

International Journal of Advanced Biochemistry Research



ISSN Print: 2617-4693
 ISSN Online: 2617-4707
 NAAS Rating (2026): 5.29
 IJABR 2026; 10(5): 698-702
www.biochemjournal.com
 Received: 20-02-2026
 Accepted: 25-03-2026

Shrilla Elangbam
 ICAR-Indian Veterinary
 Research Institute, Izatnagar,
 Uttar Pradesh, India

Hari Om Pandey
 ICAR-Indian Veterinary
 Research Institute, Izatnagar,
 Uttar Pradesh, India

Angella Elangbam
 ICAR-Indian Veterinary
 Research Institute, Izatnagar,
 Uttar Pradesh, India

V Apanai Celina
 ICAR-Indian Veterinary
 Research Institute, Izatnagar,
 Uttar Pradesh, India

Peyi Mosing
 ICAR-Indian Veterinary
 Research Institute, Izatnagar,
 Uttar Pradesh, India

Ashmita Debnath
 ICAR-Indian Veterinary
 Research Institute, Izatnagar,
 Uttar Pradesh, India

Dimalie Michui
 ICAR-Indian Veterinary
 Research Institute, Izatnagar,
 Uttar Pradesh, India

Corresponding Author:
Shrilla Elangbam
 ICAR-Indian Veterinary
 Research Institute, Izatnagar,
 Uttar Pradesh, India

Towards smart pig farms: AI-based animal monitoring and farm record keeping in pig production

Shrilla Elangbam, Hari Om Pandey, Angella Elangbam, V Apanai Celina, Peyi Mosing, Ashmita Debnath and Dimalie Michui

DOI: <https://www.doi.org/10.33545/26174693.2026.v10.i5i.8496>

Abstract

The growing global demand for pork and animal-derived protein has accelerated the intensification and expansion of pig production systems. Smart pig farming employs technologies that enable the collection and analysis of biometric and behavioural data such as feeding patterns, locomotion, vocalisation, body temperature, activity levels, growth performance and welfare indicators, thereby supporting the early identification of disease, stress, and abnormal behavioural patterns. In addition to animal monitoring, AI-driven systems have demonstrated significant potential in automated farm record keeping. By integrating and applying available technologies, livestock farmers can collect a wide range of data that enables automated animal monitoring while enhancing pig health, welfare, and environmental sustainability.

Keywords: Artificial intelligence, smart farms, piggery, computer vision, precision pig farming

Introduction

The rapidly growing global population and increasing demand for animal-derived food products have intensified the need for sustainable and efficient livestock production systems. Reports from the Food and Agriculture Organization (FAO) and the United Nations estimate that food production must increase substantially by 2050 to meet future nutritional demands. In this context, the livestock sector, particularly pig production, plays an important role in supplying high-quality protein-rich food and supporting agricultural economies in many developing countries (Röös *et al.*, 2017) [9]. Consequently, smart swine farming has emerged as an important technological approach for improving the efficiency, sustainability, and productivity of pig production systems.

Smart swine farming involves the application of Information and Communication Technology (ICT), the Internet of Things (IoT), artificial intelligence (AI), robotics, wireless sensor networks, and big data analytics for monitoring and managing farm operations. In pig production, these technologies support precision livestock farming (PLF) through automated monitoring, real-time data collection, and digital farm record keeping, enabling more accurate and timely management decisions.

Modern smart farming systems utilise sensors, cameras, microphones, accelerometers, and radio-frequency identification (RFID) devices to continuously monitor physiological, behavioural, and environmental parameters in pigs. Furthermore, digital record-keeping systems enable accurate management of farm data including feed and water intake, body weight, breeding performance, vaccination schedules, medication records, disease occurrence, mortality, and overall herd management. The integration of monitoring technologies with farm record management improves traceability, production planning, and data-driven decision-making.

Smart farming technologies also facilitate early disease detection, automated environmental control, behavioural monitoring, and precision feeding, thereby improving animal welfare and farm efficiency. Moreover, these technologies contribute to economic sustainability by reducing labour requirements, lowering production costs, improving feed efficiency, and enhancing overall productivity. Therefore, ICT-and AI-driven smart swine farming systems are increasingly recognised as essential components of sustainable, welfare-oriented, and technologically advanced pig production systems.

