BUL 1143

Using Precision Livestock Farming to Support Dairy Management Decisions

Izabelle A. M. A. Teixeira
Dairy Extension Specialist, University of Idaho Department of Animal, Veterinary, and Food Sciences, Twin Falls, Idaho

Pedro A. Sampaio
PhD Student, University of Idaho Department of Animal, Veterinary, and Food Sciences, Twin Falls, Idaho

Melina C. Tamiozzo
PhD Candidate, University of Pelotas, Department of Animal Science, Pelotas, Brazil

Contents

1 Introduction
1 How Precision Livestock Farming Works on Dairy Farms
3 Sensors and Data Collection
5 From Data to Decisions in Dairy Systems
6 Challenges and Future Perspectives
6 Further Reading

University of Idaho Extension

Introduction

DAIRY PRODUCERS MANAGE large amounts of information every day, including milk production, milk components, reproduction, animal health, and feeding. Identifying problems early and making timely decisions are critical for maintaining productivity, animal welfare, and farm efficiency. However, as herd sizes increase and labor becomes more limited, consistently monitoring individual animal performance becomes more challenging.

Precision livestock farming (PLF) provides tools to help address, in part, these challenges. By using sensors and automated systems, PLF allows continuous monitoring of individual cows, capturing information on activity, behavior, milk production, and health. Producers can use the data to detect changes earlier than visual observation allows, supporting more timely and informed management decisions.

This bulletin provides an overview of PLF concepts, how PLF works in dairy systems, the technologies currently available, how data are translated into management decisions, and key considerations for adopting these tools on dairy farms.

How Precision Livestock Farming Works on Dairy Farms

The PLF systems operate through a series of steps that transform raw data into management actions. First, sensors collect information from individual animals, such as activity, milk production, behavior, or temperature. The data are then transferred to a local computer or cloud-based platform, where they are stored and analyzed. The results are used to generate alerts, recommendations, or automated actions that support daily management decisions.

The simplest systems provide basic alerts, such as identifying cows in heat or flagging potential health issues such as lameness or elevated somatic cell counts. More advanced systems integrate multiple data sources, including milk production, feed intake, and environmental conditions, to detect more complex patterns.

Decision support systems (DSS) analyze the data and provide recommendations, while the producer remains responsible for management decisions about the animals. In contrast, Automated decision-making (ADM) systems may perform predefined actions without requiring immediate human input, such as sorting cows or adjusting feed delivery. Table 1 summarizes the main differences between the two approaches.

Table 1. Comparison of DSS and ADM in dairy applications. The approaches differ in the level of human involvement and speed of response to animal events.

Feature	DSS	ADM
Role	Provides alerts, recommendations, or options	Takes direct action automatically
Human Involvement	Farmer reviews information and makes the final decision	Minimal human involvement
Example	Alert: "Cow 48 likely in estrus. Insemination recommended."	Sorting gate opens automatically to direct Cow 48 to the insemination pen
Risk	Alerts may be misinterpreted or ignored	Incorrect actions if data or algorithm are inaccurate
Benefit	Maintains farmer control and flexibility	Saves time and enables rapid response
Safeguards	Requires human confirmation; decisions can be reviewed	Includes fail-safe systems and manual override options

One advantage of DSS is that it keeps producers directly involved in herd management, allowing them to combine system recommendations with their own observations and management experience. However, this approach also requires time and attention to review alerts and management decisions may vary according to individual interpretation, management preferences, or farm-specific circumstances. The ADM systems reduce the need for continuous review of alerts by automatically responding to predefined conditions, providing faster and more consistent responses for routine management tasks. But because these responses rely on predefined algorithms and system settings, they reduce opportunities for real-time producer judgment when unusual situations require additional consideration.

Modern milking systems, for instance, illustrate how PLF works in practice. Sensors in the milking parlor measure milk yield, composition (fat, protein, and lactose), and electrical conductivity. Changes in electrical conductivity indicate mastitis risk, especially when combined with other indicators such as milk production and somatic cell count. The measurements allow earlier detection of potential health issues compared to visual observation alone. Rumen boluses provide another practical example of PLF technologies. These devices continuously monitor reticulorumen temperature, which serves as a proxy for core body temperature, allowing early detection of fever associated with conditions such as mastitis, metritis, or respiratory disease. Because changes in body temperature can precede obvious clinical signs, continuous temperature monitoring enables producers to intervene earlier, supporting more timely treatment decisions, improving animal welfare, and potentially reducing disease severity and associated treatment costs.

