Biological Times

Volume No. 5 | Issue No. 8 | Pages 21-22

Precision Livestock Farming (PLF): A Future of Dairy and Livestock Farming in Pakistan

Rana Muhammad Shahbakht[1], Zubair Azhar Nomi[1], Muhammad Zeeshan Anwar[2*], Shehryaar Shahid[2] and Muhammad Rehan[3]

1. Faculty of Veterinary and Animal Sciences, Muhammad Nawaz Shareef University of Agriculture, Multan, Pakistan
2. Department of Livestock Production, PMAS-Arid Agriculture University, Rawalpindi
3. Institute of Animal and Dairy Science, University of Agriculture, Faisalabad, Pakistan

*Corresponding Author: **Zeeshan.anwar@uaar.edu.pk**

ABSTRACT

Precision Livestock Farming (PLF) is a rapidly evolving management strategy for livestock that brings together engineering, animal science, information technology and artificial intelligence (AI) to enable continuous, automated and personalized management of livestock. Instead of relying on traditional herd management, PLF uses wearable sensors and biosensors, computer vision, the Internet of Things (IoT), and robotics and machine learning algorithms to provide real-time data on animal health, behavior, reproduction, productivity and environmental conditions. These technologies help to detect disease early, monitor animals' reproductive status, assess their welfare status and also aid in management of feed and water – all of which enhance production efficiency with fewer labour hours, less environmental impact and fewer antimicrobials. In the dairy and livestock sectors, the implementation of PLF has been gaining momentum due to rising global awareness about food security, climate change, antimicrobial resistance, and animal welfare. Still, even with great technological advances, the implementation has been limited in many developing nations due to the cost of investments, lack of digital infrastructure, lack of interoperability between technologies, and lack of technical expertise. The potential for further advancements in precision livestock management and more sustainable and resilient animal production systems through integration of multimodal sensing, predictive analytics, edge computing and digital phenotyping is expected in the future. The scientific development of Precision Livestock Farming is summarized, its technological background and applications are discussed and opportunities and challenges for the future are pointed out, especially in the context of developing livestock production systems.

Keywords: Precision Livestock Farming, Artificial Intelligence, Dairy Cattle, Internet of Things, Biosensors, Precision Feeding, Animal Welfare, Smart Agriculture

To cite this article: Shahbakht RM, ZA Nomi, MZ Anwar, S Shahid & M Rehan. Precision Livestock Farming (PLF): A Future of Dairy and Livestock Farming in Pakistan. Biological Times. 2026. August 5(8): 21-22.

Introduction

Global livestock production is under increasing pressure to meet the growing demand for animal-derived food while addressing challenges related to resource efficiency, animal welfare, environmental sustainability, and climate change. Traditional livestock management, mainly based on periodic visual observation and management decisions taken at the herd level, is proving to be inadequate for the modern intensive production system where continuous monitoring of individual animals is necessary [1]. Precision Livestock Farming (PLF) is a new paradigm of managing farms that combines advanced technologies such as Internet of Things (IoT), wearable sensors, biosensors, computer vision, artificial intelligence (AI), robotics, and big data analytics to keep track of animal health, animal behaviour, reproduction, productivity and environment, at all times. PLF translates real-time biological and environmental data into information which can be used for early disease detection, precision feeding, reproductive management and welfare assessment, thereby enhancing production efficiency whilst decreasing labour needs and losses in production. PLF aims to replace the traditional herd management system with individual animal management by continuously monitoring them digitally. This move towards proactive management, instead of reactive, offers the opportunity to detect changes in behaviour and physiology before clinical disease occurs, enabling timely and appropriate management measures that will benefit the animal's health, reducing antimicrobial use, and improving the sustainability of the farm. This has led to PLF becoming an important aspect of sustainable livestock production, and it can fit with the One Health–One Welfare approach as it is able to improve animal welfare, food safety, environmental sustainability and profitability [2] While PLF technologies have been successfully used in the developed livestock industries, their application in the developing countries, especially in Pakistan, is still not in widespread use due to their high investment, lack of digital infrastructure, technical knowledge and awareness of farmers. However, digitalisation of agriculture and the development of low-cost sensor technology offer many opportunities to incorporate PLF into the dairy and livestock production systems. Hence, the aim of this review is to summarise the technological principles, main applications, obstacles and future prospects of Precision Livestock Farming, especially on the topic of sustainable dairy and livestock production.

