

DEVELOPMENT OF A WEB-BASED INFORMATION SYSTEM FOR SURVEILLANCE OF REPRODUCTIVE PERFORMANCE, DISEASES AND BIOSECURITY IN SWINE FARMS IN PAMPANGA

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ABSTRACT

This study addresses the critical need for efficient livestock health and productivity monitoring by developing a user-friendly, web-based prototype information and decision support system tailored for smallholder hog producers. The current manual, fragmented systems cause delays and inefficiencies in disease detection, reproductive recording, and data management, hindering timely decision-making. The developed system, built on open-source software, integrates data entry, user interface, and database management to assess key reproductive performance indicators against Philippine production standards. It offers technical evaluations of sow reproductive efficiency and delivers customized management recommendations. Additionally, the system incorporates biosecurity surveillance aligned with the Philippine College of Swine Practitioners' guidelines, generating quantitative risk ratings and actionable improvement recommendations. A novel, prototype image-processing module enhances disease detection by comparing user-submitted photos against a curated reference database, supporting early identification and improving infectious disease reporting. The platform includes protocols to mitigate disease spread and is accessible at <https://www.salazaris.com>. While promising as a cost-effective alternative to proprietary solutions, the system needs to be validated through on-farm trials to assess its accuracy, usability, and overall effectiveness. Future studies will concentrate on field testing and ongoing improvements to enhance user acceptance and influence swine production management.

Keywords: biosecurity, decision support system, disease detection, reproductive performance, swine production

INTRODUCTION

The Philippine swine industry faces numerous challenges that impact productivity and sustainability. Over the past decade, Pampanga has consistently ranked third among Region III's hog producers (PSA, 2020). To sustain and enhance this position, there is a critical need for innovative solutions that improve access to agricultural information, streamline reporting processes, and support informed decision-making. Developing a web-based information support system offers a promising approach to meeting these needs by facilitating efficient sourcing, real-time data acquisition, and comprehensive decision-making support. Establishing a web-based information support system will facilitate more

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effective sourcing of agricultural data and information, accelerate reporting processes, and improve decision-making support tools (Department of Agriculture, 2020).

This system is envisioned to serve local city and municipal agriculturist officers by providing timely and accurate swine production data, generating more precise and faster analytical reports, and strengthening overall decision support. Furthermore, the platform will equip local agricultural units with an online monitoring tool to evaluate hog farm productivity, provide producers with up-to-date, interpretable data on breeding performance, and recommend evidence-based management adjustments to optimize swine production.

In addition to productivity enhancement, the system aims to incorporate disease diagnosis capabilities, empowering users to implement immediate first-aid interventions and thereby limit the spread of infectious diseases within hog populations. Special focus is also given to backyard hog raisers, enabling them to analyze and interpret production data and technical indicators to assess their farm’s efficiency and productivity. The platform will offer tailored recommendations to improve management practices and facilitate informed decision-making.

Moreover, the project aims to assess the biosecurity status of small-scale hog farms, ensuring protection against pathogenic threats and thereby contributing to the health and safety of local swine populations. Di Lorenzo *et al.* (2019) noted that the efficiency of Web-GIS surveillance systems can be increased by using specialized software for data collection and analysis, providing competent authorities with tools to focus surveillance activities and disease control measures better. Ultimately, this initiative aims to establish a comprehensive sow reproductive efficiency assessment and monitoring portal, specifically generate a web-based prototype decision-support system, biosecurity surveillance, and disease detection tool explicitly tailored for backyard hog raisers in Pampanga, fostering sustainable growth and resilience in the local swine industry.

MATERIALS AND METHODS

System Development Cycle

The system’s development followed an iterative methodology, facilitating continuous refinement through recurrent cycles of analysis, design, implementation, and evaluation (Figure 1). This approach was strategically selected for its versatility in identifying system defects and operational inefficiencies, thereby enabling timely recommendations for improvements and corrections during the development and data acquisition phases.