A common example of PLF in dairy systems is the use of activity collars. These devices track movement patterns and can be combined with other data, such as milk yield and feed intake. When the system detects consistent changes, such as reduced activity, lower milk production, and decreased intake, it alerts the producer to check the animal. In this case, the system functions as a DSS, providing information and leaving the management decision to the producer/manager. This process typically follows five steps: data collection, integration, detection, recommendation, and action. Figure 1 illustrates this workflow. Depending on the level of automation, the final step may be performed by the producer or automatically through ADM.

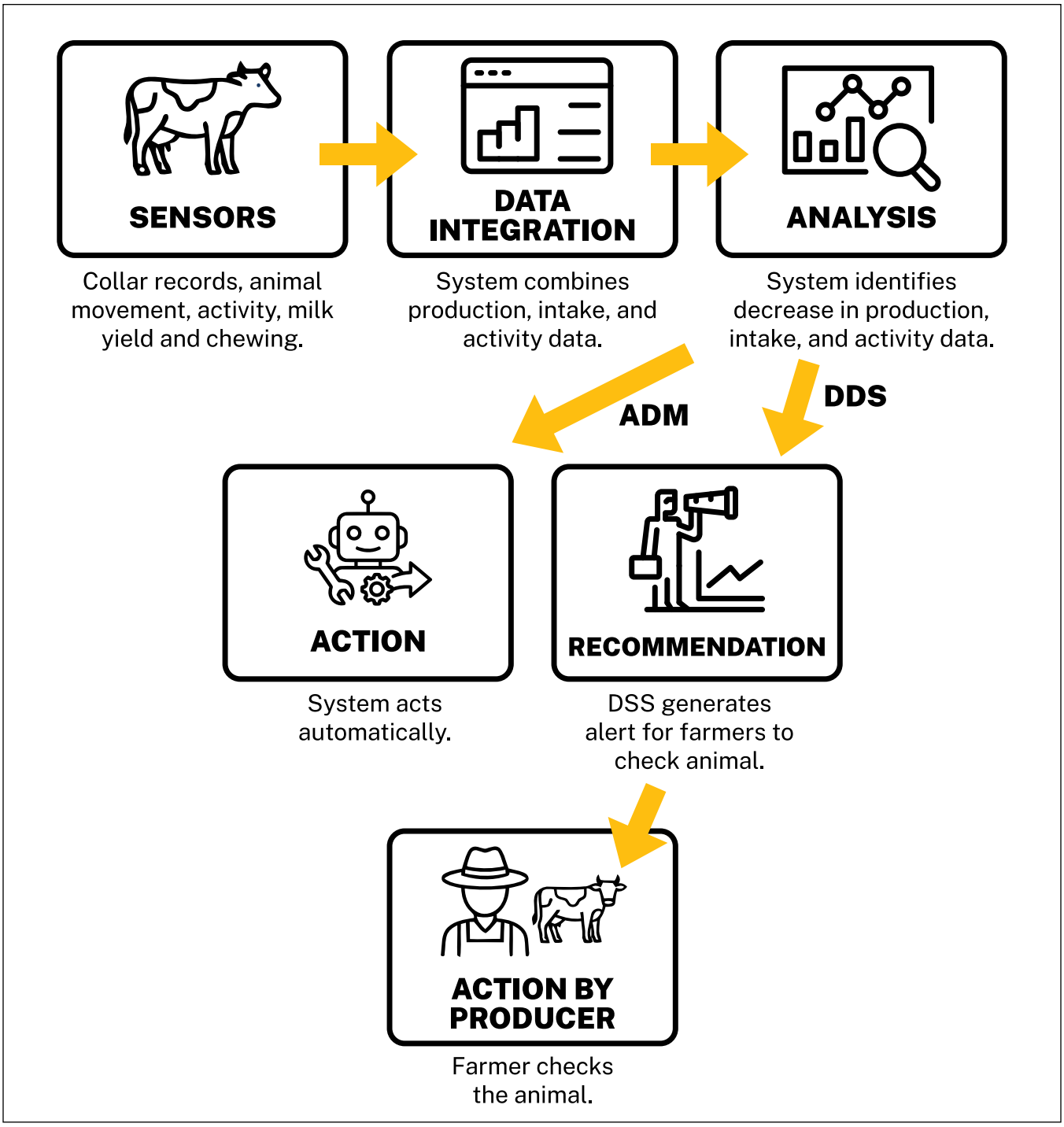


Figure 1. Example of the DSS workflow for dairy cows. Sensors collect data on each animal, which the system analyzes to detect events and generate alerts or recommendations. The user reviews this information and decides what management action to take.

