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Application of Precision Livestock Farming for Improved Goat Management and Production

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Abstract

The rising economies of South America and Asia, which have also experienced an increase in the consumption of animal products, are substantially responsible for the increased nutritional needs of the world's population over the last four decades. As a result, the scale and management of animal production systems have significantly increased. Since grazing animals are frequently raised in herds, the producer's capacity to personally evaluate each animal is constrained by labor and financial constraints. Alive and Well Livestock The use of sensors and computer algorithms in real-time continuous monitoring and control systems for agriculture helps producers better understand the needs of individual animals while also spotting problems early. These include uncrewed aerial vehicles (UAVs), robotic weighing scales, RFID sensors for tracking individual animals' behavior and body temperatures, virtual fencing for managing herds and grazing, robotic weighing scales, geographic information systems (GIS) for assessing and improving pastures, robotic weighing scales, and virtual weighing scales. Despite the availability of some commercial products, mainly for cattle, social, economic, and cultural constraints, as well as a dearth of suitable technological infrastructure, limit the adoption of these systems. In addition to providing recommendations for additional study and improvements to precision livestock farming (PLF) adoption and application in contemporary large-scale livestock systems, this paper outlines PLF systems and uses for grazing animals.

Keywords: Sensors, grazing animals, precision livestock farming (PLF), livestock applications

Introduction

The demand for dairy products is anticipated to increase steadily as the world population rises from 7.7 billion in 2019 to 9.7 billion in 2050. In recent years, intensive agricultural practices have been adopted extensively to suit the demands and requirements of consumers. Despite the fact that the size of dairy farms throughout the world is expanding due to rising expenses and extra advantages of economies of scale, the ratio of animal caretakers to total livestock is declining (1). "Individual animal management by continuous real-time monitoring of health, welfare, production/reproduction, and environmental impact" is how PLF is defined. Advances in engineering and biomaterials research that have lowered the cost of electronics and allowed for the miniaturization of electronic devices have greatly increased the prevalence of PLF (2). Farmers consequently have less time to evaluate the requirements of individual animals, and there is a feed shortage for grazing animals, which has an adverse effect on their welfare and raises concerns about their functionality and health (3). Due to climate instability, goals for sustainable development, demands for production efficiency, and the growing influence of consumer perception, both limited and extensive systems for the

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production of animal cattle worldwide have faced enormous potential and obstacles. In light of the enormous areas in question, the Intergovernmental Panel on Climate Change states that "impacts of climate change on livestock productivity, particularly of mixed and extensive systems, are critical." Through increased temperatures and variable precipitation, which both have an impact on water availability, climate change negatively affects cattle output (4). For flock or animal management, the PLF is based on real-time data collecting and processing. Advanced technology and automats are other inventive tools used to accomplish this. As farms grow and individual animal monitoring is no longer practical without electronic assistance, such advancements become more crucial (5). They have a good effect on neighborhood socioeconomic activity and are crucial for maintaining rural communities, ecosystems and the creation of distinctive, prized foods like lamb meat and cheeses (6). Additionally, a shift in dietary preferences in favor of animal-based protein is projected as the economic climate in developing nations improves, which will increase demand. Farmers are forced to grow and extend their businesses as a result of economies of scale, which increases output. As a result, it is projected that farms with more elevated heads will exist and be managed by fewer farmers (7). Overall, 33% of the protein consumed by humans comes from cattle. PLF, a holistic strategy that incorporates information and communication technology (ICT) to enhance the farming process, has recently come into existence (8). Digital technology is incorporated into PLF. By carefully overseeing agricultural activities, it aims to increase productivity, reproduction, animal welfare, and targeted resource usage to have a less negative environmental impact. PLF relies on the use of digital technologies to capture information about specific animals, animal species, or the environment. Daily tasks in the agriculture sector have become easier thanks to the usage of technology (9). The productivity per animal of livestock production systems around the world has increased recently. Intensification involves social issues that influence how customers perceive aspects of animal welfare, human health, food security, safety, and sustainability. An intensive production system that stands out for its high level of organization and efficiency is said to give the highest chances for sustainability (10).

