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African Swine Fever Disease Risk Assessment Using Multi-Criteria Decision Analysis: An Input for GIS-Based Risk Mapping

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Abstract: African Swine Fever (ASF) has severely impacted the Philippines' pig industry, caused socioeconomic losses, and affected income, supply, demand, and prices. There needs to be more understanding regarding the risk factors associated with ASF introduction into pig farms and the level of risk each farm faces. Accordingly, using a quantitative research method, this study used the Analytical Hierarchy Process (AHP) to categorize ASF risk factors into biosecurity and spatial risk factors. Twenty-five (25) respondents were selected using a purposive participatory approach to rank the importance level of each risk factor as per the two risk factor categories. The AHP analysis revealed that the highest-risk biosecurity factors are the "absence of protocols for changing clothes, separate entry and exit, disinfection of objects, restriction on food introduction, and external individuals accessing the farms." In the spatial risk factor ranking, the analysis showed that the "distance to pig farms utilizing swill feeding" was the highest risk factor, indicating its significant contribution to the overall risk of farms. A farm risk assessment was also performed based on the AHP results and the level of compliance of each farm on the different risk factors. The study was conducted on selected pig farms in the municipality of Echague by evaluating their compliance with the identified risk factors and determining the level of risk they posed. The risk assessment results for African swine fever on farms reveal a concerning scenario. With 70% of farms assessed as "high risk" in terms of biosecurity and 74% classified as "medium risk" in spatial vulnerability, the overall assessment indicates that 84% of farms are at a moderate risk level. This suggests a widespread need for improved biosecurity practices and disease monitoring to prevent the introduction and spread of African swine fever. The 16% of farms deemed "high risk" pose a significant threat, requiring immediate action to prevent disease outbreaks. These findings emphasize the importance of implementing stringent biosecurity measures, enhancing surveillance efforts, and raising awareness to safeguard the pig industry from the devastating impacts of the ASF disease, like the rising cost of meat and pork-based commodities. Furthermore, these show the importance of considering the biosecurity and spatial risk factors for a more comprehensive risk assessment. The AHP ranking and risk assessment process is crucial in developing a GIS-based risk mapping and surveillance system. This offers government authorities a valuable decision-making tool to proactively prevent the introduction of African swine fever (ASF) and mitigate the necessity for widespread culling of pigs. By implementing targeted interventions informed by the study results, the government can work towards safeguarding the pig industry.

Introduction

The global pig industry is a significant agricultural and food production sector. African Swine Fever (ASF) is a highly contagious and devastating viral disease affecting domestic and wild pigs worldwide (Cadenas-Fernández et al., 2022; Juszkiewicz et al., 2023). It poses a significant threat to the global pork industry and food security, with severe socioeconomic implications. ASF

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continues to remain a prominent challenge, spreading across regions and causing substantial losses in pig populations (Hsu et al., 2023a; Hsu et al., 2023b; Rogoll et al., 2023). It is spreading throughout Asia and causing severe economic losses in pig production in several countries, including the Philippines (World Organization for Animal Health, 18 C.E.).

In 2019, the Philippines experienced its first African Swine Fever outbreak, causing over 300,000 pig slaughters and a 20.8% drop in pork output in 2021. The government implemented laws and public health initiatives, including the National Zoning and Movement Plan. The 1-7-10 protocol required mandatory ASF disease surveillance, active testing, and rapid culling of pigs within a 1-kilometer radius. This led to mass culling and higher pork prices.

However, ASF is still spreading despite continuous efforts to stop it. This underscores the need for better biosecurity protocols and a thorough comprehension of the geographic risk factors connected to the illness. The prevention and control of ASF outbreaks in domestic pig farms may be enhanced by knowledge and understanding of potential supportive and important risk factors (Bergmann et al., 2021; Malakauskas et al., 2022). Current strategies for managing ASF are primarily reactive, focusing on containment and eradication after an outbreak. However, these strategies have proven insufficient to prevent the spread of the disease. There is growing recognition of the urgent need for proactive and innovative measures for ASF disease surveillance, prevention, and mitigation.

