Advance Sustainable Science, Engineering and Technology (ASSET)
Vol. 6, No.4, October 2024, pp. 02404011-01 ~ 02404011-08
ISSN: 2715-4211 DOI: https://doi.org/10.26877/asset.v6i4.997

Risk Mitigation Strategies for Sustainable Poultry Supply Chain Management

Haswika[1], Agus Mansur[2*], Meilinda F. N. Maghfiroh[3]

[1]Faculty of Business and Technology, Institut Teknologi dan Bisnis Nobel Indonesia, South Sulawesi, Indonesia

[2]Faculty of Industrial Technology, Universitas Islam Indonesia, Yogyakarta, Indonesia

[3]Faculty of Transport and Logistics, Muscat University, Muscat, Oman

* agusmansur@uii.ac.id

Abstract. The livestock sector is an important pillar in providing animal protein and sustaining the rural economy. However, the sector faces major challenges from environmental and socio-economic issues, such as climate change and environmental degradation, which can threaten its sustainability. Negative impacts such as environmental contamination can reduce production quality and quantity and increase supply chain operational costs. This study aims to identify effective risk mitigation strategies to reduce these negative impacts and improve the sustainability of supply chain management. Data were collected from laying duck farms and analyzed using the House of Risk (HOR) method with a Phase 1 and 2 approach. This approach allows the identification of the most critical risks and risk agents and mapping mitigation priorities. Key findings indicate that providing drugs or vaccines to prevent animal virus outbreaks is the highest priority mitigation strategy, while strategic policy decision-making has the lowest priority. Overall, 15 risks and 21 risk agents were identified. This study implies that the implementation of effective mitigation strategies can significantly reduce operational risks, strengthen the resilience of the livestock sector, and support the sustainability of supply chain management as a whole.

Keywords: Risk Management, Sustainable Agriculture, Poultry Supply Chain, House of Risk

(Received 2024-08-23, Accepted 2024-08-30, Available Online by 2024-08-31)

1. Introduction

The rapid growth of the world's population has led to an increase in livestock production to meet global food demand [1]. In Southeast Asia, where agriculture-based economies predominate, the livestock sector plays a significant role and is heavily relied upon to support these economies [2]. The livestock sector provides animal protein sources, such as meat, milk and eggs, which are an important part of people's diets [3]. However, this sector faces increasingly complex challenges related to climate

change and environmental degradation that could threaten its sustainability [4].

In the context of livestock farming, integration between crop and livestock production often occurs, where waste products from one process can be used as inputs for another, creating a more sustainable system [5]. In rural areas, agriculture is often the backbone of the local economy, providing livelihoods for a large proportion of the population and contributing to social stability [6]. Ducks are one of the most widely cultivated poultry in rural areas, mainly because they are more resistant to less ideal environmental conditions than other poultry, such as chickens [7]. However, rural duck farming often faces significant issues, such as limited access to modern technology, unstable markets, and livestock health challenges that are often difficult to address without adequate support [8]. The main issue is the lack of knowledge about proper farm management and biosecurity practices, which often leads to disease outbreaks that can reduce productivity and increase operational costs [9]. These challenges are further exacerbated by environmental degradation, limited access to markets and technology, and the socio-economic threats posed to livestock farming, particularly in regions vulnerable to the climate crisis [10].

Although duck farming has great potential in supporting the rural economy, existing research has not extensively explored systematic and integrated risk management approaches in addressing these challenges. This study aims to fill that gap by applying the HOR and SCOR models to enhance the sustainability of supply chain management in duck farming. This research offers adaptive solutions that can be implemented by farmers in rural areas to address issues such as environmental degradation and socio-economic threats

Environmental contamination has the potential to affect food production, reduce the quality and quantity of output, and increase operational costs in the supply chain [11]. As a result, the distribution of contaminated livestock products can threaten food safety and cause significant disruptions to the logistics system and the sustainability of supply chain management [7]. Therefore, an effective risk mitigation strategy is needed to handle the distribution of contaminated livestock products, in order to ensure food safety and economic destruction of this sector [12]. To address the challenges in rural duck farming, the application of risk management models such as HOR (House of Risk) and SCOR (Supply Chain Operations Reference) is highly appropriate. These models focus on identifying and mitigating risks, as well as supporting sustainability through a systematic and measured approach. The essence of risk management lies in identifying the occurrence of risks and their main causes [13]. With good risk management, farmers can be more proactive in addressing problems, reducing negative environmental impacts, and ensuring long-term economic sustainability.