Smart pig farming

Smart farming system is a concept that combines various technologies to improve and address the challenges associated with animal production. Smart pig farming systems integrate the use of sensors, cameras, microphones, radio frequency identification (RFID), thermal imaging, IoT, robotics, deep learning, and big data analytics to enable continuous, real-time and non-invasive monitoring of pigs and farm conditions (Marić *et al.*, 2025) ^[6].

ICT-based smart technologies, including smart ear tags, intelligent sensors, IoT devices, deep learning, big data systems, and robotics, can actively support agricultural operations. These technologies have proven effective in collecting, processing, and analysing farm data, helping farmers improve management, productivity, and animal welfare. Table 1 highlights the major applications of smart tools in the modern swine industry and demonstrates how advanced technologies improve pig farming.

Importance of smart pig farming

Smart swine farming has emerged as an important technological approach integrating ICT, IoT, artificial intelligence (AI), robotics, wireless sensor networks, and big data analytics into pig farming. These technologies facilitate real-time collection and analysis of data related to feeding behaviour, locomotion, growth performance, environmental

conditions, physiological responses, and welfare indicators.

Pigs are exposed to stressors including overcrowding, restricted movement, poor ventilation, thermal stress, and harmful gas accumulation, all of which negatively affect immunity, growth, reproduction, feed efficiency, and welfare. In addition, welfare issues such as tail biting, aggression, neonatal mortality, and stress-related disorders can significantly reduce productivity and economic returns. Smart farming technologies provide opportunities for early disease detection, automated environmental control, behavioural monitoring, and precision feeding, thereby minimizing stress and improving animal welfare and farm productivity. Furthermore, IoT-based systems support accurate farm record keeping, including feed and water intake, body weight, vaccination schedules, medication records, disease incidence, and environmental parameters, enhancing farm management efficiency and operational sustainability.

The integration of these smart technologies not only enhances operational efficiency and economic productivity but also contributes towards environmentally sustainable and welfare-oriented pig production systems (Table 1). Therefore, the adoption of AI-based animal monitoring and smart farm record-keeping technologies represents a promising advancement towards the development of intelligent, resilient, and sustainable pig farming systems.

Table 1: Applications of smart tools in modern swine industry (Mahfuz *et al.*, 2022) ^[5]

Smart Tool	Uses
Radio Frequency Identification (RFID)	Identification of pigs, individual animal data, date of birth, mortality, pen number, farm number or group number, etc.
Infrared thermal imaging	Temperature of individual pigs or whole herd, muscle injuries, infectious disease, ovulation etc.
Microphone/cough detector/sound detector	Detection of normal or abnormal sound for sickness, coughing sound, heat detection, group behaviours of pigs
ZigBee technology	To detect environmental parameters: temperature, relative humidity, concentrations of carbon dioxide and ammonia in pig house
Deep learning/image analysis	Auto locomotion, movement pattern, behaviours, posture, tail biting, temperature, body weight, etc.
Two-dimensional(2D) cameras	Individual identification of pigs based on color, pigs' locomotion, behaviours, posture, house environment, etc.
Three-dimensional(3D) cameras	Feeding time, body weight, posture, lameness, injuries, group behaviours, etc.
Accelerometer	Pigs' movement pattern including standing time, posture, monitoring, and welfare, etc.

AI based animal monitoring

"Even the best herdsman find it difficult to keep an eye on animals in groups" NPB—Animal Science Committee (Hostetler *et al.*, 2018) ^[3]. Using real-time analysis of photos, sounds, tracking data, weight and body condition, and biological parameters in livestock. PLF entails automated remote identification and monitoring of identifiable individuals for animal health and welfare. As a result, early disease or physiological condition detection at the farm level is possible.

Smart farming systems and PLF are closely interlinked concepts that use advanced technologies to optimise management in pig production and improve pig health and

welfare (Marić *et al.*, 2025) ^[6]. These systems are based on modern technologies such as the IoT, artificial intelligence (AI) and advanced real-time data analytics. By collecting, processing, and analysing real-time data, smart farming and PLF enable farmers to make accurate management decisions, increase productivity, reduce labour requirements, and maintain higher animal welfare standards.

PLF has significantly expanded because to computer science skills, low-cost sensors, and expanding computer capabilities for data collection and processing.