Implementing risk-based prevention and surveillance strategies is necessary to stop and lessen ASF's impacts (Kim et al., 2021). A risk assessment can be done that would focus on biosecurity risk factors and spatial risk factors. Biosecurity is a set of practices to prevent diseases, particularly ASF, from spreading within and between pig farms. Bio-security risk factors are elements or practices that increase the likelihood of African Swine Fever (ASF) transmission and spread. Examples of biosecurity risk factors include unauthorized access to pig production areas, swill feeding or potential contamination of feed ingredients, lack of double fencing, contaminated equipment, inadequate cleaning and disinfection, presence of small and domestic mammals, a lack of quarantine measures, insufficient pest and vector control, etc. Addressing these risk factors through robust biosecurity measures is essential to preventing the introduction and spread of ASF and protecting pig populations from this highly contagious disease. On the other hand, spatial risk factors refer to the geographic distribution and characteristics of areas that may influence the likelihood of ASF introduction and spread.

Multi-criteria Decision Analysis (MCDA) offers a promising approach to achieving this goal. MCDA is a decision-making methodology that considers multiple factors and criteria when evaluating different alternatives (Dean, 2022). The Analytical Hierarchy Process (AHP), a variant of MCDA, is a powerful tool for decision-making that systematically ranks risk factors based on their relative importance. It has been utilized in various fields, showcasing its effectiveness in resource allocation, risk management, healthcare decision-making, and environmental management (Mawi, 2017; Rogoll et al., 2023). However, its application in the context of ASF is relatively unexplored.

This study aims to fill this gap by using AHP to rank identified biosecurity and spatial risk factors for ASF for a more complete farm risk assessment. The results of this ranking would be used to assess farm risk levels in Echague, Isabela, providing a valuable tool for the proactive management of ASF. It addressed a critical need in ASF disease management. Developing a proactive, data-driven approach to risk assessment contributes to the ongoing efforts to control the spread of this devastating disease and protect the local and global swine industry. Furthermore, the ranking of biosecurity and spatial risk factors would be used as input to a GIS-based ASF disease risk mapping using a web-based application that would guide decision-makers to prioritize and select the most suitable control measures and interventions for managing ASF outbreak scenarios. By identifying high-risk farms, interventions can be targeted more effectively, reducing the likelihood of ASF outbreaks and minimizing their impact when they do occur. This approach ensures that resources are allocated to interventions with the highest potential for success, thus optimizing the use of limited resources in combating ASF effectively.

Materials and Methods

This study addressed the critical need to develop a proactive, data-driven approach to African Swine Fever (ASF) disease risk assessment and management. The Multi-criteria Decision Analysis (MCDA) framework based on the Analytical Hierarchy Process (AHP) was used to evaluate various risk factors and identify priority levels based on their importance and impact on the overall risk of ASF.

Biosecurity and spatial risk factors are the two categories of ASF risk factors identified from existing literature and inputs from agriculture experts.

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Table 1. List of identified biosecurity risk factors of ASF.

Risk No.	Biosecurity Risk Factor	References
1	Swill feed or potential contamination of feed ingredients	Hsu et al., 2023b; Lee et al., 2022; Schettino et al., 2023
2	Lack of double fencing	Hsu et al., 2023b; Jiménez-Ruiz et al., 2022; Schettino et al., 2023
3	The presence of flies and/or ticks	Hsu et al., 2023b; Bergmann et al., 2022
4	Presence of small and domestic mammals (e.g., rats, dogs, cats, and other farm animals)	Hsu et al., 2023b; Bergmann et al., 2022
5	Absence of Protocols for changing clothes, separate entry and exit, disinfection of objects, restriction on food introduction, and external individuals accessing the farms	Hsu et al., 2023b
6	Allowance for cars and trucks to enter the premises	Hsu et al., 2023b; Bergmann et al., 2022
7	Non-closed herd with the recent introduction of new animals (requiring importation of pigs) without a quarantine station within 1 km from premises or sharing of personnel	Hsu et al., 2023b
8	Movement of personnel (including vets, inseminators, and technicians) between this farm and other farms without biosecurity measures	Hsu et al., 2023b
9	Area with the presence of feral pigs	Hsu et al., 2023b; Bergmann et al., 2022

On the other hand, spatial risk factors were also adopted from different research papers that show the relevance of the following spatial risk factors in introducing and transmitting ASF disease. This factor was also used for a separate ranking using AHP through pairwise comparison. The spatial risk factors are listed below.