2. Literature Review

In the study [14], risks were assessed and mitigated in sustainable tuna supply chains in Ambon using the House of Risk (HOR) approach. The study identified 15 risk events and 26 risk agents across environmental, social, and economic dimensions. Seven risk agents were prioritized based on their ARP values. Fifteen mitigating techniques were proposed, with twelve selected based on their effectiveness to difficulty (ETD) value in HOR Phase II. Meanwhile, the study [15] identifies risks in potato seed production and formulates risk control strategies. The method used is House of Risk, which reveals 39 risk events, with rotting potatoes as the most impactful risk. Among the 32 identified risk agents, two primary priorities must be addressed first. The most effective control strategies include training, certification of potato seed farmers, potato seed certification, and purchasing seeds from vegetable crop research centers and other seed breeders.

The research [16] focuses on developing a set of key performance indicators (KPIs) to measure sustainability in industrial supply chains. It proposes a new set of KPIs based on the Balanced Scorecard-Supply Chain Operations Reference Framework. The set aims to provide a balanced coverage of sustainability pillars, address different levels of decision-making, and evaluate the performance of the entire supply chain. Empirical validation in three supply chains and seven focus companies confirms the comprehensiveness, usefulness, and ease of use of the set, making it suitable for various contexts and the assessment of overall supply chain sustainability.

The House of Risk (HOR) has been used effectively in various studies to identify and prioritize risks and design mitigation strategies. For example, in studies on tuna and seed potato supply chains [14] & [15], HOR helped in identifying key risks and selecting suitable mitigation techniques. Integration of HOR with other methods such as Probability Impact Matrix (PIM) and Analytical Network Process (ANP) has also shown improvement in mitigation planning. On the other hand, SCOR has been used to evaluate supply chain performance in various industries, providing a framework for thorough analysis of all aspects of the supply chain. The combination of HOR and SCOR offers a comprehensive approach, enabling simultaneous risk identification and performance evaluation. The application of these two methods in the research on the supply chain of laying ducks in Sidenreng Rappang Regency will help in identifying key risks and designing effective mitigation strategies while evaluating and improving the overall supply chain performance.

3. Method

3.1. Field Study

Researchers will conduct observations, interviews and fill out questionnaires using the SCOR method by taking a sample of 5 respondents who are owners and managers of farms who play an important role in the cultivation of laying ducks. This study focuses only on laying duck breeders with at least 2 years of farming experience. The sampling process was carried out using purposive sampling to ensure that respondents met the predetermined criteria. Furthermore, data collected through observations, interviews and questionnaires will be integrated with the House of Risk (HOR) model to identify the main risks faced by laying duck breeders and determine appropriate mitigation strategies based on priorities. The HOR approach will help link business processes in the supply chain included in the SCOR model with identified risks.

3.2. Identification of Risks and Risk Agents Identification of SCM activities in laying duck farms

The identification of SCM activities in this laying duck farm uses focus group discussion and brainstorming methods with predetermined respondents followed by filling out an online questionnaire provided by the researcher.

3.3. Risk Assessment and Risk Agents

This assessment is carried out to compile HOR stage 1 by giving an assessment of the impact or severity of each risk and occurrence of risk agents. Determination of this value is done by distributing assessment questionnaires to respondents, namely laying duck farmers. The assessment used is adapted from the FMEA model with a scale of 1 to 10, meaning that a value of ten has the highest impact or risk frequency [17]. The ARP value is obtained from the result of multiplying the severity value, occurrence value and correlation value of the risk event and risk agent with the following formula [17]:

$$ARP_j = O_j \sum_i S_i R_{ij}$$

3.4. Risk Mitigation

HOR 2 stage 2 risk mitigation is selected through the highest ranking according to the top Aggregate Risk Potential value which is the result of the HOR stage 1 analysis to identify preventive action (PA) as a risk prevention strategy and then make a correlation between each preventive action and each risk agent. The next step is to calculate the total effectiveness (TEk) value of each preventive action with the following formula [18]:

$$TEk = \sum ARP_j R_k$$

Furthermore, the calculation of the Effectiveness to difficulty (ETDk) value as an illustration of the likelihood that preventive actions can be implemented. The level of difficulty is indicated by a scale (such as a Likert scale or other scale), and reflects the funds and other resources needed to take these actions. Calculate the total effective difficulty ratio using the formula [18]:

$$ETDk = TEk/Dk$$

3.5. Mitigation Action Priority Recommendation

From the results of HOR Phase 2, the highest rank is obtained through the calculation of the ETDk value, and it can be seen that the recommended mitigation action strategy for each risk cause is adapted to the conditions and circumstances of the company's environment.

4. Result and Discussion

4.1. SCM Business Process

Based on the results of the questionnaire given to the laying duck farmers, the SCM business processes derived from the SCOR model [19] are obtained as in table 6.

Table 1. SCM Business Process

Business Process	Business Sub Process
Plan	Demand Forecasting and Egg Distribution Duckling Purchase Planning Duckling availability check
Source	Procurement of Egg Ready Ducks Procurement of Duck Feed Duck Egg Quality Check
Make	Feed Checking Egg Packaging
Deliver	Receiving ducks from suppliers
Return	Egg Delivery

4.2. Identification of risks and risk agents

Identifying risks and risk agents is an important first step in managing risk in layer duck farming. By understanding the risks present and the agents that cause them, farmers can design more effective mitigation strategies and implement preventive measures to minimize negative impacts to their operations. This information helps in better planning and resource management, thereby improving the resilience and sustainability of the farm. Based on the results of discussions with farmers, 15 risks and 21 risk agents were found as in tables 1 and 2.

Table 2. Risk Event of Laying Duck Farming

Code	Risk Event	Severity
E1	Demand Forecast Calculation Error	9
E2	Duck demand cannot be met	8
E3	Discrepancy in the quality of harvested eggs	8
E4	Instability of duck prices	7
E5	Mismatch between duck purchases and arriving ducks	9
E6	Delay in payment to supplier	6
E7	Discrepancy in egg size	6
E8	Late payment by consumers	5
E9	Inappropriate egg packaging	7
E10	Small egg size	7
E11	Unstable egg crop	7
E12	Supplier cancels duck order	9
E13	Poor feed quality	8
E14	Consumer cancels order	7
E15	Broken or cracked eggs	4

Table 3. Risk Agent Laying Duck Farming

Code	Risk Agent	Occurance
A1	Market price information not available	10
A2	Discrepancy between budget plan and real-time condition	8
A3	Delivered ducks or eggs do not meet specifications or quantity	6

A4	Consumer requests are sudden and needed immediately	6
A5	Arrival of ducks, eggs or feed is not according to schedule	8
A6	Negotiation time with supplier	6
A7	Lack of diligence in checking inventory of feed, ducks or eggs	5
A8	There is a disease outbreak affecting the animals	6
A9	Unfavorable or extreme weather	9
A10	Uneven harvest period	8
A11	Unhealthy or deformed ducks	9
A12	Inadequate storage facilities	6
A13	Inadequate farm location	5
A14	Ducklings or eggs not sold	5
A15	There are local regulations that govern farmers' obligations to the region.	7
A16	Incorrect delivery of feed, ducks or eggs	7
A17	Negotiation of purchase and sale price does not result in best price	10
A18	Out of stock feed or eggs	7
A19	Inappropriate distribution planning	8
A20	Demand cannot be met	5
A21	No sales and purchase orders for feed, ducks or eggs	10