A typical precision pig farming system is composed of four key modules (Fig. 1)

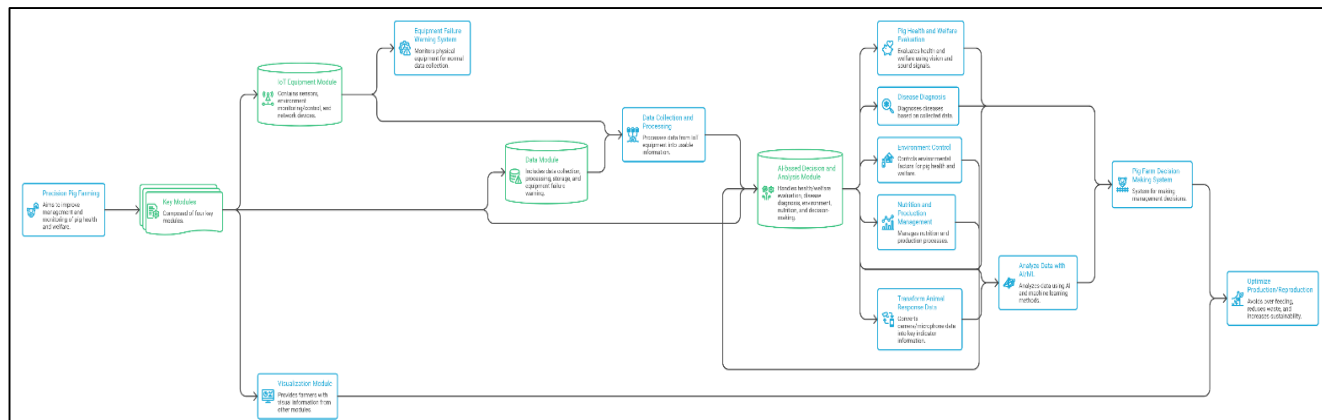


Fig 1: Framework of Precision Pig Farming System (Created with Napkin AI)

Monitoring technologies in pig production

1. Physiology, body condition, and automatic weight detection

Live weight, shape, growth and body composition are critical factors in the management of swine production because individual pig weight and growth have an impact on the herd in terms of barn flow, space allowance, and audit parameters (Nguyen *et al.*, 2023) [7]. Research has demonstrated potential and commercialisation in the field of automatically estimating pig mass and weight by extracting their 3D shape. According to Kashiha *et al.* (2014) [4], using image analysis on a real-time basis, the accuracy rate of fattening pigs' weight was approximately 97.5% (0.82 kg errors) at the group level and 96.2% at the individual level (1.23 kg errors). This imaging technique can provide accurate automated body weight of individual pigs, whereas handling pigs frequently by manual methods causes heavy stress that negatively affects production and is labour-intensive. Additionally, farmers can identify slow-growing pigs by using smart weighing procedures, and they can then make the right decisions to properly manage this. According to some research, the top view of a pig's body can be used to estimate its weight.

2. AI-Based sound detection for pig disease and estrus diagnosis

In addition to vision for monitoring abnormal pig behaviours, sound is also the most obvious external manifestation for pig diseases. Pig's coughing sounds could be used as a feature to identify pig respiratory diseases. For monitoring and recognition of pig coughs and estrus sounds, data preprocessing and sound recognition models are two important aspects. In terms of data preprocessing, as the pig cough sound spectrum, the environmental noise frequency band of pig farming is usually below 5 KHz, which overlaps with the pig cough sound frequency band. In order to better remove fan noises in pig farming, Dong *et al.* proposed a Discrete Cosine Transform-based enhancement algorithm for pig cough sound signal denoising. An algorithm for voice analysis can be applied to sound recordings in order to identify heat stress and high frequency "screams" of pain resulting from fighting or tail biting. Soundtalks R (Leuven, Belgium), a commercial sound detection package, can identify sounds in a specific region, allowing for ventilation adjustments and respiratory disease treatment at the pen level rather than the barn as a whole (Pluym *et al.*, 2013) [8]. If there are not enough microphones or the barn is noisy, sound detection may be impeded. Pigs would be able to

"speak for themselves" about their well-being if they could reliably differentiate between normal and stress-related vocalisations.