Table 2. List of identified spatial risk factors of ASF.

Risk No.	Spatial Risk Factor	References
1	Distance to road	Thanapongtharm et al., 2022; Asambe et al., 2019; Bergmann et al., 2022
2	Distance to landfill	Thanapongtharm et al., 2022; Asambe et al., 2019 ; Bergmann et al., 2022
3	Distance to pig farms using swill feeding	Thanapongtharm et al., 2022; Asambe et al., 2019
4	Density of small pig farms	Thanapongtharm et al., 2022; Asambe et al., 2019
5	Distance to slaughterhouse	Thanapongtharm et al., 2022 ; Asambe et al., 2019 ; Bergmann et al., 2022

Table 3. Sample of the study.

Group	No of Participants
Livestock Experts from PVO and Local MAO	15
Academe	5
Industry Practitioners	5
Total	25

Twenty-five (25) participants from different stakeholders involved in ASF risk monitoring were selected using the purposive-participatory approach technique of sampling. These stakeholders included veterinary medicine doctors, other livestock experts from the Provincial Veterinary Office (PVO) of Isabela, experts from various Municipal Agriculture Offices (MAO) in various towns within the Province of Isabela, five (5) professors from academia, and five (5) pig production industry practitioners. This approach allows for a targeted selection of participants with expertise or experience in African Swine Fever disease management, ensuring that the study includes individuals who can provide valuable insights and perspectives.

The top 4 regions with high ASF cases in the municipality of Echague, Isabela, were selected as the location of the study for farm risk assessment. For each region, the most affected barangay was chosen as the participating barangay.

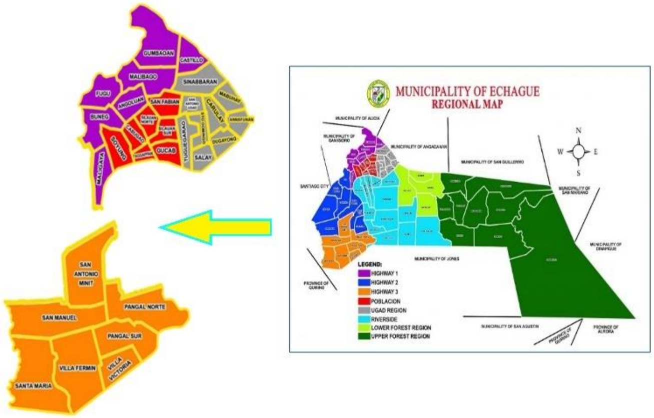

Figure 1. Location of the Study.

The Municipal Agriculture Office provided a list of affected farms per barangay to identify prospective farms.

Table 4. The selected barangays for farm assessment.

Region	No of Barangay	No of Farms
Ugad	1	10
Poblacion	1	5
Highway 3	1	25
Highway 1	1	10
Total	4	50

Using purposive-participatory sampling, prospective farms in each barangay were visited for risk assessment.

Creating precise pairwise comparison matrices defined by users is one of the main processes of AHP (Tavana et al., 2023). In this study, we used the Analytic Hierarchy Process Software by Splicelogic to perform the pairwise comparison as follows: (1) First, we determined the decision-making objective, structured the decision hierarchy, and constructed the objectives from a broad perspective of the study; (2) then, from a pairwise comparison-based questionnaire, participants were asked to assign a level of importance from 1 (equal importance) to 9 (extreme importance), following the matrix shown below.