4.3. House Of Risk Phase 1

HOR serves to determine the level of each risk cause or risk agent through the Aggregate Risk Potential (ARP) value. At this stage, the model is used to identify and assess potential risks throughout the supply chain, as well as determine risk priorities based on their level of significance [20]. After identifying correlations and calculating Aggregate Risk Potentials (ARP), the last step in the House of Risk phase 1 method is to create a House of Risk phase 1 table by combining data on risk events, risk agents, correlations and the results of the calculation of Aggregate Risk Potentials (ARP) into a table. One example of ARP calculation is as follows [18]:

$$ARP_j = O_j \sum_i S_i R_{ij}$$

The calculation results can, risk handling should prioritize the risk agents with the highest ARP values, namely A21 and A8. Effectively addressing these risk agents will reduce the significant negative impact on layer duck farming operations. Implementation of mitigation strategies focused on addressing disease outbreaks and ensuring continuity of sales and purchasing processes are important steps to improve the success and resilience of the farm.

4.4. House Of Risk Phase 2

After completing the stages in House of Risk phase 1, the next step enters the House of Risk phase 2 stage used to provide a priority assessment of the risks that arise in the supply chain. This model helps in prioritizing risks based on the evaluation results from HOR 1, so that proactive measures can be taken to deal with risks that are considered significant [19]. The following House of Risk phase 2 table can be seen in table 3.

Table 4. House Of Risk Phase 2

Risk	Proposed Mitigation							ARPj
	PA1	PA2	PA3	PA4	PA5	PA6	PA7	
A21	3					3		710
A8	3	1						660
A5				3			1	600
A18					9			553
A20		9				3		520

A1			3		3			510
A15				3			9	504
TEk	4110	5340	1530	3312	6507	3690	5136	
Dk	4	4	5	3	4	5	5	
ETDk	1028	1335	306	1104	1627	738	1027	
Priority	4	2	7	3	1	6	5	

Based on the HOR phase 2 table above, a sequence of mitigation strategies is obtained based on the highest ETDk value. The following is the rank priority table of the mitigation strategies based on Phase 2 HOR calculations can be seen in table 4.

Table 5. Proposed Mitigation

Code	Proposed Mitigation	Priority
PA5	Provide medicines or vaccines to prevent virus outbreaks	1
PA2	Animal	2
PA4	Create SOPs for buying or selling	3
PA1	Use alternatives that are easy to use	4
PA7	Monitor deliveries	5
PA6	Perform detailed forecasting of needs, ordering and maintenance	6
PA3	Inspect and procure on a regular basis	7

The findings of this study indicate that the prioritized risk mitigation strategy is PA5, which involves the provision of drugs or vaccines to prevent virus outbreaks, as it has the highest ETD value. This aligns with previous literature emphasizing the importance of preventive actions in livestock health risk management. For comparison, the study by [21], which applied IoT technology in risk mitigation for smart farming, found that early detection and preventive actions, such as intrusion detection using machine learning, were highly effective in reducing potentially harmful risks. Although the contexts differ between smart farming and duck farming, the underlying principle of the importance of preventive measures remains relevant. Additionally, the PA3 strategy, which has the lowest priority in this study, namely regular inspection and procurement, can be compared with approaches in the literature that suggest continuous monitoring, although necessary, may not always yield significant impacts if not accompanied by other proactive actions. For instance, the study by [22] on climate impacts on Pakistan's agricultural sector emphasized that reactive or routine actions alone are insufficient to address significant risks without innovation in mitigation approaches.

4.5. Managerial Implication

In order to enhance the efficacy of risk reduction solutions, duck farm management must implement ongoing enhancements and modifications to the existing management approach, which encompass: Managers should emphasize the early detection of risks and take immediate action to mitigate them before they can have any negative influence on operations. This strategy has the potential to enhance the durability of supply chains and decrease the probability of disruptions. Furthermore, managers can deploy resources more efficiently. Instead of allocating resources broadly across all potential risks, it is more effective to concentrate on the most crucial areas that have the potential to cause a significant effect on the supply chain. This focused strategy guarantees the optimal utilization of resources to achieve the highest possible risk reduction.

