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Role of Precision Livestock Farming In Sustainable Animal Husbandry

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ABSTRACT

As the world's population increases, livestock agriculture must adapt to produce more livestock products more effectively while simultaneously addressing concerns about animal welfare, environmental sustainability, and public health. In reaction to these difficulties Precision livestock farming (PLF) technology have surfaced as a viable answer to these problems, offering a sustainable means of producing cattle. PLF technologies give farmers the chance to boost productivity while reducing their negative effects on the environment, protecting their livelihoods, and improving the health and welfare of their animals. However, the adoption of PLF technologies poses severallimitations, risks and ethical concerns for farmers and also for animal welfare. The role of PLF is becoming increasingly significant and will help farmers make decisions, alter their role on the farm and their management perspective, and enable product traceability and quality control of products and animal living conditions as demanded by stakeholders and policymakers.

Keywords: Precision livestock farming, animal husbandry, carbon emission, sustainability.

INTRODUCTION:

Livestock production is essential to global agriculture because it provides essential food, means of subsistence, and opportunities for innovation. Mass production and high resource consumption are characteristics of modern activities that have significantly accelerated climate change and environmental harm. Livestock production currently faces the twin global challenges of reducing environmental impact and improving animal welfare while meeting the growing demand for meals derived from animals. In order to maintain or improve animal health and welfare, sustainable animal husbandry requires production systems that are robust, efficient (producing more per unit input), and that reduce negative environmental externalities.Around 7.6 billion people live on Earth today; by 2030, that number is expected to rise to 8.6 billion, and by 2050, it will reach 9.8 billion (UN, 2017). Most of the population growth will occur in developing nations. Growing populations and better development will increase the demand for animal products in developing countries. Livestock farming provides stable food supplies, job opportunities, and opportunities for income growth in developing countries. A significant amount of the demand for animal products will be met by local production. Despite the growing population and demand for animal protein, consumers are becoming more concerned about the negative impacts of livestock production on the environment, public health, and animal welfare (Ochs et al., 2018).Given the declining availability of water and land resources, livestock farmers must create techniques to boost productivity while utilizing their limited resources in a sustainable fashion (Baldi & Gottardo, 2017). Economic difficulties continue to rise on modern-day livestock farmers. Most farmers today find themselves in a situation where they, in order to retain their livelihood, must use the economies of scale. Stakeholders in the livestock sector are increasingly concerned with animal welfare and strive to manage and slaughter animals in more humane ways (Blokhuis et al., 2019).

There are chances to increase production efficiency and lower emissions per unit of animal output in all livestock production systems, and these opportunities are now being developed. While some of this alternative's need

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for innovative technology solutions, others are "simple" concepts that are already applicable in the majority of industrial systems. As farms continue to grow in size and benefit from economies of scale, farmers are always looking for new tools and technologies to lower operating costs and improve sustainability.Rapid technological advancements improve interactions between animals and farmers, despite obstacles. In the early 1990s, Halachmi and Guarino (2016) observed an increase in research on ICT-supported cattle farming systems.Modern technology allows farmers to interact with their animals more closely. Precision livestock farming (PLF) uses process engineering techniques to automate animal management and offer farmers with more information.

DEFINITION OF PRECISION LIVESTOCK FARMING:

Precision livestock farming (PLF) is described as the application of information and communication technology to improve management of fine-scale animal and physical resource variability in order to maximize economic, social, and environmental dairy farm performance (Eastwood et al., 2012).Precision livestock farming integrates health, genetics, nutrition, social behavior, and resource availability and utilization to meet the needs of individual animals in larger herds. This can be facilitated by sensor technologies incorporated into monitoring systems.By keeping updated on each animal's health, welfare, productivity, and effects on the environment, it seeks to manage each one in real time.The term "continuous" refers to PLF technology that measures and analyzes every second, 24/7. The PLF system alerts farmers when something goes wrong and directs them to the appropriate animal(s) for immediate attention. A camera with real-time image analysis, a microphone with real-time sound analysis, or sensors on or near the animal can all be used for monitoring. As shown in Figure 1, PLF usually involves the use of technology that permits automated and continuous real-time animal monitoring (Papakonstantinou et al., 2024).

