Research Article

Determinants of Biosecurity Adoption and Goat Health in North Samarinda

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Abstract | Traditional smallholder goat farming systems frequently face animal health constraints due to limited adoption of biosecurity measures. This study assessed biosecurity implementation strategies and their implications for caprine health in North Samarinda District using a mixed-methods approach. Quantitative and qualitative data were collected from 30 goat farmers through structured questionnaires, in-depth interviews, and field observations, and analyzed descriptively and strategically using Strengths, Weaknesses, Opportunities, and Threats (SWOT) and the Quantitative Strategic Planning Matrix (QSPM) frameworks. The findings revealed low levels of farmer awareness and understanding of biosecurity principles, which were associated with limited implementation of essential practices, including sanitation, disinfection, and routine health monitoring. Major barriers to adoption included insufficient formal training, inadequate farm infrastructure, and continued reliance on traditional husbandry practices. In contrast, opportunities for improvement were identified through government extension services and increasing market demand for healthier livestock products. Strategic analysis indicated that the collaborative development and dissemination of simplified, low-cost biosecurity Standard Operating Procedures (SOPs) involving governmental agencies and farmer cooperatives represent the most effective intervention. The implementation of this strategy is expected to improve animal welfare, reduce disease transmission risks, and enhance productivity and sustainability in traditional goat farming systems.

Keywords | Biosecurity, Goat farming, Livestock health, SWOT analysis, North Samarinda

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INTRODUCTION

The Province of East Kalimantan, specifically North Samarinda District, sustains a segment of the population for whom caprine husbandry serves as either a primary or supplementary economic activity. As reported by the Central Statistics Agency (BPS) of East Kalimantan (2024), the regional caprine population was documented at 4,551 head, with North Samarinda constituting a principal hub for this agricultural sector. While consistent market demand underpins the practice's prevalence, production methods remain predominantly conventional. This traditional management approach poses substantial challenges, particularly in relation to pen sanitation, which plays a critical role in determining livestock productivity (Maru *et al*., 2025; Murat *et al*., 2026; Paradis *et al*., 2024). Accordingly, there is a clear need to implement improved management practices to enhance the sustainability, productivity, and overall quality of goat farming systems in the region (Bromfield, 2023; Fountain *et al*., 2023; Murat *et al.*, 2026).

The implementation of a robust biosecurity system is paramount for safeguarding caprine health and ensuring productivity (Duarte *et al.*, 2026; Henry *et al.*, 2024; Paradis *et al.*, 2024). Defined as a set of preventive protocols designed to prevent the introduction and spread of infectious pathogens within farming operations (Robertson, 2020; Varga *et al.*, 2025), biosecurity encompasses comprehensive measures including sanitation, disinfection, vaccination, animal movement control, and waste management (Maru *et al.*, 2025). Nonetheless, adoption among smallholder farmers is frequently hindered by a confluence of factors, such as limited technical expertise, insufficient infrastructure, and constrained access to pertinent information (Maru *et al.*, 2025; Morris *et al.*, 2023). The absence of such measures has direct consequences, contributing to diminished productivity, elevated mortality rates, and a reduction in meat quality (Bedekelabou *et al.*, 2022; Butucel *et al.*, 2022; Windsor, 2017). Furthermore, substandard and unhygienic housing conditions act as a significant reservoir for pathogen dissemination, posing a non-negligible zoonotic transmission risk to human populations (Bedekelabou *et al.*, 2022; Fountain *et al.*, 2023; Henry *et al.*, 2024).