2. Technological foundations of precision livestock farming.

Precision Livestock Farming (PLF) has become a complete decision support system for contemporary livestock enterprises, with the rapid development of sensing technology, automation and artificial intelligence (AI). PLF brings together several technologies to continuously gather, analyse and interpret real-time data from individual animals, which allows for timely and evidence-based management decisions. Some of the most common PLF technologies are wearable sensors such as accelerometers, pedometers, rumination collars, and radio-frequency identification (RFID) tags. These devices can continuously record behavioural and physiological parameters including activity, feeding behaviour, rumination, body temperature and locomotion which can help to identify lameness, mastitis, metabolic disorders and estrus before clinical signs are observed. The advent of computer vision and image analysis has also enhanced the ability of PLF, allowing for the automated monitoring of BCS, gait, feeding motivation and social interaction processes by means of non-invasive cameras and AI algorithms [3]. Biosensors and automated milking systems, on the other hand, are able to monitor a number of health and reproductive parameters along with measuring milk yield, milk composition, somatic cell count, milk progesterone content, and health and reproductive biomarkers continuously, which enables precision disease diagnosis and reproductive management [6]. The combination of Internet of Things (IoT) platforms, cloud computing and machine learning allows the analysis of large multidimensional data sets. Predictive models powered by AI detect minute changes in an animal's behavior and physiology, enabling farmers to proactively take action, rather than reactive measures. This moves livestock management from a point-in-time to ongoing, individual monitoring, thus enhancing production efficiency, animal welfare and environmental sustainability [4]. All of these technologies have helped to advance modern systems of precision livestock management, which allow for data-driven management practices to optimize productivity and sustainable, welfare-focused livestock production.

3. Applications of Precision Livestock Farming in Dairy and Livestock Production

Precision Livestock Farming (PLF) has transformed how livestock are managed by allowing for tracking of each animal and making use of data to inform management decisions. PLF integration of sensors, Artificial Intelligence (AI) and automated monitoring contributes to the enhancement of animal health, productivity, welfare and environmental sustainability. One of the biggest applications of PLF is early detection of disease. Physiological and behavioral parameters like body temperature, rumination, feeding behavior, milk conductivity, and activity are monitored continuously by wearable sensors, biosensors, thermal imaging and automated milking systems. The changes in these parameters can occur several days before clinical symptoms of disease such as mastitis, lameness,

ketosis and respiratory infections, so early intervention and reducing treatment costs and losses and the usage of antimicrobials are possible [2]. PLF has also applied great advances in reproductive husbandry to dairy herds. Activity monitors, pedometers and pedometer collars with an accelerometer are very effective at detecting estrous from changes in activity and/or movement. Automated heat detection also results in higher conception rates than visual heat detection, and better reproduction efficiency and shorter calving interval. One such is the use of precision feeding which involves using an automatic feeding system that combines the data from sensors and a nutritional model to provide the feed needed for individual animals. This not only helps to reduce feed cost and nutrient losses but also helps to reduce methane and N emissions while enhancing feed conversion efficiency which promotes environmentally responsible livestock production [4]. PLF technologies also have proven useful in the assessment of animal welfare. Ongoing measurements of ruminations, lying behaviour, locomotion, social interactions and environmental conditions can be taken, allowing for early identification of stress, pain, heat stress and behavioural abnormalities. Furthermore, environmental sensors that measure temperature, air humidity, ammonia and ventilation show the state of housing of animals, and keep farmers from opting for animals' optimal housing. This also helps to ensure comfort by animals as well as prevention of disorders related to welfare in the housing [1]. In total, all these applications and more demonstrate that PLF is more than just an increase in productivity but a full precision management system combined with a health management, reproductive efficiency, nutritional optimization, welfare monitoring and environmental sustainability. PLF will continue to play a crucial role in the future of sustainable livestock production systems, especially with the advent of AI and predictive analytics [5].