Sensors and Data Collection

Sensors are the foundation of PLF because they continuously monitor individual animals, allowing earlier detection of problems and more timely management decisions than relying on visual observation alone. Dairy operators commonly use several types of sensors. Activity monitors, such as accelerometers in collars or ear tags, track movement patterns and are widely used for heat detection and health monitoring. Milk sensors in the parlor or automated milking systems measure yield, composition, and electrical conductivity, which

helps to identify changes associated with mastitis or other health issues. Temperature sensors, including boluses and wearable devices, detect fever or heat stress. Environmental sensors monitor conditions such as temperature, humidity, and airflow, helping producers manage housing and reduce stress on animals.

Camera-based systems are also becoming more common. These technologies allow noncontact monitoring of animals and identify cows, track behavior and movement, estimate body weight and body condition score, and detect signs of health problems, such as lameness. This reduces the need for handling while still providing continuous information on individual animals (Table 2). Although camera-based systems have been tested for animal identification, radio frequency identification (RFID) remains the standard on most dairy farms. Image-based recognition systems are being explored as an alternative, allowing animals to be identified without physical tags and reducing issues such as tag loss or damage.

Many of these technologies are already integrated into daily management on dairy farms. For example, activity collars are widely used to detect estrus by identifying increases in movement and behavior associated with heat. When combined with milk production and feeding data, these systems also help to identify early signs of health problems. In automated milking systems (AMS), collar data also monitors cow traffic, milking visits, and feeding patterns, supporting improvements in milking efficiency and herd management.

Combining multiple data sources, such as activity, milk production, and feeding behavior, improves producers' ability to detect issues such as lameness and metabolic disorders earlier than visual observation alone, often before clinical diagnosis. For example, changes in movement patterns can indicate lameness, while variations in milk yield, composition, or electrical conductivity can signal mastitis risk or other health issues.

These systems support earlier intervention and improve herd management, but they are not perfect. Their performance depends on the quality of data collected, system calibration, and farm conditions. Supplement interpreting alerts with visual observation and other available information.

Table 2. Common camera technologies used in dairy operations and their typical applications.

Camera Type	What It Captures	Common Uses on Dairy Farms	Advantages	Limitations
RGB (standard camera)	2D color images	Monitor behavior (lying, feeding, locomotion), animal identification, general surveillance, and basic lameness detection based on movement patterns	Low cost, widely available, easy to use, mature software	Affected by lighting conditions, cannot measure depth, may miss animals in groups due to occlusions
Depth/3D cameras	3D shape and structure	Body condition scoring, body weight estimation, posture and movement monitoring, lameness detection	More accurate measurement of body shape and size	Higher cost, requires calibration, performance can be affected by sunlight
Infrared thermal cameras	Surface temperature map	Detect heat stress, inflammation, mastitis risk, and hoof problems	Can detect temperature changes without contact	Affected by environment (distance, airflow, temperature), less precise for diagnosis
Multispectral/ hyperspectral	Light beyond visible spectrum	Evaluate forage or pasture conditions, feed quality (limited use on individual animals)	Provides detailed information on plant and feed characteristics, good for large-area pasture monitoring	Expensive, complex to use, limited application for individual cow monitoring, less common in on-farm continuous monitoring

The PLF technologies are also used in calf management, particularly during the preweaning period, when animals are more susceptible to health issues. Automated milk feeders record feeding behavior, including milk intake, visit frequency, and drinking speed. Changes in these patterns, such as reduced intake or fewer visits, can indicate potential health problems before visible symptoms appear, allowing earlier intervention. Wearable sensors also monitor calf activity and behavior. For example, increases in lying time and reduced activity may signal the onset of health issues, such as diarrhea, often up to twenty-four hours before visible symptoms appear.

Environmental monitoring also plays an important role. Sensors that track temperature, humidity, and air quality help to identify conditions that increase the risk of heat stress or respiratory problems, supporting adjustments in ventilation and housing.

Table 3 summarizes common applications of PLF technologies in dairy systems and how they are used to support management decisions. Together, these technologies provide the foundation for data-driven decision-making on dairy farms, which is discussed in the next section.