PLF technologies are being created in response to this issue to continually and autonomously monitor animal welfare and health indices, enabling increased production and the early identification of health issues (11). Future animal farming will focus on precision, sustainability, and intelligence. Although PLF is still in its infancy and has a wide range of potential applications, it is an essential component in the long-term development of smart farms (12). The study (13) examines how present livestock practices affect the environment and explores the benefits of PLF as a viable method for reducing environmental concerns. PLF is described as "the application of process engineering principles and techniques to livestock farming to automatically monitor, model, and manage animal production". In developed nations, consumption of animal products like milk, eggs, and meat has leveled down, but it is rapidly increasing in underdeveloped nations. To meet demand, agriculture will need to produce more food, which will pave the way for applications of PLF, increasing automation, and technological innovation (14). A number of PLF technologies have been

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created to continually and instantly identify the physical and behavioral changes that animals go through. PLF technologies were designed to optimize agricultural procedures. The study (15) was to investigate how current PLF technology might help with pig welfare evaluation. Online research for commercially available PLF for pigs produced 83 innovations. Precision livestock farming is becoming increasingly important as farming becomes more important. It would make it possible to track and monitor product quality and animal welfare in accordance with corporate and governmental requirements, assisting farmers in making better decisions (16). All production industries are showing an increasing amount of interest in Augmented Reality (AR) technologies. According to the authors, there is currently a lack of knowledge on the use of augmented reality via smart glasses in the livestock and agricultural sectors. The study (17) was to examine the potential value and breadth of an augmented reality head-wearable device for managing precise herds of cattle. PLF is a method that equips animals with sensors that give farmers livestock-related data, allowing for real-time animal monitoring. PLF offers a variety of advantages and ensures the best possible use of farm resources, allowing for the management of animal health and the potential reduction of greenhouse gas (GHG) emissions. (18). Animal husbandry, farm animal welfare, and the supply chains for animal-based goods will all be significantly impacted by PLF. Although customers ultimately foot the bill for advances, little research has been done on how they view PLF technologies. Six focus groups were undertaken in Finland, the Netherlands, and Spain to examine consumer perceptions of PLF technology in the pig and dairy value chains (19). To guarantee the best level of consumer protection, the "from farm to fork" food chain continuum must be regulated. For a consistent source of food, it is necessary to have healthy livestock. PLF can efficiently track biological or behavioral indicators of an animal's welfare and health (20). This section covers the use of precision livestock farming for enhanced goat management and output**.**

Materials and Methods

PLF for Grazing Cattle

Over the past four decades, the typical person's intake of milk and dairy products has been steadily rising, and it is predicted that by 2050, it will have increased by 50% compared to that of 2010. The ability of farmers to determine the needs of individual animals deteriorated as the number of animals per herd increased, and high milk-yield cow breeds were introduced into the production process throughout the past century. As a result, the relationship between animals and people, the condition of animal health, and the increasing demand among customers for high-quality goods that are safe for their consumption have an impact on production factors. PLF technologies have shown a lot of promise in analyzing or even resolving these issues. No matter the size of the herd, the farmer can see the animals' daily activities without interfering and evaluate agricultural methods from a computer. PLF systems, therefore, have the potential to boost soil health, pasture utilization, and management, as well as improve animal performance and increase farmers' yearly income.

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Little Ruminant PLF

Small ruminants are particularly interested in extensive grazing-based systems because they have lower input costs and better resistance to market volatility. Small-scale goat ranches are typical, and although there are variations around the world, their owners are typically conservative and reluctant to adopt new technology. These factors prevent the routine implementation of PLF within the production process. Inadequate technological infrastructure and other financial barriers further restrict PLF's frequent adoption.

EID (Electronic Identification Device) systems

To ensure electronic identification in the EU, radio frequency identification (RFID) tags that broadcast data to the tag reader at different radio frequency levels are generally utilized. RFID can automatically provide data on growth performance, reproductive efficiency, milk yield, and medical treatments using other PLF applications. RFID is a practical method for tracking and keeping an eye on specific animals. Contrarily, ceramic boluses provide permanence once they are inserted into the rumen of small ruminants. Subcutaneous temperature transponders are another option, but you should take into account your goats' propensity for migration and the difficulties associated with removing them due to this.

Utilizing Robotics, Drones, and Image Analysis for Virtual Fencing and Flock Monitoring

Machine learning, inexpensive time-lapse cameras, and photo registration might all be used to follow goats very sensitively and precisely. It should be made clear that for such a system to work there must be nothing inside the meadow besides animals. Furthermore, there must not be a backdrop color that could be mistaken for an animal's hue.