3. Activity monitoring at the pen level for grower and nursery pigs

Video pictures to measure pen level activity, such as antagonistic behaviours, chasing, tail and flank biting, fighting, and head-to-head knocks between pigs can be used to improve welfare and automate pig monitoring. Sensor data distinguishes between standing and moving pigs, lateral and sternal recumbency, and lying patterns of pigs (thermal comfort behaviour). Pig whereabouts, feeding, drinking, and aggressive interactions among pigs can all be monitored with depth imaging tracking. Pigs tend to pile and lie close together hence it is currently challenging to apply sensor tracking for individual pig movement in a large group. Using 3D cameras and machine learning to identify pig activity and automatically warn about tail-biting "outbreaks" was one method of pen monitoring.

4. AI-Based vision system for recognition of pig mounting and estrus behaviours

Pigs' mounting behaviours often appear in overcrowded environments and mounting behaviours between pigs increases the risk of injury. Moreover, improving the reproductive efficiency of sows can reduce management costs and feed costs per pig. In natural mating, sows mate at least three times to increase the likelihood of fertilisation. However, the boar will produce behaviours such as climbing and straddling when it is in estrus. Therefore, accurate identification of mounting and estrus behaviours is essential to ensure sow fertilization and pig health and welfare. AI-based vision systems can continuously monitor pig activity in real time, enabling early detection of abnormal or reproductive behaviours with higher accuracy and reduced labour requirements.

5. Lameness and mobility

Lame sows can be expected to behave differently due to physically reduced locomotion, pain or general discomfort and sickness behaviour. Unfortunately, because fewer personnel are handling more animals, lameness often goes undiagnosed until it is moderate to severe. Accelerometers, imaging, and pressure mat or force plate devices are methods for autonomously scoring lameness. Reliable methods that can detect irregular or asymmetric gaits in lame pigs include force plates (Matscan R and SowSIS

(Tekscan, South Boston, MA; Institute for Agricultural and Fisheries Research, Melle, Belgium) and pressure-sensing mats (GAITFour R (CIR Systems, Inc., Havertown, PA, USA). Leg loading and weight shifting, weight distribution on sows' four legs, and claw pressure distribution have all been measured using force plates. Other factors that have been used to classify lameness include swaying from side to side, shorter or irregular steps, and decreased walking speed. Motion tracking and topological analysis of these animals can identify these visual characteristics.

6. Recognition of pig nursing, lying down and other behaviours

Productivity in commercial piglets' production is largely dependent on the number of weaned piglets per sow. However, one of the main reasons for high pre-weaning mortality in piglets is starvation. In addition, pig lying and other behaviours are also important characteristics in judging the healthy diet and pig disease. With the development of AI algorithms, a variety of deep learning-based approaches have been proposed to detect pig behaviours to maximize the welfare and economic benefit of pig rearing. The deep learning-based pig feeding behaviours, posture and other behaviours recognition often train models using images, video and 3D data.

7. Monitoring welfare

Pigs are housed in groups in large-scale commercial farms, making it more challenging for farmers to keep an eye on individual animals. Animals are non-invasively monitored to determine their welfare and forecast productivity using sensors (cameras, microphones, and accelerometers) that blend images, sounds, and movements with algorithms. According to Benjamin and Yik (2019) ^[1], this remote livestock monitoring offer quantitative and early alerts to situations of poor welfare. Continuous video-based monitoring of pigs establishes prompt alerts of welfare issues and interventions to avoid or reduce harmful behaviour. Farmers may check the living conditions of pigs in real time by using continuous video-based monitoring. For example, pig farmers may receive an alert that contains the location and travelling trajectory of the attacker in the case of an aggressive event. This makes it possible to take the necessary steps right away to lessen such behaviour.

Smart Record Keeping Technologies for Swine Farms

According to Mahfuz *et al.* (2022) ^[5], conventional methods of farm record keeping and animal monitoring, such as manually recording data in notebooks or isolated digital devices without data-sharing capabilities, are inadequate for modern intensive swine production systems. With the continuous expansion of the global pork market and increasing consumer demand, swine farm sizes are becoming progressively larger, making individual animal monitoring and timely management more challenging for farmers.