From Data to Decisions in Dairy Systems

Sensors and imaging technologies collect large amounts of data on animal health, behavior, and productivity, but these data alone have limited value. The real impact of PLF comes from how the data are analyzed and interpreted. Artificial intelligence and machine learning are used to identify patterns, detect changes, and make predictions, such as early signs of mastitis, shifts in feeding behavior, or reproductive events. They help to convert data into information that supports management decisions. Figure 2 illustrates this process from data collection to decision support. Based on these analyses, DSS helps producers and managers save time while making more consistent, evidence-based decisions related to health, reproduction, feeding, and overall herd management. On many farms, these systems already provide alerts, rankings, or recommendations based on real-time data, turning complex information into guidance for daily farm management.

The value of these systems depends on the quality and consistency of data collection, as well as how the collected data are processed and interpreted.

Table 3. Common applications of PLF technologies in dairy operations.

Application Area	What Is Monitored	How It Is Used on Dairy Farms
Health Monitoring	Temperature (including deviations from normal temperature), rumen conditions (pH, temperature), behavior	Detect early signs of disease and support timely intervention
Lameness Detection	Movement patterns, gait monitoring, lying time	Identify mobility issues before symptoms become visually apparent
Milk Quality and Udder Health	Milk yield, composition, and electrical conductivity	Detect mastitis risk and monitor production changes
Reproduction (Estrus Detection)	Activity (e.g., number of steps, head and neck movements) and behavior patterns (standing and lying time)	Identify cows in heat and improve timing of artificial insemination
Feeding Behavior	Intake, eating time, rumination, chewing	Detect changes related to health or diet
Feed Monitoring	Feed availability and bunk conditions (e.g., feed presence, refusals)	Support feeding management and ensure consistent feed access
Calf Management	Milk intake, feeding behavior, activity	Detect early signs of illness and monitor development
Environmental Conditions	Temperature, humidity, air quality	Detect heat stress risk and improve housing conditions

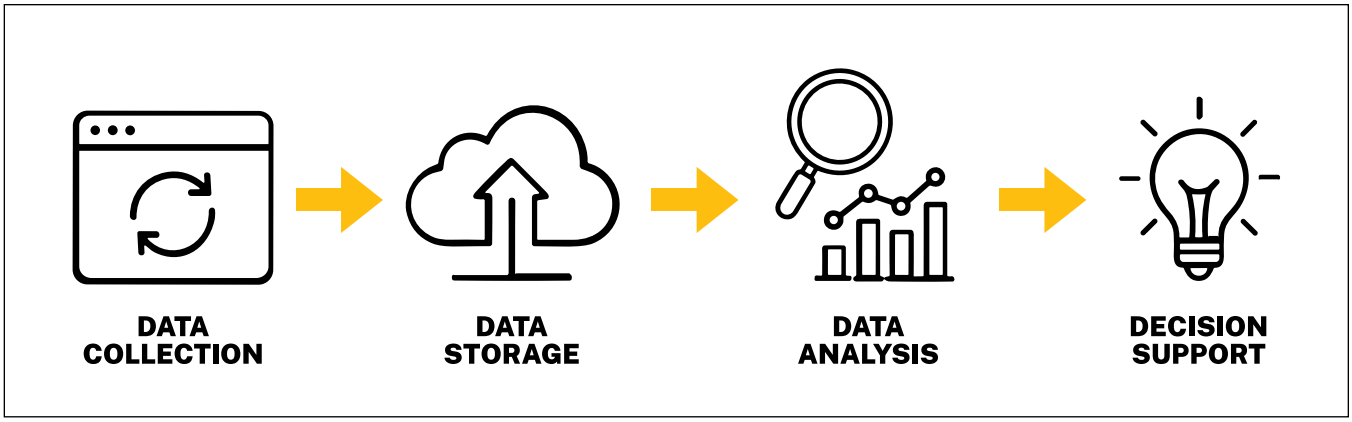


Figure 2. Workflow of data analytics in dairy operations, showing how sensor data are processed and translated into decision support tools that generate alerts, recommendations, or automated actions.

Effective data analysis is important to generate reliable information and timely alerts that support on-farm decision-making. Integrating multimodal data streams, such as behavior, physiology, and environmental measurements, also presents additional challenges, including differences in sampling frequency and data format, as well as the need for algorithms capable of combining the heterogeneous inputs into a single, interpretable output.

Challenges and Future Perspectives

Although PLF technologies have advanced rapidly, several challenges remain. Ensuring that systems provide accurate and reliable information is a fundamental concern. Misinterpretation of data and/or inaccurate information may lead to inappropriate decision-making, potentially compromising animal health and welfare. In addition, the implementation of these technologies depends on capital availability and adequate infrastructure, including reliable power supply, data storage, system compatibility, and internet connectivity, which may limit their adoption in some operations. Many tools depend on establishing baseline patterns for individual animals, such as normal activity, health parameters thresholds, and behavior patterns, to generate meaningful alerts and support decision-making.