The answers to the comparison from the questionnaire given to the expert participants for each risk factor were entered into the AHP software of the Splicelogic system, which automatically obtained the weight values for the biosecurity and spatial risk factors. Two critical measures were used to assess the consistency of these comparisons: the Consistency Index (CI) and the Consistency Ratio (CR).

The Consistency Index (CI) quantifies the extent of inconsistency in the pairwise comparison matrix. It is computed by subtracting the number of elements compared from the matrix's maximum eigenvalue (λ_max) and dividing the result by (n-1).

$$CI=(\lambda max-n)/(n-1)$$

The CI provides a numerical value that indicates the degree of inconsistency in the judgments made during the pairwise comparisons.

On the other hand, the Consistency Ratio (CR) is a measure that further evaluates the acceptability of the consistency in the pairwise comparisons. It is obtained by dividing the CI by the Random Consistency Index (RI), which is a predetermined value based on the matrix size.

CR=CI/RI

The CR is used to compare the CI against a threshold value of 0.1, and if the CR exceeds this threshold, it suggests potential inconsistency in the judgments.

To ensure reliable results, the CI should be as low as possible and preferably close to zero. Additionally, the CR should ideally be 0.1 or less, indicating satisfactory

Table 5. The scale used to rank the ASF Risk Factors.

Level of Importance	Description
1	Equal Importance
3	Moderate Importance
5	Strong or essential importance
7	Very Strong Importance
9	Extreme Importance
2,4,6,8	Intermediate values
Reciprocals	Values for Inverse comparison

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consistency in the pairwise comparisons. If the CR exceeds 0.1, it implies that the judgments may be unreliable, necessitating a reassessment of the decision-making process (Saaty, 2002). Upon obtaining a satisfactory Consistency Ratio (CR) for the biosecurity and spatial risk factors, the corresponding weight for each risk factor was utilized to assess the farm risk level.

The farm risk assessment involved multiplying the weight assigned to each risk factor from the AHP ranking by the level of compliance demonstrated by each farm in each risk category.

The level of compliance for each farm was evaluated on a scale of 1 (low compliance) to 5 (excellent compliance). A separate risk score was calculated for the biosecurity and spatial risk category. The Total Risk Score (TRS) was determined by summing the risk scores for each category and dividing the sum by two.

Total Risk Score = (Biosecurity Total Risk Score + Spatial Total Risk Score)/2

The risk level was categorized using the Likert scale below, adopted from the study of Thanapongtharm et al. (2022).

0.263 risk priority score. This implies that most experts believe protocols must be followed inside each farm to avoid transmitting ASF disease from other contaminants. This supports the findings of Hsu, Montenegro et al. (2023) that a closely connected network of swine and swine-related products may facilitate disease spread, especially if most farms are densely located at one location and no protocol is available.

The bio risk factor 1 "Swill Feed or potential contamination of feed ingredient," got the second highest significant risk priority, showing it is a major risk influencing SF outbreak occurrence (Gallardo et al., 2015; Nantima et al., 2015). The ASF virus can survive in carcasses and cured or frozen meat for several months. If pigs are fed with infected pork products, either through swill or unintentionally via discarded food scraps, there is a potential for the virus to be transmitted. Furthermore, due to the high price of commercial feeds, some farmers are still feeding their pigs with waste foods from neighbors and restaurants that may contain ASF from ASF-infected meats.

Table 6. Risk level scale used for farm risk assessment.

Range	Risk Level
1.00 -1.80	Very High Risk
1.81 - 2.60	High Risk
2.61 - 3.40	Medium risk
3.41 - 4.20	Low Risk
4.21 - 5.00	Very Low Risk

Results and Discussion

The following shows the risk priority score (weight) and ranking of the different biosecurity and spatial risk factors based on the Analytical Hierarchy Process (AHP) pairwise comparison result. The result of the farm assessment conducted based on the risk priority score and farm level of compliance with the different risk factors is also presented and discussed.

Risk Factor Ranking

Biosecurity Risk Factor Ranking

For biosecurity risk factor ranking, the AHP resulted in a 0.051 consistency ratio, which is less than .01, which is the reasonable range for acceptable judgment for the pairwise comparison.