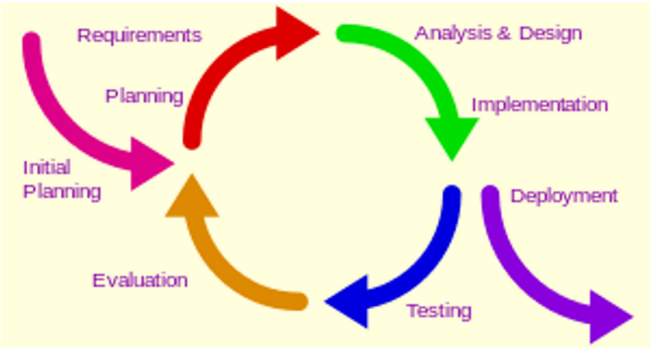


Figure 1. System development cycle (Chowdhury *et al.*, 2017).

System Development and Architecture

This system was specifically designed to analyze herd management factors affecting reproductive efficiency in swine production. The interactive database was structured into three primary categories: standing, operation, and value datasets. The backend database employed MySQL, a robust, open-source relational database management system extensively adopted for managing structured biological data (Christudas, 2019). Data manipulation and user interface were implemented through a PHP-based web application framework, complemented by Visual Studio Code as the primary integrated development environment (IDE) for code editing, debugging, and live preview (Microsoft, 2023). The web server environment was hosted by GoDaddy, a service initially established as a domain registrar and currently offering comprehensive web hosting solutions (Pradhan and Jain, 2023). The application runs on Microsoft Windows, which effectively manages hardware resources and supports multitasking, essential for sustained system operations (Meilinaeka, 2023). Machine learning functionalities were integrated using TensorFlow, an advanced, open-source library that provides both low-level and high-level APIs (including Keras and Estimators) and supports multiple programming language interfaces, offering enhanced flexibility in model development (Pang *et al.*, 2019). The system is accessible online at <https://www.salazaris.com>.

Algorithm Generation for Indices Calculation

The user interface captures detailed reproductive events for each sow, including breeding, farrowing, and weaning records (Figure 2). Upon initial registration, each sow's breeding dates were logged. Pregnancy status was monitored post-breeding to identify cases requiring re-breeding, which significantly influences the actual farrowing/litter index (ALI) and non-productive days (NPD) metrics. Following the standard gestational period of approximately 114 days, farrowing data, including actual farrowing date, piglets born alive, stillbirths, mummified fetuses, fostered piglets, and average birth weight, were recorded. These parameters are critical for computing key reproductive performance indicators such as piglets born alive (PBA) and pre-weaning mortality rate (%PWM). Weaning data, typically collected 30–35 days post-farrowing, included the weaning date, total number of piglets weaned, and average weaning weight, which were used to calculate the number of piglets weaned per litter (PW/L). PW/L was subsequently multiplied by ALI to estimate piglets weaned per sow per year (PWSY). Additionally, the Sow Productive Life (SPL) was quantified as the interval from the first breeding date to the last recorded weaning date.

The system automates the calculation and assessment of reproductive performance indices via predefined formulae encoded in MySQL queries. SPL was determined by counting the number of completed breeding cycles from breeding to weaning. ALI was calculated by dividing the number of farrowing events (parity number) by SPL, representing the average annual farrowing frequency per sow. Other indices followed similar computational procedures upon validation of complete and accurate data entry. The system cross-referenced computed indices against benchmarks from the Swine Production Performance standards in the Philippines to generate interpretive remarks and targeted recommendations, serving as decision support for swine producers.

The generated decision support outputs provide technical assessments of sow reproductive performance. Hog raisers use these assessments to inform management decisions, either adopting or rejecting system-generated recommendations. Poor performance

indicators trigger corresponding decision-support messages that offer customized tips and suggestions to address the identified issues. This feedback loop enhances producers’ ability to optimize herd productivity through data-driven interventions.