Despite the availability of biosecurity information across print and electronic media, its dissemination frequently lacks the specificity and comprehensibility required for effective adoption by farmers in rural communities (Chen, 2020; Duarte *et al.*, 2026; Morris *et al.*, 2023). Concurrently, extension programs and technical assistance offered by local governmental bodies remain underutilized by the farming cohort (Fountain *et al.*, 2023; Windsor, 2017). Extension programs are underutilized primarily due to a systemic focus on production metrics (growth rates and breeding) rather than preventative health protocols. The previous studies (Duarte *et al.*, 2026; Fountain *et al.*, 2023; Henry *et al.*, 2024) revealed that government outreach often lacks the specialized veterinary technical staff needed for farm-level biosecurity auditing. When implemented correctly, biosecurity constitutes a critical long-term investment, functioning to mitigate epizootic risks, guarantee operational sustainability, and satisfy market prerequisites for wholesome and safe caprine products. These prevailing circumstances underscore the necessity for dedicated research into biosecurity implementation strategies within North Samarinda's goat farming sector. Such a study is anticipated to delineate the extant on-the-ground conditions, diagnose the specific constraints encountered by farmers, and subsequently develop a framework of recommendations for simple, effective, and contextually appropriate biosecurity protocols. The ultimate objectives of this research are to enhance livestock health, diminish disease incidence, and elevate the overall productivity and resilience of the regional goat farming industry.

MATERIALS AND METHODS

This study was conducted in North Samarinda District, Samarinda City, East Kalimantan Province, Indonesia, over a three-month period from February to April 2025. The study area was purposively selected due to its relatively high concentration of smallholder goat farms and the predominance of traditional husbandry practices, which provided a suitable context for examining biosecurity constraints at the farm level. The research adopted a convergent parallel mixed-methods design (Figure 1), in which quantitative and qualitative data were collected concurrently, analyzed separately, and subsequently integrated during interpretation to provide a comprehensive understanding of biosecurity barriers among goat farmers. A purposive sampling strategy was employed to select 30 goat farmers who met predefined inclusion criteria, namely ownership of more than five goats, a minimum of two years of continuous goat-farming experience, and permanent residence within North Samarinda District. This non-probability sampling approach was chosen to capture a range of practical experiences and informed perspectives on disease management and biosecurity implementation among active smallholder farmers. Consequently, the findings are intended to support analytical generalization rather than statistical inference to a wider population. Quantitative data were collected using structured questionnaires administered through face-to-face interviews with all selected farmers. The questionnaire assessed farmers' knowledge, attitudes, and self-reported implementation of key biosecurity practices, including animal isolation, sanitation, disinfection, and movement control. To ensure content validity, the questionnaire was reviewed by two livestock experts with expertise in animal health and smallholder production systems. Prior to formal data collection, the instrument was pilot-tested with five goat farmers in a neighboring district with comparable production characteristics. Feedback from the pilot test was used to refine question wording, clarify technical terminology, and ensure that all items were understood as intended.

In parallel with questionnaire administration, direct on-site observations were conducted at each farm to assess the actual implementation of biosecurity measures under real farming conditions. Observations focused on housing systems, hygiene and sanitation practices, waste management, animal movement control, and the presence or absence of isolation facilities. Observational data were recorded using standardized checklists and served to complement and validate self-reported questionnaire responses.

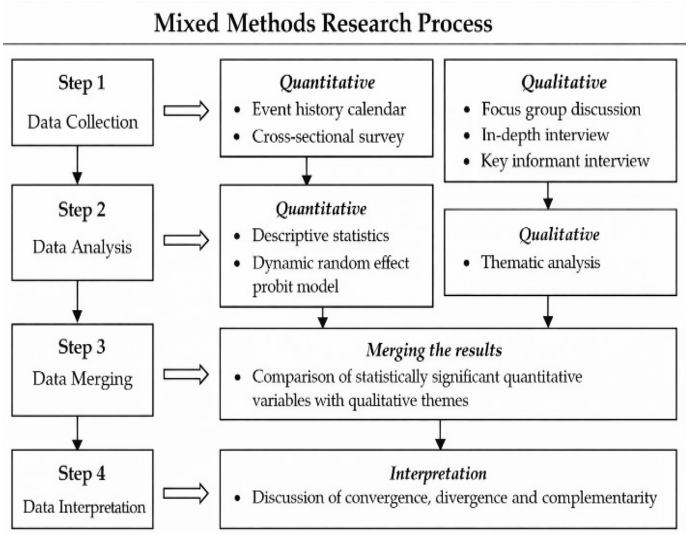

Figure 1: Mixed method research flowchart (Gempes, 2025).