The results indicate that within the biosecurity risk factor 5, “Absence of Protocols for changing clothes, separate entry and exit, disinfection of objects, restriction on food introduction, and external individuals accessing the farms” is the most significant risk factor that may introduce ASF to the pig farms by the participants with

ASF-infected meats.

Additionally, biosecurity risk 2, 'Lack of double Fencing," gets the next highest priority, which is critical as a key biosecurity measure to prevent the introduction of the virus. It points out that inadequate separation of pigs from the external environment due to incomplete fencing is a major risk. The lack of gates limiting the entrance to the farming area and the absence of external fences along the entire farm boundary to keep out visitors and wild animals can act as a gateway for the ASF disease. Appropriate outside fencing, such as double fences to lessen the possibility of pigs and wild boar coming into direct contact, is essential for stopping the ASF virus from spreading (Rusinà et al., 2023).

This further implies that factors like swill feeding, human behaviors such as following protocols, and environmental conditions like the presence of ticks, flies, small animals, and feral pigs have great importance and must be addressed accordingly to mitigate the spread of ASF (Bellini et al., 2021; Nantima et al., 2015).

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Table 7. AHP Pairwise Comparison of Biosecurity Risk Factors.

Bio Risk Factor	Bio Risk 1	Bio Risk 2	Bio Risk 3	Bio Risk 4	Bio Risk 5	Bio Risk 6	Bio Risk 7	Bio Risk 8	Bio Risk 9	Risk Priority Score	Rank
BioRisk 1	1	4.02	4.71	5.42	0.59	7.69	3.44	4.21	7.29	0.25	2
BioRisk 2	0.25	1	3.09	3.55	0.37	7.02	2.67	3.35	4.75	0.15	3
BioRisk 3	0.21	0.32	1	2.06	0.22	3.03	0.45	0.42	2.9	0.059	6
BioRisk 4	0.18	0.28	0.49	1	0.22	2.84	0.32	0.39	2.71	0.047	7
BioRisk 5	1.69	2.71	4.45	4.45	1	5.97	3.67	4.14	7.53	0.263	1
BioRisk 6	0.13	0.14	0.33	0.35	0.17	1	0.26	0.27	0.43	0.023	9
BioRisk 7	0.29	0.37	2.2	3.16	0.27	3.82	1	2.34	3.81	0.098	4
BioRisk 8	0.24	0.3	2.37	2.59	0.24	3.65	0.43	1	3.36	0.077	5
BioRisk 9	0.14	0.21	0.35	0.37	0.13	2.32	0.26	0.3	1	0.029	8

Spatial Risk Factor Ranking

The AHP result for the spatial risk factor presented in Table 8 resulted in a 0.062 consistency ratio lower than 0.01, which is also the reasonable range for acceptable judgment for the pairwise comparison. The result indicates that spatial risk factor 3, “Distance to Pig farms using Swill Feeding” is the most critical. It supports the study of Bellini et al. (2021), which considers swill feeding to be a primary risk factor for the virus's proliferation.

Furthermore, spatial risk 1 "distance to road," and spatial risk factor 4 "density of small pig farms," also play a substantial role in accelerating the spread of ASF, as noted in the studies by Herrera-Ibatá et al. (2017) and Martínez-López et al. (2015).

Table 8. AHP Pairwise Comparison of Spatial Risk Factors.

Spatial Risk Factor	Spatial Risk 1	Spatial Risk 2	Spatial Risk 3	Spatial Risk 4	Spatial Risk 5	Risk Priority Score	Rank
Spatial risk 1	1	5.34	0.36	3.93	4.53	0.29	2
Spatial risk 2	0.19	1	0.18	0.40	0.48	0.05	4
Spatial risk 3	2.81	5.56	1	5.11	4.81	0.46	1
Spatial risk 4	0.25	2.51	0.20	1	2.67	0.12	3
Spatial risk 5	0.22	2.10	0.21	0.38	1	0.08	5

On the other hand, the "distance to landfill" and "distance to the slaughterhouse" are ranked as the least significant factors among the spatial risk factors in ASF transmission. However, despite their lower rank, they should be considered in ASF management, as indicated in the study of Asambe et al. (2019). This implies that spatial risk factors are as important as biosecurity risk actors in the spread of ASF into different pig farms.