As wearable devices such as collars and tags become more common, noncontact monitoring using imaging and computer vision is also expanding. These technologies reduce the need for animal handling, helping to minimize stress, and allow continuous monitoring of behavior and other indicators. Data governance is another important consideration, including who owns and can access the information generated on dairy farms. Producers need to be confident that their data are secure and used transparently.

The integration of connected devices and data analytics is increasing the use of data-driven management on dairy farms. These systems combine real-time sensing, advanced data analysis, and decision support to improve management, animal welfare, and resource use. Looking ahead, continued development of PLF technologies needs to address practical challenges such as cost, data standardization, system integration, and scalability. Ensuring that these tools are affordable and accessible is essential for their adoption across different types of dairy operations.

Further Reading

Alwadi, M., A. Alwadi, G. Chetty, and J. Alnaimi. 2024. "Smart Dairy Farming for Predicting Milk Production Yield Based on Deep Machine Learning." *International Journal of Information Technology* 16:4181–90. https://doi.org/10.1007/s41870-024-01998-5.

Berckmans, D. ed. 2010. *Advances in Precision Livestock Farming*. Springer. 442 p.

Cockburn, M. 2020. "Application and Prospective Discussion of Machine Learning for the Management of Dairy Farms." *Animals* 10(9):1690. https://doi.org/10.3390/ani10091690.

Kaur, U., V. M. R. Malacco, H. Bai, T. P. Price, A. Datta, L. Xin, S. Sen, et al. 2023. "Invited Review: Integration of Technologies and Systems for Precision Animal Agriculture—A Case Study on Precision Dairy Farming." *Journal of Animal Science* 101: skad206. https://doi.org/10.1093/jas/skad206.

Liu, N., J. Qi, X. An, and Y. Wang. 2023. "A Review on Information Technologies Applicable to Precision Dairy Farming: Focus on Behavior, Health Monitoring, and the Precise Feeding of Dairy Cows." *Agriculture* 13(10):1858. https://doi.org/10.3390/agriculture13101858.

Lovarelli, D., J. Bacenetti, and M. Guarino. 2020. "A Review on Dairy Cattle Farming: Is Precision Livestock Farming the Compromise for an Environmental, Economic and Social Sustainable Production?" *Journal of Cleaner Production* 262:121409. https://doi.org/10.1016/j.jclepro.2020.121409.

Menendez, H. M., J. R. Brennan, C. Gaillard, K. Ehlert, J. Quintana, S. Neethirajan, A. Remus, et al. 2022. "ASAS–NANP Symposium: Mathematical Modeling in Animal Nutrition: Opportunities and Challenges of Confined and Extensive Precision Livestock Production." *Journal of Animal Science* 100(6): skac160. https://doi.org/10.1093/jas/skac160.

Niloofar, P., D. P. Francis, S. Lazarova-Molnar, A. Vulpe, M.-C. Vochin, G. Suciu, M. Balanescu, et al. 2021. "Data-Driven Decision Support in Livestock Farming for Improved Animal Health, Welfare and Greenhouse Gas Emissions: Overview and Challenges." *Computers and Electronics in Agriculture* 190:106406. https://doi.org/10.1016/j.compag.2021.106406.

Simitzis, P., C. Tzanidakis, O. Tzamaloukas, and E. Sossidou. 2022. "Contribution of Precision Livestock Farming Systems to the Improvement of Welfare Status and Productivity of Dairy Animals." *Dairy* 3(12):12–28. https://doi.org/10.3390/dairy3010002.

Issued in furtherance of cooperative extension work in agriculture and home economics, Acts of May 8 and June 30, 1914, in cooperation with the U.S. Department of Agriculture, Barbara Petty, Director of University of Idaho Extension, University of Idaho, Moscow, Idaho 83844. It is U of I policy to prohibit and eliminate discrimination on the basis of race, color, national origin, religion, sex, sexual orientation and gender identity/expression, age, disability, or status as a Vietnam-era veteran. This policy applies to all programs, services, and facilities, and includes, but is not limited to, applications, admissions, access to programs and services, and employment.

U of I is committed to providing reasonable accommodations to qualified individuals with disabilities upon request. To request this document in an alternate format, please contact CALS Extension Publishing at 208-885-7982 or calspubs@uidaho.edu.



BUL 1143 | Published October 2026 | **© 2026 by the University of Idaho**