Qualitative data were collected concurrently through in-depth, semi-structured, face-to-face interviews with the same group of farmers. Interview questions explored farmers' perceptions of disease risk, experiences with animal health challenges, socio-economic and cultural constraints, and perceived feasibility of biosecurity measures. All interviews were audio-recorded with participant consent and transcribed verbatim for analysis. Qualitative findings were used to contextualize and explain quantitative patterns rather than to develop or modify the quantitative instruments.

Quantitative data derived from questionnaires and observations were analyzed descriptively and subsequently organized into Strengths, Weaknesses, Opportunities, and Threats (SWOT) related to farm-level biosecurity. These factors were then evaluated using a Quantitative Strategic Planning Matrix (QSPM) to prioritize biosecurity improvement strategies based on weighted importance and attractiveness scores. Qualitative interview data were analyzed thematically to identify recurring barriers, enabling factors, and farmer-driven recommendations. Integration of quantitative and qualitative findings occurred during the interpretation phase through triangulation, whereby qualitative insights were used to corroborate, clarify, and enrich the SWOT–QSPM results. Supporting documentation, including photographic records of farm conditions and digital audio recordings of interviews, was collected as secondary data to strengthen data credibility and verification. Ethical considerations were observed throughout the study, and informed consent was obtained from all participants prior to data collection.

RESULTS AND DISCUSSION

The research results regarding respondent characteristics, including name, gender, educational background, age, farming experience, and participation in livestock training, are presented in Table 1.

Table 1: Respondent characteristics.

Respondent ID	Education level	Educational field/major	Farming Exp. (Years)	Biosecurity training
R1 - R3	Elementary	N/A	>10	No
R4 - R5	Junior high	N/A	5-10	No
R6 - R15	Senior high	N/A	5-10	4 Yes/ 6 No
R16-R17	Diploma	Health/ Technical	2-5	Yes
R18-R30	Bachelor's	Non-agricultural	1-5	4 Yes / 9 No

Gender

The gender composition of goat farmers in North Samarinda District, where men accounted for nearly two-thirds of respondents, reflects a persistent yet increasingly fluid division of labor within smallholder livestock systems. The predominance of male farmers is commonly attributed to the physically demanding nature of core husbandry activities, such as feed transport and housing maintenance (Fischer and Wittich, 2019; Henry *et al*., 2024; Issahaku and Policy, 2018; Morris *et al*., 2023). However, the findings from North Samarinda suggest that this pattern should not be interpreted as a rigid gender boundary. Women were not confined to auxiliary roles; instead, they demonstrated a capacity to assume labor-intensive tasks when household labor availability shifted, particularly in response to economic or time constraints (Fischer and Wittich, 2019). This adaptive allocation of roles is consistent with recent livestock and rural sociology studies that emphasize flexibility rather than strict gender segmentation in smallholder systems. For instance, Fischer and Wittich (2019) argue that women's participation in physically demanding farm work often increases when men engage in off-farm employment, highlighting labor substitution as a household resilience strategy. The North Samarinda results deepen this argument by showing that such flexibility also operates at the micro-task level, where responsibilities such as animal bathing or pen cleaning are negotiated pragmatically rather than normatively.

Compared with studies from other developing regions that report more entrenched gender divisions in small ruminant farming, the North Samarinda context appears moderately progressive. This may be linked to the semi-urban setting and increasing market orientation, which require both men and women to balance production, marketing, and household duties. Nevertheless, the continued association of physically demanding work with men indicates that structural and cultural constraints remain. Addressing these through gender-sensitive extension services could enhance labor efficiency and improve overall farm resilience (Fischer and Wittich, 2019).