Utilizing RFID

Cattle routinely employ Radio Frequency Identification (RFID) technology while grazing because it offers a dependable, affordable method for non-contact, remote, continuous animal identification and monitoring. On RFID tags, important information, including age, sex, breed, weight, and physical condition, is maintained. Depending on the frequency at which they operate, RFID systems can be categorized into two groups: low-frequency, which is mainly used for animal identification, and high-frequency, which is mainly used to track populations rather than individuals. Depending on whether they transmit radio waves, RFID tags can also be categorized as passive or active. In contrast to passive tags, which have a reading range of only slightly more than 3 m, active tags emit high frequencies that range between 455 MHz, 5.8 GHz, and 2.45 GHz, with a reading range between 20 and 100 m. Using information from ear tags, management software has been developed that automatically stores and maintains personal data on each individual, including medical treatments, growth performance, genetic makeup, and reproductive qualities.

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Systems using GPS and GIS

The difficulties of data collecting and preservation are to blame for the paucity of knowledge on more holistic grazing system options. In rangelands, where animals frequently graze in severe conditions, traditional animal tracking techniques are difficult and time-consuming. The majority of foraging and grazing activity, it should be mentioned, occurs at night, which makes data collection much more difficult. Technologies like GIS and GPS may be able to aid with this issue. A low-cost tool for ongoing observation of grazing animals is this kind of equipment. Additionally, these technologies could assist farmers in controlling the herd's grazing behaviour in a more environmentally benign way as grazelands become more intensive and biodiversity is under danger of extinction.

Applications of Other Multi-Sensors PLF

PLF is a group of different sensor combinations and mathematical models for management-improving strategies and welfare assessment. Complex systems are made up of numerous sensors cooperating to gather data from a single focused analytic system. For instance, data on many variables, including daily milk output, milk quantity, quality, temperature, body weight, and concentrate consumption, are gathered using automatic milking robots. A different commercial application known as virtual fencing (VF) has been promoted as a substitute for traditional grazing management over the past twenty years. Inside the grazing area, a GPS-based virtual barrier is set up in various locations, and each animal is given a collar that can mimic sound signals. When the animal gets close to the stationary or moving limits of the virtual fence, the collar may send an electrical stimulus, an aural signal, or even both.

Results and discussion

Health Monitoring

PLF devices can monitor the health of individual goats or groups in real time, enabling the early identification of conditions like infections, lameness, or respiratory disorders. Wearable technology is frequently used in these systems, including smart collars and ear tags that monitor vital signs, activity levels and thought patterns.

Reproduction Management

PLF can help to improve reproduction control by keeping an eye on fertility, estrus behavior, and heat detection. Automated monitoring systems can send signals for the best times to breed, enhancing breeding effectiveness and raising the goat herd's overall reproductive performance.

Feeding and Nutrition

PLF technologies can assist with nutrient analysis, feed formulation optimization, and feed intake monitoring. In order to improve nutrition and decrease feed waste, automated feeding systems with sensors can accurately distribute precise amounts of feed based on individual goat requirements.

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Environmental Monitoring

Within goat housing facilities, PLF systems can monitor and regulate environmental factors like temperature, humidity, and ventilation. By preserving ideal environmental conditions, goat welfare, health, and productivity can be improved.

Behavior Analysis

PLF technology, such as video surveillance and computer vision, may monitor goat behavior and spot unusual patterns, such as interactions with other goats, feeding habits, and movement patterns. With early intervention, this information can aid in the detection of stress, hostility, or inappropriate behavior, enhancing welfare.

Data Analytics and Decision Support

PLF creates a substantial amount of data, which can be examined to learn more about patterns in goat health, productivity, and performance. Tools for decision assistance and data-driven analytics can help farmers allocate resources more efficiently and increase overall agricultural output. Table (1) depicts the fastest increase in goat populations. Goat populations are growing at the fastest rate, as shown in Figure (1).