The farm risk assessment conducted on selected pig farms

The farm risk assessment was conducted by multiplying the AHP ranking results with the level of compliance of the farm to various risk factors within two categories, biosecurity risk factor and spatial risk factor and getting their average.

In terms of biosecurity risk factors, seventy (70) percent of the farms were assessed as "High Risk," while twenty-eight (28) percent were assessed as “Medium Risk”, and the remaining two (2) percent were assessed as "Low Risk”. This implies that most farms have a "High Risk" level of biosecurity with an average risk score of 2.29. Furthermore, one hundred (100) percent of the farms rated as “High Risk” and “Medium Risk” have low scores on the risk factors “Absence of Protocols for changing clothes, separate entry and exit, disinfection of objects, restriction on food introduction, and external individuals accessing the farms” and “Lack of Double Fencing” which significantly contributes to their risk assessment. This implies that most of the assessed farms

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have low biosecurity compliance. Previous studies by Liu et al. (2021) highlight the importance of observing these risk factors. Strictly observing and implementing measures supporting these risk factors can effectively cut off the transmission route of the ASF virus. In conclusion, to effectively prevent the spread of ASF, efficient enforcement by government authorities of the biosecurity standards and the farmers' compliance with them(Kruszyński et al., 2023) should be done. This could explain the fast spread of the ASF disease among pig farms among the smallholder category of pig farms, which comprise the majority of pig farms in Echague, Isabela.

Table 9. Summary of Risk Assessment of Farms in terms of Biosecurity Risk Factors.

Biosecurity Risk Level	No of farms
Very High Risk	0
High Risk	35
Medium Risk	14
Low Risk	0
Very Low Risk	1

Figure 2. Biosecurity Risk Assessment Map.

Table 10. Summary of Risk Assessment of Farms in terms of Spatial Risk Factors.

Spatial Risk Level	No of farms
Very High Risk	0
High Risk	3
Medium Risk	37
Low Risk	6
Very Low Risk	4

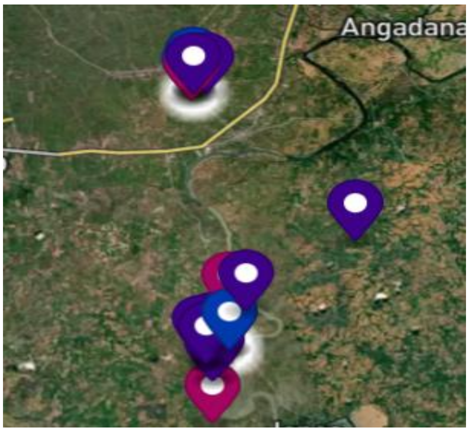

Figure 3. Spatial Risk Assessment Map

In terms of spatial risk factors, seventy-four (74) percent of the farms were assessed as "Medium Risk" while twelve (12) percent of the farms were assessed as "Low Risk". Additionally, eight (8) percent of the farms were assessed as "Very Low Risk," and the remaining six (6) percent of the farms were assessed as "High Risk". This implies that most of the farms have a "Medium Risk" level of spatial risk with an average risk score of 2.99. Eighty (80) percent of the assessed farms got low compliance scores due to their proximity to the road, landfill, and pig farms using swill feeding.

Table 11. Summary of Total Weighted Risk Assessment of Farms.

Risk Level	No of farms
Very High Risk	0
High Risk	8
Medium Risk	42
Low Risk	0
Very Low Risk	0

The overall risk level of the farms was determined by combining the risk scores from two categories and getting their average. As shown in Table 10 below, the farm assessment conducted in the municipality of Echague, Isabela, revealed that eighty-four (84) percent were assessed with a "Medium Risk" level with an average risk score of 2.86. The remaining sixteen (16) percent of the farms were identified as having a "high risk" level status with an average risk score of 2.50.