Educational background

The educational background of goat farmers in North Samarinda District demonstrates substantial heterogeneity, ranging from elementary education to bachelor's degrees. Notably, 43% of respondents possessed university-level qualifications; however, these degrees were predominantly in non-agricultural disciplines such as Law and Economics. This finding suggests that formal education alone does not necessarily equate to technical competence in livestock production, particularly when educational content is not aligned with agricultural contexts. Qualitative interviews further revealed that highly educated farmers often conceptualized goat farming as a secondary activity or long-term investment rather than a primary livelihood. Consequently, their engagement with husbandry practices tended to be selective, focusing on cost efficiency and risk avoidance rather than intensive productivity enhancement.

Despite this, education remains a critical determinant of farmers' cognitive capacity to process information, evaluate risks, and make strategic decisions (Du *et al*., 2025; Oli *et al*., 2025). Previous studies have consistently shown that higher educational attainment enhances farmers' ability to adopt improved management practices and biosecurity measures, particularly in disease prevention and health management (Du *et al*., 2025; Liu, 2018; Ninh, 2026; Oli *et al*., 2025). This pattern is partially reflected in the North Samarinda findings, where better-educated farmers demonstrated greater awareness of disease risks and market dynamics. However, this awareness did not always translate into optimal on-farm practices, indicating a gap between knowledge and application.

A key explanatory factor emerging from the interviews was the perceived inadequacy of existing extension materials. Farmers described available training resources as overly theoretical, lacking practical relevance, and insufficiently supported by visual or step-by-step guidance. This perception aligns with broader critiques in the literature, which emphasize that ineffective knowledge transfer rather than limited education per se often constrains technology adoption among livestock farmers (Du *et al*., 2025; Fountain *et al*., 2023; Liu, 2018). Therefore, the North Samarinda case underscores the importance of tailoring extension approaches to farmers' educational profiles and motivations. Overall, these findings suggest that while higher education enhances analytical reasoning and decision-making capacity, its positive impact on goat farming performance is contingent upon the relevance, accessibility, and practical orientation of advisory services. Strengthening applied, visually supported training may help bridge the gap between formal education and effective on-farm implementation, thereby improving productivity and disease management outcomes (Du *et al*., 2025; Oli *et al*., 2025).

Age

Of the respondents, the majority (13 farmers) fell within the 41-50 years age cohort, followed by 8 farmers in the 31–40 year range. This distribution indicates that goat farming in the region is predominantly managed by individuals within their peak productive and experiential years. A notably lower level of participation was observed among younger generations, with only 4 respondents belonging to the 21–30 age group, highlighting a concerning trend of limited youth engagement in the sector that threatens its long-term sustainability and regeneration. Meanwhile, the continued involvement of older farmers remained evident, with 3 respondents aged 51–60 and 2 aged 61–70, despite the potential physical demands of the work.

Existing literature underscores the considerable influence of age on farmers' comprehension and implementation of biosecurity protocols. Older farmers often bring a wealth of practical experience in livestock management, including the application of biosecurity measures aimed at preserving animal health and mitigating zoonotic disease risks (Dessart *et al*., 2019; Fountain *et al*., 2023; Tsegaye *et al*., 2023). Correspondingly, where some authors (Bedekelabou *et al*., 2022; Evans *et al*., 2025; Fountain, *et al*., 2023) pointed out and observed that senior farmers tend to exhibit more nuanced understanding in areas such as waste management and animal health-practices intrinsically linked to biosecurity. Furthermore, experienced farmers are generally more inclined to adopt effective management techniques, including pen sanitation, pest control, and the utilization of quality feed (Bedekelabou *et al*., 2022; Dessart *et al*., 2019; Duarte *et al*., 2026; Varga *et al*., 2025). In summary, goat farming in North Samarinda is characterized by a demographic dominance of middle-aged and older farmers. To enhance the resilience and continuity of the sector, targeted efforts to attract and retain younger farmers are imperative. Such initiatives should be reinforced through dedicated human resource development programs and supportive policy frameworks.