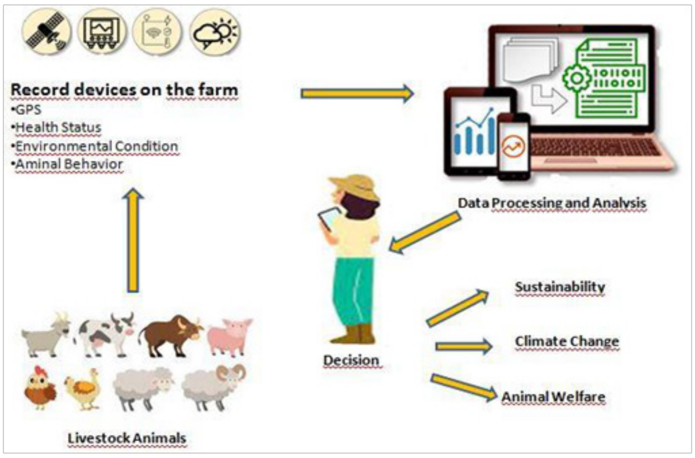

Figure 1. Precision Livestock Farming (PLF) in modern animal husbandry (Papakonstantinou et al. 2024)

APPLICATIONS AND BENEFITS OF PLF IN LIVESTOCK PRODUCTION:

PLF technology can be called as the use of modern technologies and data analysis in livestock production systems and management to enhance animal welfare, productivity of the animal and health while reducing environmental impact and maximizing resource utilization. It is the application of technology that enables automation, real-time and continuous monitoring of livestock. Cameras, sensors, and acoustic devices are being combined with the help of artificial intelligence to streamline data processing and collecting in real time and linked to livestock production, such as environmental factors, behavior, and health (Berckmans, 2017).

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PLF promotes sustainability in many ways, including enhancing the animal welfare with health, boosting productivity, optimized use of resources (energy, water, and feed) and facilitating précised management that lowers waste and mortality. Some of the key areas are-

1. Animal health and disease management

PLF plays a very crucial role in early disease detection which leads to precise treatment. By continuously monitoring behavioral and physiological abnormalities (such as decreased activity, prolonged lying, elevated body temperature and cough sounds), disease can be identified before clinical symptoms worsen, allowing for prompt treatment measures. When targeted treatments are used, it lowers morbidity, increase productivity and could decrease widespread prophylactic antimicrobial use. A direct benefit for sustainability comes from the fact that healthy, productive animals need less feed and produce less pollution per unit of product. Early treatments lower death rates and growth obstacles lead to decrease resource utilization per kilogram of product.

2. Nutrition and feed efficiency

Automated feed intake measurement and individual feeding systems allows giving animals the right amount of food for their needs, which improves the feed conversion ratio (FCR) and cuts down on both overfeeding and underfeeding. PLF systems connect individual intake, growth which can make efficient and healthier diets for the animals. Evidence from feedlots and dairies shows that PLF can improve FCR and lower variability. This leads to utilization of less input per unit output and have less effect on the environment.

3. Reproduction and productive performance

Accelerometers and activity monitors can increase accuracy of heat detection, which in turn improves conception rates and insemination timing. Automated weight and body condition tracking helps in early detection of cows or sows which improves reproductive management. Reproductive efficiency decreases replacement rates and unproductive days, which lowers emissions and resource consumption per unit of produce (Michelena et al., 2024).

4. Monitoring of Environmental emission and its mitigation

Digital animal husbandry maximizes resource utilization and eliminates waste and has the potential to support environmental sustainability. However, it also raises concerns about increasing energy consumption, e-waste, and carbon emissions from equipment manufacturing, maintenance, and disposal (Berckmans et al., 2013). PLF systems help the environment in both direct and indirect ways. Removing of manure through automated systems and controlling the climate can lower emissions and energy use. Direct sensor arrays can check the levels of barn gases (NH_3, CH_4, and CO_2) at the room level to improve ventilation and manure handling.