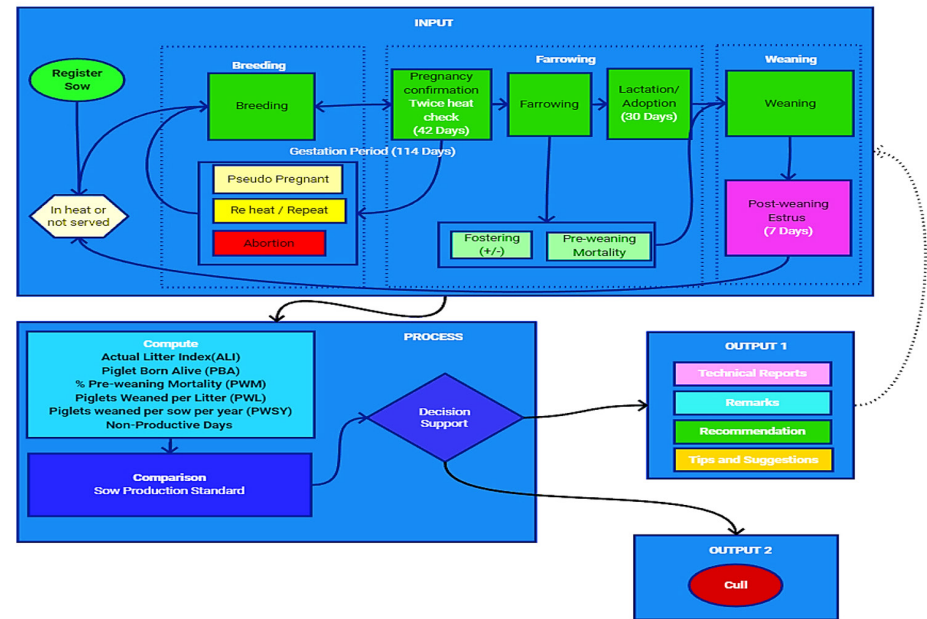


Figure 2. Reproductive events of the sow.

Biosecurity Assessment of Swine Farms in Pampanga

The system incorporates a biosecurity assessment module adapted from established surveillance parameters defined by the Philippine College of Swine Practitioners and the Bureau of Animal Industry. It generates a quantitative biosecurity score along with tailored recommendations, enabling swine producers in Pampanga to evaluate and improve their farm biosecurity protocols. Future developments aim to integrate a more comprehensive biosecurity assessment tool tailored for commercial swine operations, further enhancing disease prevention measures.

Image Processing and Analysis for Common Swine Disease Diagnosis

Rapid and accurate diagnosis of common swine diseases is critical for improving farm productivity and profitability. To address this challenge, the system incorporates an image processing and analysis component designed to aid in the identification of swine infectious diseases such as erysipelas and neonatal colibacillosis. This module utilizes image datasets comprising photographs and footage of actual clinical, pathognomonic signs captured from hog farms, downloaded from reliable textbooks and literature on affected animals, and processed using TensorFlow, a well-trained machine learning algorithm refined with input from veterinary specialists. The system generates preliminary diagnostic outputs to facilitate first-aid interventions and guides users on recommended biosecurity protocols to mitigate disease transmission. Continuous veterinary consultation during development ensures the clinical relevance and reliability of diagnostic recommendations. This tool

also supports structured reporting of infectious disease outbreaks to relevant authorities, enhancing surveillance and response capabilities.

RESULTS

ASF Status and Municipalities in Pampanga

At the onset of this study, only three municipalities in Pampanga, Apalit, Mexico, and Candaba, were designated as “Pink Zones.” These areas are classified as buffer zones adjacent to infected regions where African Swine Fever (ASF) has not been detected for at least 90 days, indicating recovery from prior infection (Department of Agriculture, 2021). As of August 2023, this number has increased to seven municipalities classified under the “Pink Zone” category (BAI, 2023).

Current Record-Keeping and Biosecurity Practices

Information collected revealed that most small-scale swine farms still rely on traditional, manual recording systems for breeding and reproductive events, utilizing notebooks or calendars to track dates of breeding/artificial insemination (AI), farrowing, and litter sizes. Additionally, awareness of biosecurity measures and common swine diseases remains inadequate among these farmers. Use of automated record-keeping tools and dedicated swine management software is minimal, and knowledge of biosecurity application systems is limited.

Data Import

To address the need for accurate reproductive record-keeping, a browser-based decision support system was developed and tested using existing sample datasets. The system captures key reproductive events aligned with breeding processes (Figure 2), and presents these using color-coded indicators and bilingual (Filipino-English) terminology to enhance user comprehension. For example, the mating event (“pagbulog”) is visually coded: green indicates a single breeding event and confirms gestation after two consecutive heat checks (18–21 days); yellow signals multiple breeding events (reheating), suggesting possible reproductive disorders or management errors; and red denotes three breeding attempts, often indicative of physiological disturbances or infections that lead to economic losses due to increased non-productive days.