Farming experience

A total of 6 respondents had 1–3 years of farming experience, while 24 respondents had 4–6 years. This indicates that the majority of farmers had more than three years of experience in goat farming. Longer farming experience contributes to improved knowledge and application of biosecurity measures, as experienced farmers are generally more familiar with risks and their mitigation strategies (Fountain *et al*., 2023; Henry *et al*., 2024; Morris *et al*., 2023; Oladele

Charles and Ayodele-Adekunle, 2014; Varga *et al*., 2025). A case study of Australian beef cattle farmers reported that producers with longer farming experience demonstrated stronger awareness and more consistent implementation of on-farm biosecurity practices, reflecting accumulated practical knowledge and value-driven decision-making shaped over time (Fountain *et al*., 2023). In contrast, farmers with fewer years of experience were more likely to exhibit gaps in biosecurity understanding and compliance, often due to limited exposure to disease risk management and weaker integration of biosecurity within their farming values framework, as highlighted in the study on biosecurity behaviors of Australian beef cattle farmers (Fountain *et al*., 2023).

Training

In North Samarinda District, out of 30 goat farmers, only 10 had attended biosecurity training, while 20 had never participated. Farmers who have attended training are more likely to possess better knowledge of disease prevention, pen hygiene, human and animal traffic management, and biological risk control. The economic aspect was framed as "biological risk management". Farmers were asked to compare the low cost of recurring sanitation (disinfectants) against the potential 100% capital loss from an outbreak of contagious diseases like Orf or PPR, common in the region. Conversely, those without training are more vulnerable to unhygienic practices and higher risks of disease transmission within their farms. With the majority lacking training, there exists a knowledge and skills gap in implementing biosecurity. Farmers without training are at risk of management errors, such as failing to isolate sick animals or neglecting pen sanitation (Bedekelabou *et al*., 2022; Dessart *et al*., 2019; Duarte *et al*., 2026). According to previous study (Duarte *et al*., 2026; Fountain *et al*., 2023), small scale farmers often face challenges in understanding biosecurity due to limited awareness and lack of exposure to its application. This lack of understanding is reflected in the difficulties encountered in improving livestock health. Inability to effectively manage animal health not only affects productivity but also undermines farmers' competitiveness in the market (Bromfield, 2023; Manyweathers *et al*., 2022; Meyer *et al*., 2025). Furthermore, it is also could Increase livestock mortality due to disease results in economic losses (Henry *et al*., 2024; Meyer *et al*., 2025). Farmers who have undergone training generally demonstrate better knowledge of good farming practices, including pen sanitation, vaccination, and disease prevention (Dessart *et al*., 2019; Fountain *et al*., 2023; Tsegaye *et al*., 2023). With the proper implementation of biosecurity strategies, local goat farming in Indonesia is expected to reduce the risk of disease transmission and enhance overall productivity. Tsegaye *et al*. (2023) emphasized that the importance of developing continuous education programs and fostering collaboration with relevant stakeholders such as government institutions and academics to support farmers in adopting effective biosecurity practices.

Matrix IFAS and EFAS

From these analyses, an IFAS and EFAS Matrix can be constructed as presented in the following Table 2 and 3. The data represent a combination of the IFAS (Internal Factors Analysis Strategy), which includes strengths and weaknesses, and the EFAS (External Factors Analysis Strategy), which includes opportunities and threats. The total score of the IFAS matrix is 2.95, while the EFAS matrix totals 2.98.

The SWOT analysis diagram is used to determine strategies for implementing biosecurity in goat farming in North Samarinda by plotting the coordinates on the X and Y axes through the difference between internal factors (strengths minus weaknesses) and external factors (opportunities minus threats). The analysis shows that the strength score is 1.20 and the weakness score is 1.74, resulting in a difference of –0.53. Meanwhile, the opportunity score is 1.33 and the threat score is 1.65, resulting in a difference of –0.32. These results are then plotted on the SWOT analysis diagram at the coordinates (X = –0.53; Y = –0.32).