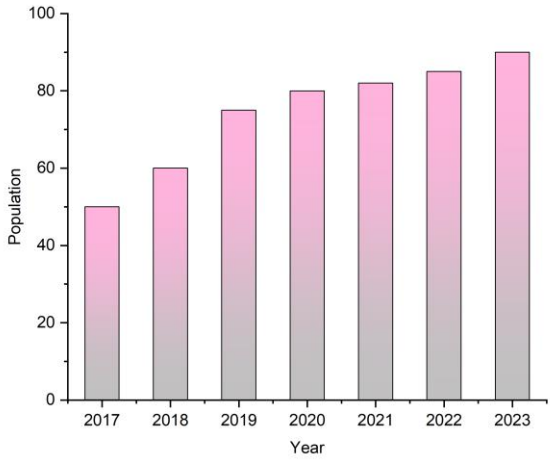

Figure (1): Goat population growth is fastest

Table (1): Fastest increase in goat populations

Year	Goat Population
2017	50
2018	60
2019	75
2020	80
2021	82

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2022	85
2023	90

Antibiotics

A class of medications known as antibiotics is used to treat bacterial infections. They function by eradicating or preventing bacterial development, assisting the body's immune system in battling the infection. Since viruses are not like bacteria, antibiotics are ineffective against viral infections like the common cold or the flu. Figure (2) displays the explanations provided by livestock owners for the use of antibiotics in various species. The justifications livestock owners gave for using antibiotics on diverse species are shown in Table (2).

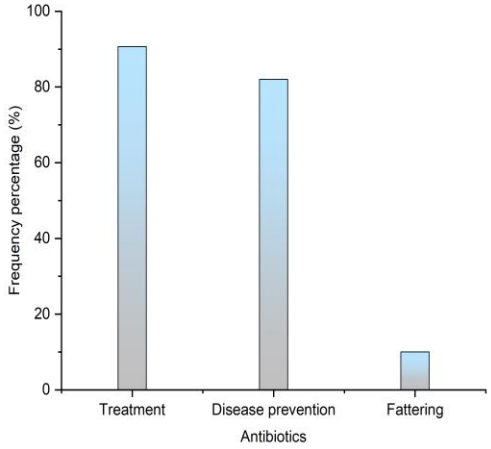

Figure (2): Proportion of Antibiotics

Table (2): Frequency percentage of antibiotics

Antibiotics	Frequency percentage (%)
Treatment	90.7
Disease prevention	82
Fattering	10

Anthelminitic

Anthelminitic, usually spelled anthelmintic, refers to a drug or medication used to cure or prevent parasitic worm infections in people or animals. Roundworms, tapeworms, flukes, and hookworms are a few examples of these worms. Anthelminitic medications cause the worms to be paralyzed or killed, allowing the body to eliminate them through bowel motions**.**In both the highland and lowland mixed crop-livestock systems, the government or official veterinarian served as the primary supply of veterinary drugs for livestock owners, but pastoralists most frequently obtained medications from the private vendors depicted in Figure

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(3). Table (3) lists the explanations livestock owners made for using antheliminitic on various animals.

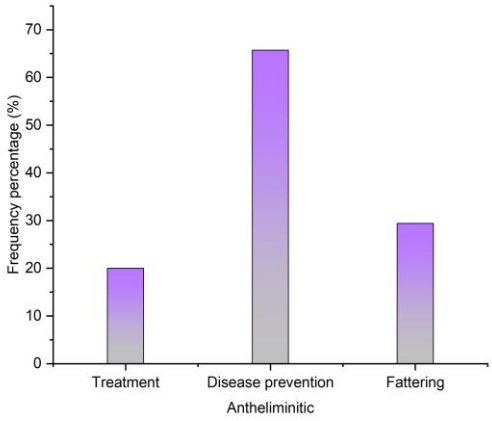

Figure (3): Proportion of Anthelminitic

Table (3): Frequency percentage of anthelminitic

Anthelminitic	Frequency percentage (%)
Treatment	20
Disease prevention	65.7
Fattering	29.4

Conclusion

In this study, goat management and productivity have benefited greatly from the use of PLF. PLF makes use of cutting-edge technologies, including sensors, data analytics, and automation, to improve goat farming's different monitoring, control, and optimization processes. This novel method has many advantages that enhance goat welfare, productivity, and farm efficiency as a whole. The capacity to track goats using sensor technology in real time is a significant benefit of PLF. These sensors are capable of measuring a wide range of variables, including body temperature, heart rate, amount of activity, and feeding behavior. Farmers can quickly identify any symptoms of illness or discomfort, identify individual goat health and well-being, and take the necessary actions in a timely manner by continuously gathering and analyzing this data. In addition to enhancing animal well-being, this proactive strategy also lowers the danger of disease outbreaks and eliminates the need for strenuous manual labor.

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