5. Conclusion

To summarize, the examination of risks in duck farming identifies 15 specific risks and 21 related risk agents that could disrupt farming activities. The most crucial risk factors found through the Aggregate Risk Potentials (ARP) technique are the occurrence of livestock-infecting outbreaks and the lack of standardized operating procedures (SOPs) for the sales and acquisition of feed, ducks, or duck eggs. To deal with these risks, specific measures need to be implemented to reduce their impact.

Additionally, establishing Standard Operating Procedures (SOPs) for sales and purchases ensures improved operational control and uniformity. Moreover, these findings have broader implications for supply chain management in similar agricultural contexts. By addressing these risk factors, the resilience of the entire supply chain can be enhanced, leading to greater stability and sustainability. Future research should focus on refining these strategies and exploring their application in other areas of agricultural supply chains, ensuring that the lessons learned in duck farming can be generalized and adapted to improve practices across the industry.

References

[1] B. Koul, M. Yakoop and M. P. Syah, "Agricultural waste management strategies for environmental sustainability," *Environmental Research,* vol. 206, no. 112285, 2022.

[2] R. Chopra, C. . Magazzino, M. I. Shah, G. D. Sharma, A. Rao and U. Shahzad, "The role of renewable energy and natural resources for sustainable agriculture in ASEAN countries: Do carbon emissions and deforestation affect agriculture productivity ?," *Resources Policy,* vol. 76, no. 102578, 2022.

[3] S. I. Santoso, A. Setiadi and W. D. Prastiwi, "Sustainability Performance of Indonesian Duck Farming and the Related Determinants," *Advances in Animal and Veterinary Sciences,* vol. 7, no. 11, pp. 1176-1182, 2023.

[4] S. H. Muhie, "Novel approaches and practices to sustainable agriculture," *Journal of Agriculture and Food Research,* vol. 10, no. 100446, 2022.

[5] P. K. Rai, C. Sonne and K.-H. Kim, "Heavy metals and arsenic stress in food crops: Elucidating antioxidative defense mechanisms in hyperaccumulators for food security, agricultural sustainability, and human health," *Science of The Total Environment,* vol. 874, no. 162327, 2023.

[6] N. Valizadeh, V. Karimi, B. F. Heleileh, D. Hayati and M. Bijani, "Formulating of small-scale farmers' perception towards climate change in arid areas: Facilitating social interventions for agricultural sustainability," *Water and Environment Journal,* vol. 36, no. 2, pp. 199-213, 2021.

[7] L. Hutahaean, E. Sirnawati, E. S. Rohaeni and B. Bakrie, "Duck business development strategy in duck farming center area of Indramayu Regency, West Java Province of Indonesia," in *E3S Web of Conferences*, 2022.

[8] X. Hu, Y. C. Yang, K. Zhou, G. Tian, L. Bo, H. He, L. Zhang, Y. Cao and B. Bian, "Verification of agricultural cleaner production through rice-duck farming system and two-stage aerobic composting of typical organic waste," *Journal of Cleaner Production,* vol. 337, no. 130576, 2022.

[9] T.-T. Vo, V.-T. Dang, D.-H. Le and T.-H. Nguyen, "Identification, serotyping, and antimicrobial susceptibility of Riemerella anatipestifer isolated from ducks in Vietnam," *Open Veterinary Journal,* vol. 12, no. 3, pp. 391-398, 2022.

[10] Y. X. G. S. N. Yuan, Z. Nie, H. Li, L. Zhang, Y. Gong, Y. He, I. Ma, H. Zhang, J. Zhu, J. Duan and P. Xu, "Valuation of Ecosystem Services for the Sustainable Development of Hani Terraces: A Rice–Fish–Duck Integrated Farming Model," *International Journal of Environmental Research and Public Health,* vol. 9, no. 14, 2022.

[11] V. Kumar, E. Singh, S. Singh, A. Pandey and P. C. Bhargava, "Micro- and nano-plastics (MNPs) as emerging pollutant in ground water: Environmental impact, potential risks, limitations and way forward towards sustainable management," *Chemical Engineering Journal,* vol. 495, 2023.

[12] L. Wang, W.-M. Wu, N. Bolan, D. C. S. Tsang, Y. Li, M. Qin and D. Hou, "Environmental fate, toxicity and risk management strategies of nanoplastics in the environment: Current status and future perspectives," *Journal of Hazardous Materials,* vol. 401, 2021.