Decision Support System Outputs

The developed system provided a range of decision-support features to help smallholder swine raisers improve reproductive efficiency and farm management. The Individual Sow Technical Result (ISTR), as shown in Figure 3, enables users to evaluate each sow’s performance against benchmark reproductive parameters established by PCAARRD and PSFI. Parameters labeled “Poor” were interactive, allowing users to click to receive immediate pop-up recommendations, including possible causes and practical improvement tips. At the herd level, the Sow Herd Technical Result (SHTR) in Figure 4 aggregated performance data for all sows on a particular farm, helping farmers identify reproductive inefficiencies and make informed decisions about culling or retention. Detailed insights into underperforming parameters were provided in Figure 5, which presented suggested causes, remedial actions, and management tips when the “Poor” remark was clicked.

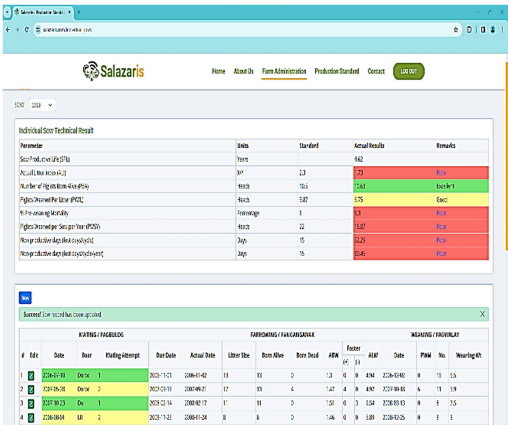


Figure 3. Individuals sow reproductive indices technical results with equivalent remarks.

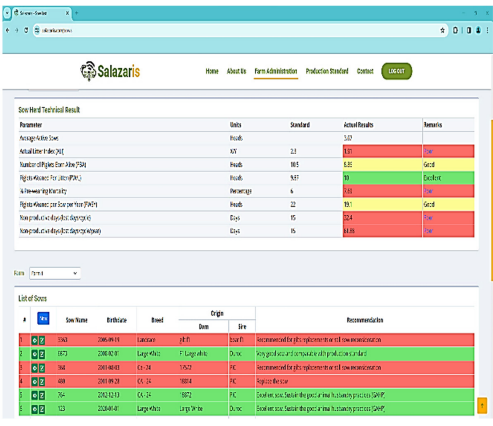


Figure 4. Sow herd reproductive indices technical results with equivalent remarks.

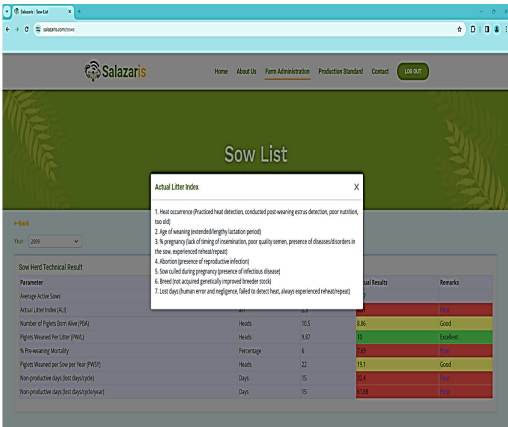


Figure 5. Tips, suggestions, and causes of "poor" remarked parameters.

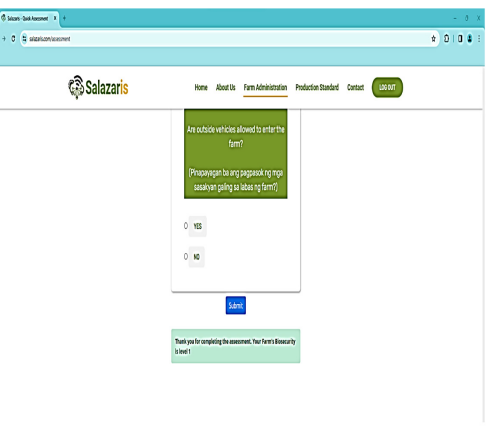


Figure 6. Notification of biosecurity level.