5. Welfare assessment and enrichment

With the help of PLF, it possible to get objective, ongoing welfare indicators like lying time, social interactions, patterns of movement, and thermal stress. This makes sure that welfare standards are met, distress is reduced and housing or enrichment programs are evaluated.

LIMITATIONS, RISKS AND ETHICAL CONCERNS:

Precision Livestock Farming is not without risks and limitations. Some of the limitations and risks associated with it are like-

1. Over-reliance on technology: Farmers still require expert guidance because flawed algorithms can result in false positives or negatives, which ultimately lead to erroneous interventions.

2. Welfare trade-offs: Some PLF technologies (implants, ear tags) cancreate welfare issues if the application is not done properly or ethically.If welfare norms are not followed properly, PLF might leads to reduction in natural behaviors.

3. Equity and accessibility: Unequal access to PLF might exacerbate productivity disparities between well-resourced commercial farmers and smallholder farmers, ultimately affecting the social sustainability.

4. Security and privacy: Precision livestock farming depends extensively on security and privacy to protect sensitive information, particularly financial transactions, animal health data, and farm productivity figures. Large amount of data are created by the application of different PLF technologies; if such information is available to unknown individuals, they can misuse or exploit the information in the market. Farmers need to be assured that their data is stored in proper manners, shared only after their approval.

FUTURE POTENTIAL OF PRECISION LIVESTOCK FARMING INLIVESTOCK PRODUCTION:

Precision livestock farming methods along with sensors, block chain technology, and big data analytics plays a very important role in sustainability of the environment and welfare of the animal. With the development of technology, farmers from all over the world will have greater access to these tools, especially those in developing nations as they grow to feed expanding populations (Alonsoet al., 2020).For the successful application of PLF solutions, some of the environmental factors in animal barns must be addressed first whichinclude dust, dampness, dung-derived ammonia, and insects.Some of the behavior like lying is crucial for research and monitoring methods, as evidenced by the fact that it is one of the most commonly evaluated characteristic while employing precision livestock farming (PLF) technology, particularly tri-axial accelerometers. But there is also clear lacking of evaluation of some of the important habits, such sleeping and resting (Pesenti Rossiet al., 2024).A wireless sensor network is also necessary for the usage of sensors, and it may need to operate over great distances in order to send data from an animal room to the base computer (Chuanzhonget al., 2017).

Since most of the developers developing these technologies are not aware of the farm condition and have very less interact witrh the farmers, so their sensors may not function properly in actual farm settings. More cooperation between bioengineers, farmers, animal scientists, and other experts would support the development of reliable technologies suitable for long-term use in agricultural settings.The relationship between humans and animals is probably going to shift as PLF technology becomes more prevalent on dairy farms. It is probable that there will be a further “alienation” between the animals and the people who are in charge of them. The animal would be reduced to a stationary object of the production system and are becoming more and more efficient. On the other hand, PLF appears to be very good techniques for improving their ability and address the needs of animals as well as preventing variables that might be harmful for their health.

CONCLUSIONS:

Precision livestock farming will become avery crucial method for the livestock farmers in the near future for monitoring animals in both intensive and extensive livestock farming systems.Precision livestock farming provides a powerful set of tools to encourage sustainable animal husbandry by enabling accurate interventions and ongoing, individual-level monitoring.PLF promotes sustainability by improving animal health and welfare, increased feed and reproductive efficiency, resource optimization and better management that minimizes the production of waste from the animal. The probable decreases in emissions intensity and increased productivity in a number of livestock sectors, especially in intensive dairy and swine systems, are suggested by empirical and modeling research. However, the benefits of PLF are not assured moreover it depend on appropriate planning, validation, farmer uptake, data governance, and adherence to welfare and environmental laws.

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