[13] L. Rohmah and E. Aryanny, "Risk Mitigation in Cold Chain Sytem using ANP and FMEA: A Case Study of PT XYZ," *Advance Sustainable Science, Engineering and Technology (ASSET),* vol. 6, no. 4, pp. 0240405-01 ~ 0240405-08, 2024.

[14] D. B. Paillin, J. M. Tupan, J. B. Paillin and W. L. V. O. Latuny, "Risk Assesment and Risk Mitigation In A Sustainable Tuna Supply Chain," *International Scientific Journal about Logistics ,* vol. 9, no. 1, pp. 51-61, 2022.

[15] E. Wulandari, E. Ernah, H. Hapsari and H. Amelia, "Risk Management of Granola Potato Seeds Production: A Study in Kertasari, West Java, Indonesia," *Caraka Tani: Journal of Sustainable Agriculture,* vol. 36, no. 2, pp. 308-318, 2021.

[16] A. Neri, E. Cagno, M. Lepri and A. Trianni, "A triple bottom line balanced set of key performance indicators to measure the sustainability performance of industrial supply chains," *Sustainable Production and Consumption,* vol. 26, pp. 648-691, 2021.

[17] F. Salasamuharram, A. H. Hamid, V. Zikria, L. N. Ginting, Z. Zulkarnain, E. Marsudi and A. Baihaqi, "Mitigation of gayo arabica coffee supply chain risk using the house of risk method in Aceh Tengah," in *IOP Conference Series: Earth and Environmental Science*, 2024.

[18] N. M. Zuhri, N. Puspita, W. I. Santoso, A. Khamdi and N. M. S. Ayomi, "Risk Management on Sustainable Corn Supply Chains: Evidence from Central Java, Indonesia," in *E3S Web of Conferences*, 2024.

[19] M. A. T. Dvaipayana, I. K. Sriwana and Y. Prambudia, "Design of supply chain risk mitigation system using house of risk and Fuzzy AHP methods in precast concrete," *Sinergi (Indonesia),* vol. 28, no. 1, pp. 93-102, 2024.

[20] S. G. Partiwi, V. N. Islami and H. Firmanto, "House of Risk (HOR) Approach to Manage Risk involving Multi-stakeholders: The Case of Automotive Industry Cluster of Multifunctional Rural Mechanized Tool (MRMT)," *Operations and Supply Chain Management,* vol. 16, no. 1, pp. 133-139, 2023.

[21] A. Raghuvanshi, "Global rangeland production systems and livelihoods at threat under climate change and variability," *Journal of Food Quality,* vol. 2022, 2022.

[22] A. Syed, "Climate Impacts on the agricultural sector of Pakistan: Risks and solutions," *Enviromental Challengs,* vol. 6, 2022.

[23] F. Vorimore, A. Thébault, S. Poisson, D. Cléva, J. Robineau, B. d. Barbeyrac, B. Durand and K. Laroucau, "Chlamydia psittaci in ducks: a hidden health risk for poultry workers," *Pathogens and Disease,* vol. 73, no. 1, pp. 1-9, 2015.

[24] P. Aendo, R. Netvichian, Viriyarampa, T. Songserm and P. Tulayakul, "Comparison of zinc, lead, cadmium, cobalt, manganese, iron, chromium and copper in duck eggs from three duck farm systems in Central and Western, Thailand," *Ecotoxicology and Environmental Safety,* vol. 161, pp. 691-698, 2018.

[25] J. Henning, D. U. Pfeiffer, M. Stevenson, D. Yulianto, W. Priyono and M. Joanne, "Who Is Spreading Avian Influenza in the Moving Duck Flock Farming Network of Indonesia?," *PLoS ONE,* vol. 11, no. 3, 2016.

[26] M. Asrol, Marimin, Machfud, M. Yani and E. Taira, "Risk Management for Improving Supply Chain Performance of Sugarcane Agroindustry," *Industrial Engineering & Management Systems ,* vol. 20, no. 1, pp. 9-26, 2021.