Furthermore, Figure 6 illustrates the Biosecurity Level Assessment feature, which enables the system to evaluate and report a farm's biosecurity status and notify the user of necessary corrective actions. Complementing these modules, Figure 7 displays the First Aid Treatment Suggestions provided by the system in response to specific disease symptoms or conditions. These comprehensive decision-support features aimed to improve reproductive outcomes, optimize herd performance, and promote proactive farm management practices in smallhold swine production systems.

Biosecurity Level

A user-friendly biosecurity evaluation tool (Figure 8), adapted from the Philippine College of Swine Practitioners, was embedded in the system. The assessment consisted of 21 yes-or-no questions, each with a corresponding numeric score. Questions covered farm layout, personnel movement, vehicle access, and sanitation protocols. Filipino translations

were incorporated to improve accessibility. The results were automatically stored and linked to the system’s municipal-level monitoring interface.

Image-Based Disease Detection and First-Aid System

The study also developed an AI-driven disease detection module using image processing to identify common swine diseases based on clinical signs. This tool suggests first-aid protocols and emphasizes the importance of professional veterinary consultation to prevent reliance on self-medication Figure 9. The AI system is accessible across multiple platforms, enabling widespread use among smallholder farmers.

User Interface and Software Usability

The system is a web-based application compatible across multiple devices and operating systems (Windows, Android, iOS). It meets the user-friendliness criteria of ISO 9126, including portability (no installation/uninstallation required, auto-updates), security features (encryption and authorization controls), efficiency, maintainability, and intuitive navigation. Users can access a detailed quick guide manual to facilitate system onboarding, covering farm registration, sow management, and record editing (Figures 10, 11, 12). Furthermore, the system offers direct IT support through a “contact us” feature.

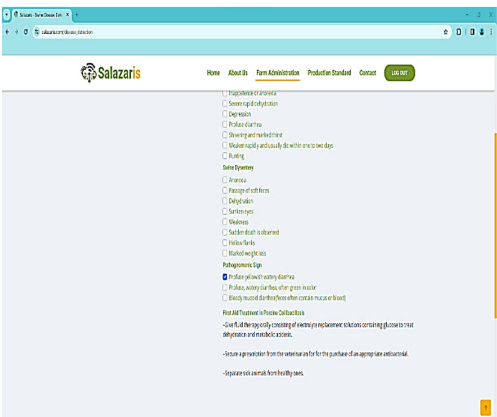


Figure 7. First-aid treatment recommendation.

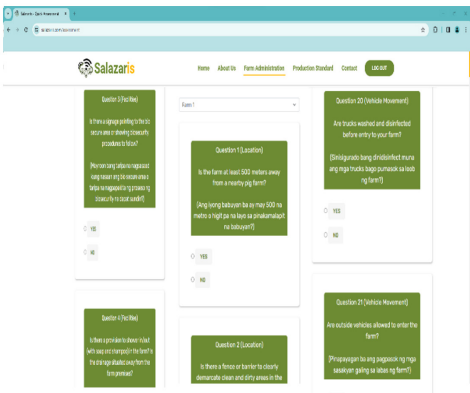


Figure 8. Web-based biosecurity assessment tool.

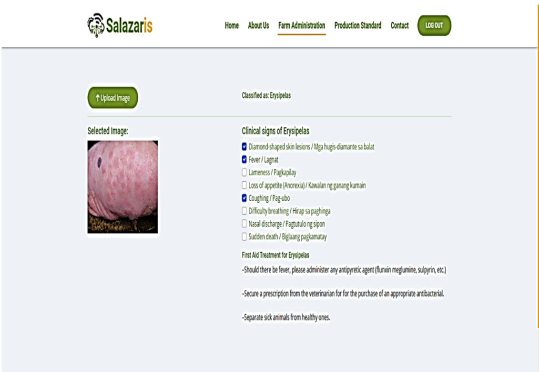


Figure 9. The generated common disease detection with first-aid treatment

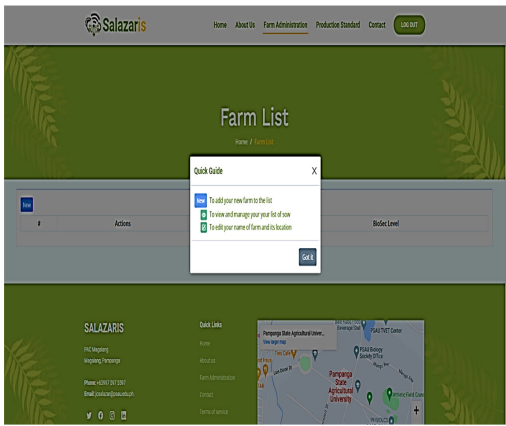


Figure 10. Quick guide for farm registration.