From the presented table of the IFAS and EFAS matrices, it can be observed that the WT strategy, with a score of 3.39, represents a defensive strategy and serves as the primary approach for implementing biosecurity in goat farming in North Samarinda, positioned in the first quadrant. The WO strategy, with a score of 3.07, falls in

Table 2: IFAS matrix (internal factors).

Internal strategic factors	Rating	Weight	Score
Strengths		0.47	1.21
Routine cleaning of pens	2.7	0.13	0.35
Low pen density (isolation capability)	3.2	0.13	0.42
Understanding of disease risks	2.67	0.08	0.21
Availability of isolation areas	2.2	0.08	0.18
Farming experience > 5 years	2.2	0.05	0.11
Weaknesses		0.53	1.74
Lack of biosecurity facilities (APD, sanitation pits)	3.8	0.17	0.65
Absence of written biosecurity SOPs	3.5	0.17	0.60
Low or non-routine disinfection	4	0.13	0.52
Lack of technical monitoring/ vet assistance	3	0.03	0.09
Absence of animal health records	2	0.03	0.06
Total IFAS Score		1	2.95

Table 3: EFAS matrix (external factors).

External strategic factors	Rating	Weight	Score
Opportunities		0.44	1.32
Market demand for healthy/certified meat	3	0.12	0.36
Access to simple technology (WhatsApp/Social Media)	2.8	0.12	0.34
Support from farmer cooperatives/Koperasi	2.4	0.1	0.24
Extension programs from universities/government	2.23	0.1	0.22
Threats		0.56	1.65
High risk of disease transmission	3.3	0.15	0.5
Lack of government follow-up and oversight	3.2	0.15	0.48
Fluctuating feed and livestock prices	3	0.1	0.3
Low interest from the younger generation	3	0.1	0.3
Extreme weather (flooding)	2.33	0.06	0.14
Total EFAS Score		1	2.98

Thus, the SWOT matrix diagram is formed as follows:

Table 4: The SWOT matrix.

Internal / External	Strengths (S)	Weaknesses (W)
	1. Routine pen cleaning 2. Isolation capabilities 3. Disease awareness	1. No written SOPs 2. Limited biosecurity facilities 3. Non-routine disinfection
Opportunities (O) 1. High market demand 2. Access to technology 3. Extension programs	SO Strategy (Aggressive) Utilizing digital platforms to market disease-free goats and showcase routine sanitation practices.	WO Strategy (Turnaround) Leveraging government extension programs to fund and build formal biosecurity facilities.
Threats (T) 1. High disease risk 2. Lack of gov follow-up 3. Low youth interest	ST Strategy (Diversification) Using existing isolation areas and experience to mitigate the risk of local disease outbreaks.	WT Strategy (Defensive) [Recommended] Developing simple, self-funded SOPs to protect the farm against disease threats independently.

Table 5: The QSPM matrix.

Rank	Strategic priority	TAS score
1	Develop simplified, low-cost biosecurity SOPs for independent use	5.24
2	Encourage self-funded record keeping and documentation	5.2
3	Coordinate with Govt/Koperasi for periodic vet assistance	5.18
3	Limit livestock exchange with zoonotic risk campaigns	5.18

the second quadrant, supporting a turnaround strategy. The ST strategy, with a score of 2.86, is located in the third quadrant, supporting a diversification strategy, while the SO strategy, with a score of 2.52, is in the fourth quadrant, supporting an aggressive strategy. The QSPM analysis prioritizes four potential strategies based on their Total Attractiveness Scores (TAS):

Developing simple SOPs for extreme weather and disease risks

Smallholder farmers are highly vulnerable to climate change and extreme weather, which can increase livestock stress and disease outbreaks. A simple, low-cost, and independent SOP is needed, focusing on weather protection, disease prevention, and emergency preparedness. Measures include pen modifications with affordable materials, ensuring ventilation, storing feed and water, and adjusting feeding schedules. Basic biosecurity, such as footbaths, handwashing, routine health checks, and isolation of sick animals, is essential. Local herbal supplements may also support animal resilience.