The risk assessment of pig farms in the Municipality of Echague, Isabela, using the Analytical Hierarchy Process (AHP), revealed critical insights into managing African Swine Fever (ASF) outbreaks. The analysis identified the significance of different biosecurity risk factors, such as the absence of protocols for changing clothes and disinfection, swill feeding, and lack of double fencing. This highlights the need for strict adherence to biosecurity measures to prevent ASF transmission. The farm risk assessment indicated that most farms were at "High Risk" due to low compliance with biosecurity measures, emphasizing the necessity of enforcing compliance to mitigate ASF transmission. This implies that all pig value chain stakeholders need higher complianceo tadopt biosecurity practices (Lee et al., 2022). Different spatial risk factors that show significance in ASF transmission were also analyzed, including "proximity to pig farms using swill feeding" and "small pig farm density". These were also emphasized as key contributors to ASF spread, underscoring the importance of understanding spatial risks for effective management. The spatial risk assessment revealed that the majority of the farms were "Medium Risk" level of spatial risk due to their proximity to the road, landfill, and pig farms using swill feeding.

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These findings highlight the importance of considering the biosecurity and spatial risks and combining them to have a full risk assessment. Furthermore, the findings also underscore the importance of strengthening preventive measures, enhancing biosecurity protocols, ensuring compliance and enforcement, raising public awareness, and informing research and policy development to effectively manage and prevent ASF within pig farming communities.

Conclusion

This study addressed a critical need in ASF disease management to develop a proactive, data-driven approach to risk assessment, contributing to the ongoing efforts to control the spread of this devastating disease and protect the local and global swine industry. The Multi-criteria Decision Analysis (MCDA) framework based on the Analytical Hierarchy Process (AHP) has been successfully used to categorize and assess ASF risk factors into biosecurity and spatial risk factors, which is crucial for identifying critical areas of concern. The analysis conducted with 25 respondents composed of livestock experts using a purposive participatory approach has provided valuable insights into the importance levels of each risk factor within these categories. The identification of high-risk biosecurity factors, such as the absence of protocols for changing clothes, separate entry and exit, disinfection of objects, restriction on food introduction, and external individuals accessing the farms, underscores the critical need for enhanced biosecurity measures.

In the spatial risk factor ranking, the analysis highlighting the significance of factors like the distance to pig farms utilizing swill feeding emphasizes the need to address specific spatial considerations to mitigate the risk of ASF introduction. The assessment of farm risk based on the AHP results, which classified 56% of the farms as "high risk" and 44% as "medium risk," underscores the varying levels of vulnerability within the industry.

The application of the Analytical Hierarchy Process proved effective in ranking the priority level of different biosecurity and spatial risk factors for the ASF virus. The identified risk factors for each risk category and the result of the biosecurity risk factor ranking, as well as spatial risk ranking based on AHP, can be used as inputs in the development of a GIS-based risk assessment mapping and surveillance system. This will allow for more accessible risk assessment and farm categorization by the Municipal Agriculture Office (MAO) in assessing pig farms. Additionally, the computation for the Total Risk Score of each farm will be easily done for all pig farms. The risk level can be easily generated based on the scale used in the study and automatically recorded along with the GPS location of the farm to create a risk map. This would provide the local government unit with the necessary data for proactive management of the disease. By implementing targeted interventions informed by the study results, the government can work towards safeguarding the pig industry, ensuring food security, and mitigating the potential economic impacts of ASF outbreaks, such as the rising cost of meat and pork-based commodities. These would also mitigate the continuous spread of the disease and the mass culling of pigs, which may significantly affect the socioeconomic status of pig farm owners. The findings of this study underscore the need for interventions, enhanced monitoring, and surveillance to mitigate ASF transmission within the municipality.

Conflict of Interests

The authors of this research declare that there is no conflict of interest regarding the publication of this paper.

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