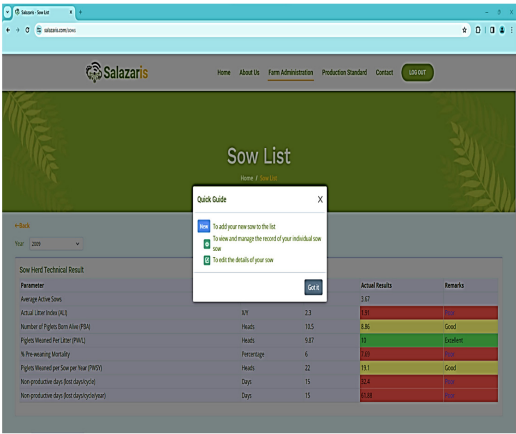


Figure 11. Quick guide for new sow registration.

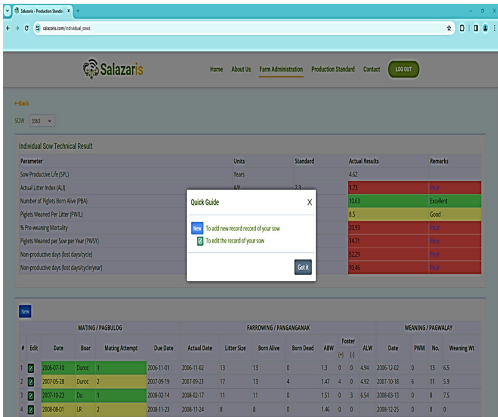


Figure 12. Quick guide for the new record of the sow.

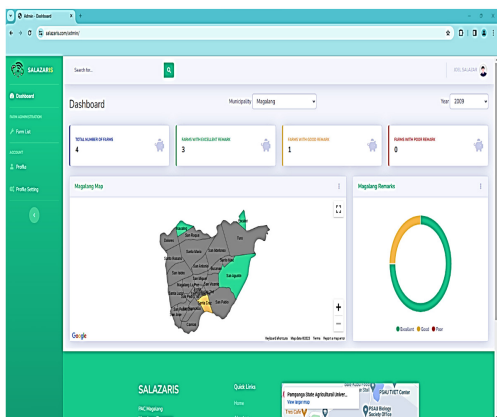


Figure 13. Dashboard of the generated monitoring and evaluation portal.

Monitoring Portal for Local Government Units

A complementary monitoring portal was created for municipal and city agriculturist officers (MAOs/CAOs) to track farm performance and biosecurity status within Pampanga. The portal displays overall farm population, performance summaries, and geo-coded maps using a color scheme to represent reproductive efficiency at the barangay level: green (excellent), yellow (acceptable with some management issues), and red (poor performance requiring intervention) (Figure 13). This platform facilitates streamlined communication between hog raisers and local authorities, supporting timely extension and veterinary services.

DISCUSSION

The findings reveal that despite the expanding “Pink Zone” buffer areas within Pampanga, smallholder swine farmers continue to rely heavily on manual, traditional record-

keeping methods that lack accuracy and timeliness. This gap underscores the urgent need for technology-enabled tools to enhance reproductive performance monitoring and adherence to biosecurity protocols. The developed web-based decision support system effectively addresses these shortcomings by providing intuitive, bilingual interfaces and actionable insights, facilitating improved farm management even among resource-limited users.

The present developed system stands alongside several notable web-based platforms designed for the reproductive efficiency and management, surveillance, and detection of animal diseases. Savini *et al.* (2007) mentioned that a web-based GIS system has been developed to manage animal disease epidemics by integrating epidemiological information with geographic data, providing real-time outbreak recording and spatial decision-making tools.

Similarly, Perez *et al.* (2009) developed the FMD BioPortal, a specialized web-based system for foot-and-mouth disease surveillance. This platform enhances near-real-time data sharing and incorporates space-time cluster analysis to identify emerging disease hotspots promptly. The BioPortal exemplifies how advanced analytical techniques can be embedded in web platforms to support timely, informed decision-making.

