions. Many AI tools are validated under controlled or large-scale commercial farms, making farmers hesitant to adopt them without proven local success stories. Poor availability of AI tools, limited digital infrastructure and computer illiteracy further restrict effective utilization. Additionally, the unavailability of local technical expertise for installation, maintenance and interpretation of AI-generated insights reduces farmer confidence.
4. This also emphasizes the challenge of skill diversity, as AI-based systems require interdisciplinary knowledge spanning animal science, data analytics and information technology. In the Indian context, addressing these limitations will require low-cost, scalable AI solutions, capacity-building programs, local language interfaces and strong extension support. Overcoming these barriers is essential for inclusive and sustainable adoption of AI in Indian livestock systems.

Strategies to Overcome Challenges

1. Here are a key strategies and approaches to overcome the challenges associated with the adoption of Artificial Intelligence (AI) in livestock and animal husbandry. One important strategy is the effective use of mass media, including television, radio, mobile platforms and social media, to disseminate information about AI-based technologies, their benefits and success stories. This helps in building trust and improving acceptance among farmers.
2. It also emphasizes the creation of multidisciplinary teams, bringing together animal scientists, veterinarians, engineers, data scientists and extension professionals. Such collaboration is essential to develop AI tools that are technically sound, biologically meaningful and farmer friendly. Another crucial approach is creating awareness through appropriate extension methods, such as on field demonstrations, farmer field schools and cooperative based outreach, ensuring that technologies are adapted to local farming conditions.
3. Capability building training programmes are vital to enhance digital literacy and technical skills among farmers, extension workers and veterinarians. Training ensures effective use and maintenance of AI-based tools. Furthermore, digital infrastructure development, including internet connectivity, cloud platforms and affordable smart devices, forms the backbone of AI adoption.

Conclusion

1. AI has the potential to transform the livestock sector by enhancing productivity, animal welfare, and sustainability, ultimately improving the livelihoods of farmers and stakeholders.
2. To realize AI's benefits, it's crucial to address challenges such as data infrastructure, farmer awareness, and accessibility to ensure equitable adoption and maximize impact.
3. By harnessing AI responsibly, the livestock sector can contribute significantly to India's food security, economic growth, and sustainable development, paving the way for a more efficient and resilient agricultural future.

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