In large-scale production systems, providing appropriate and timely care to individual pigs is critical for maintaining animal health, welfare, and productivity. Consequently, modern swine farming increasingly requires the adoption of automated and smart technologies for efficient farm management and record keeping. Technologies such as sensors, RFID systems, IoT-based monitoring devices, automated data recording systems, and artificial intelligence

enable continuous collection, storage, and analysis of farm data in real time. These systems improve the accuracy of record keeping related to feed intake, growth performance, disease occurrence, medication, breeding, mortality, and environmental conditions.

The integration of smart technologies into swine farm management not only reduces labour requirements and human error but also enhances decision-making, traceability, production planning, and overall farm efficiency. Therefore, digital and automated record-keeping systems are becoming essential components of modern smart pig farming practices.

Limitations

One of the major challenges is the high initial investment required for the installation and maintenance of advanced technologies such as sensors, automated monitoring systems, artificial intelligence, and IoT-based devices. In addition, the successful implementation of these technologies requires technical knowledge, digital literacy, and proper infrastructure, which may not be readily available to small-and medium-scale farmers. Concerns related to data ownership, privacy, system compatibility, and dependence on proprietary software platforms also remain important issues in smart farming systems.

Furthermore, the adoption of smart pig farms requires support from trusted stakeholders, including researchers, veterinarians, extension workers, technology developers, and agricultural organisations.

Despite these limitations, smart pig farming presents significant opportunities for the future livestock sector. Continuous developments in artificial intelligence, machine learning, robotics, and real-time data analytics are expected to improve the accuracy, affordability, and accessibility of smart farming technologies.

Conclusions

The increasing global population and rising demand for animal-derived food products have intensified the need for sustainable and efficient livestock production systems. In this context, smart swine farming has emerged as important approaches for improving pig production efficiency, sustainability, and animal welfare.

Smart pig farming facilitates accurate and real-time recording of feed intake, body weight, breeding performance, vaccination schedules, disease occurrence, mortality, and environmental parameters, thereby improving traceability and management efficiency. Digital farm record-keeping systems are also becoming increasingly important in large-scale pig production.

Despite these advantages, IoT-based systems are still not widely adopted due to high installation costs, technical complexity, and limited infrastructure. Nevertheless, continuous advancements in artificial intelligence, robotics, wireless sensor networks, and big data analytics are expected to further modernise pig production systems. Therefore, smart swine farming has significant potential to improve animal welfare, productivity, farm efficiency, and sustainability in future livestock production systems.

References

1. Benjamin M, Yik S. Precision livestock farming in swine welfare: a review for swine practitioners. *Animals*. 2019;9(4):133.

2. Godfray HCJ, Garnett T. Food security and sustainable intensification. *Philos Trans R Soc B Biol Sci*. 2014;369(1639).
3. Hostetler C, Stokes A, Becton L. National Pork Board request for proposals general call 2018: writing research proposals for the NPB. Ames (IA): National Pork Board; 2018. p. 1-19.
4. Kashiha M, Bahr C, Ott S, Moons CP, Niewold TA, Ödberg FO, et al. Automatic weight estimation of individual pigs using image analysis. *Comput Electron Agric*. 2014;107:38-44.
5. Mahfuz S, Mun HS, Dilawar MA, Yang CJ. Applications of smart technology as a sustainable strategy in modern swine farming. *Sustainability*. 2022;14(5):2607.
6. Marić K, Gvozdanović K, Djurkin Kušec I, Kušec G, Margeta V. Smart pig farms: integration and application of digital technologies in pig production. *Agriculture*. 2025;15(9):937.
7. Nguyen AH, Holt JP, Knauer MT, Abner VA, Lobaton EJ, Young SN. Towards rapid weight assessment of finishing pigs using a handheld, mobile RGB-D camera. *Biosyst Eng*. 2023;226:155-168.
8. Pluym LM, Maes D, Vangeyte J, Mertens K, Baert J, Van Weyenberg S, et al. Development of a system for automatic measurements of force and visual stance variables for objective lameness detection in sows: SowSIS. *Biosyst Eng*. 2013;116(1):64-74.
9. Röös E, Bajželj B, Smith P, Patel M, Little D, Garnett T. Greedy or needy? Land use and climate impacts of food in 2050 under different livestock futures. *Glob Environ Change*. 2017;47:1-12.
10. Sharifuzzaman M, Mun HS, Ampode KM, Lagua EB, Park HR, Kim YH, et al. Smart pig farming—A journey ahead of Vietnam. *Agriculture*. 2024;14(4):555.