More recently, Di Lorenzo *et al.* (2019) highlighted that the main challenge faced by surveillance systems is the need to expedite data collection and analysis. Following confirmation of an outbreak of a contagious animal disease, a pressing question is identifying the most likely sources of infection and the animals that might have further spread the disease.

The generated web-based information system builds upon these foundational models by integrating enhanced data processing capabilities tailored to the Pampanga region's unique disease detections and biosecurity surveillance contexts. Unlike many existing platforms, the system emphasizes user-friendly interfaces and adaptive algorithms that accommodate local data variability and reporting practices. By focusing on timely data collection and processing, our approach aligns with the pressing demand identified by Di Lorenzo *et al.* (2019) for expediting surveillance activities, thereby assisting competent authorities in making more informed, immediate action decisions. Compared to international platforms, the present developed web-based application system demonstrates comparable functionality while addressing gaps specific to local implementation challenges.

Color-coded visualizations of sow reproductive events and herd-level performance empower farmers to identify potential physiological and management issues early, thereby reducing economic losses associated with non-productive days and reproductive inefficiencies. Moreover, integrating biosecurity assessment within the system educates farmers on practices that inhibit pathogen introduction and spread, a critical component in ASF management.

The incorporation of AI-based disease detection and first-aid recommendation modules further extends the system's utility by enabling early recognition of clinical signs and promoting appropriate responses. This approach mitigates the risks associated with delayed veterinary care and inappropriate self-medication, common challenges among smallholders.

Usability and accessibility were prioritized, with the system surpassing established software quality standards (ISO 9126). Its responsiveness across devices and operating systems ensures that a broad user base, including farmers with limited technical skills, can benefit. The inclusion of quick guide manuals and support channels enhances system adoption and sustainability.

Significantly, the monitoring portal facilitates real-time communication between farmers and government agricultural offices, enabling coordinated surveillance and response activities. This integration demonstrates potential for broader application in regional disease control and agricultural productivity initiatives.

A significant challenge in implementing the developed web-based application system is its accessibility to smallholder hog raisers, particularly those in remote areas with limited or unreliable internet connectivity. Furthermore, varying levels of user literacy present additional barriers to effective system utilization. To address these challenges, targeted training workshops must be conducted to enable hog raisers to become proficient at navigating and using the system. Such capacity-building efforts should be supported by Livestock Inspectors and City or Municipal Agriculturists, who can provide ongoing guidance and assistance to ensure the accuracy of data collection and analysis. Moreover, to validate the system's efficacy, usability, and accuracy, a comprehensive on-farm trial should be undertaken under real-world conditions.

CONCLUSION

A study was conducted to develop a browser-based sow reproductive efficiency assessment and monitoring portal tailored for smallholder hog raisers in Pampanga, utilizing open-source software to digitalize data recording and analysis. The resulting beta version web-based system enables users to measure breeding efficiency, assess farm biosecurity levels, identify common diseases, and provide first-aid recommendations. Additionally, the portal features a color-coded geographic mapping interface specifically designed for use by municipal agricultural officers (MAOs) and city agricultural officers (CAOs), enabling remote monitoring and informed decision-making. The system streamlines data collection and reporting, reduces human error, and expedites responses to physiological and biosecurity challenges encountered in breeding sows, thereby supporting novice backyard hog farmers and enhancing local government oversight without necessitating frequent farm visits. Based on these findings, it is recommended that the project proceed to field validation and comprehensive evaluation of on-farm trials to ensure consistency and reliability. Capacity building through training workshops should be conducted for the proficiency and utilization of the system by the smallhold hog raisers. Further support from PSAU-IP TBM is advised to pursue intellectual property protection and commercialization. Strengthening collaboration with veterinarians, animal scientists, IT experts, and fisheries scientists is encouraged to enhance healthcare management, emergency disease response, and system innovation. Incorporating advanced technologies, such as environmental sensors, artificial intelligence for disease tracking, GPS/GIS capabilities, and establishing an innovation center, is also suggested. Updates to the system should include communication features for training announcements and improved responsiveness by municipal personnel. Lastly, government involvement is crucial to support ongoing software development, promote system adoption, and institutionalize its use through relevant policies or ordinances.

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