Coordination with government and cooperatives for veterinary support

Regular collaboration with government livestock services and cooperatives enables access to veterinarians or technicians for preventive care, vaccination, training, and disease management. Periodic visits strengthen biosecurity implementation, reduce mortality, and improve productivity. Such partnerships also facilitate knowledge transfer and modern farming practices.

Restricting livestock exchange without SOPs to reduce zoonosis risks

Traditional livestock exchange practices without health checks or quarantine pose significant zoonotic risks (e.g., brucellosis, leptospirosis, FMD). Implementing SOPs-including veterinary inspection, health certificates, quarantine, and animal recordkeeping-can reduce disease transmission. Farmer education on One Health principles is critical to ensure livestock movement is safe and standardized.

Encouraging simple recordkeeping Recordkeeping, even without advanced technology, is vital for farm management. Farmers should record livestock numbers, health history, vaccinations, feed, and production outcomes using notebooks or printed forms. This practice supports decision-making, disease monitoring, and access to external assistance. Training and templates from government or cooperatives can strengthen adoption.

Overall, these strategies emphasize practical, low-cost, and sustainable approaches to improve biosecurity in smallholder goat farming.

The analysis of biosecurity strategies in goat farming was conducted to evaluate the internal and external factors influencing biosecurity implementation. Internal factors consist of strengths and weaknesses, while external factors include opportunities and threats. The table above compares four alternative strategies based on Attractiveness Score (AS) and Total Attractiveness Score (TAS). The strategy with the highest TAS value is considered the most feasible to implement in order to enhance biosecurity in goat farming.

CONCLUSION

Based on the findings on biosecurity implementation and its implications for caprine health in North Samarinda District, this study demonstrates that farmers' understanding of systematic biosecurity remains inadequate, with on-farm practices largely restricted to basic measures, notably routine pen cleaning. The uptake of more comprehensive biosecurity protocols such as standardized disinfection procedures, isolation of clinically ill animals, and regular health surveillance was consistently low. Several interrelated constraints were identified as major barriers to effective implementation. These include limited access to formal training, insufficient availability of essential biosecurity infrastructure (e.g., personal protective equipment and disinfectant footbaths), the persistence of traditional husbandry systems characterized by informal livestock movement, and weak institutional engagement from governmental and veterinary services.

A salient example of culturally embedded constraints is the *Sistem Gaduhan* (livestock-sharing arrangement), in which animals are transferred between households based on social trust rather than verified health status. This practice frequently circumvents recommended quarantine measures, including the 14-day isolation period, thereby increasing the risk of disease introduction and transmission. Strategic analysis using the SWOT–QSPM framework identified the development of simplified, low-cost biosecurity standard operating procedures (SOPs) as the most effective intervention. The success of this strategy is contingent upon coordinated multi-stakeholder involvement, strengthened extension support from livestock authorities, targeted farmer education on disease transmission pathways, and the institutionalization of farmer-managed animal health records to support monitoring and traceability.

This study is subject to limitations, notably the relatively small sample size (n= 30) and its focus on a single district, which may limit the generalizability of findings to larger or more commercialized production systems. As a practical follow-up, a pilot implementation of a visually oriented "Pictorial Biosecurity Guide" is proposed, targeting farmers with non-agricultural educational backgrounds, to evaluate its effectiveness in enhancing routine sanitation practices and daily biosecurity compliance.

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AUTHOR'S CONTRIBUTION

All authors contributed equally to the mancuscript.

Generative AI and AI assisted technology statement

The authors declare that no generative AI and AI assisted technology was used in the creation of this manuscript.

Conflict of interest

The authors have declared no conflict of interest.

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