4. Challenges and future perspectives

Precision Livestock Farming (PLF) has several technological, economical and organizational questions that need to be addressed to be successful at a large scale. Sensors, automation and digital infrastructure are costly and this is a great challenge for most of the livestock production in many developing countries, which is mostly done by smallholder and medium-sized farms. Moreover, interoperability between different device brands, lack of standardised data representations and data ownership and cyber security concerns remain to be solved to facilitate PLF technologies in commercial farming systems. Furthermore, a reliable Internet connection, technical knowledge and farmer training are essential for effective PLF, but do not exist in many low and middle income countries (LMICs) [7]. In Pakistan, weak production system, lack of digital infrastructure, and lack of awareness of precision technology and poor extension service by livestock producers are a challenge. New opportunities for more gradual adoption exist however, given the increase in low cost sensors, mobile applications for agricultural management and government initiatives to promote digital agriculture [5]. National livestock surveillance programmes, precision nutrition and disease monitoring could be integrated with PLF to significantly enhance animal health, productivity and biosecurity, and help with evidence-based decision-making across the livestock sector. More work is required in the field of cost effective and scale up PLF technologies for smallholder farming system. The use of AI, multimodal sensor fusion, edge computing and digital twins should lead to more accurate real-time, automated disease prediction. It is also important that these technologies are tested under different production conditions and tested for their economic feasibility, to ensure that technological development will result in useful and sustainable improvements in livestock production.

5. Conclusion

Precision Livestock Farming (PLF) is a paradigm shift to a continuous management of individual animals instead of management of the herd as a whole. With the help of sensors, artificial intelligence, automation, and advanced data analysis, PLF enhances disease identification, reproduction efficiency, feeding accuracy, animal health, and environmental sustainability. While there are cost, infrastructure, interoperability and technical capacity issues, technological advances are continually increasing the availability of PLF, particularly in developing nations. Strategic investments in digital infrastructure, research, farmer education and supportive policies will be required for countries like Pakistan to hasten adoption. With the advancement of precision technologies, PLF will have a major impact in the future to create more productive, sustainable and welfare-oriented livestock production systems.

References

[1] Berckmans D. General introduction to precision livestock farming. Animal Frontiers. 2017 Jan 1;7(1):6-11.

[2] Norton T, Chen C, Larsen ML, Berckmans D. Precision livestock farming: Building 'digital representations' to bring the animals closer to the farmer. Animal. 2019 Jan 1;13(12):3009-17.

[3] Rutten CJ, Velthuis AG, Steeneveld W, Hogeveen H. Invited review: Sensors to support health management on dairy farms. Journal of dairy science. 2013 Apr 1;96(4):1928-52.

[4] Tullo E, Finzi A, Guarino M. Environmental impact of livestock farming and Precision Livestock Farming as a mitigation strategy. Science of the total environment. 2019 Feb 10;650:2751-60.

[5] Wathes CM, Kristensen HH, Aerts JM, Berckmans D. Is precision livestock farming an engineer's daydream or nightmare, an animal's friend or foe, and a farmer's panacea or pitfall?. Precision Livestock Farming '05. 2005 Oct 10:33-46.

[6] Caja G, Castro-Costa A, Knight CH. Engineering to support wellbeing of dairy animals. Journal of Dairy Research. 2016 May;83(2):136-47.

[7] Sani MI, van der Voort M, Tekinerdogan B, Hogeveen H. Application of precision livestock farming: challenges and opportunities. Animal Bioscience. 2026 Mar 11;39(4):250895.