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Designing a House of Risk-Based Risk Mitigation Model for Sustainable Qurban Animal Slaughtering Operations in South Sulawesi

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Abstract. *Qurban animal slaughtering operations involve various risks that may affect halal compliance, food safety, occupational safety, environmental sustainability, and operational performance. This study aims to identify risk events and risk agents affecting qurban animal slaughtering operations in South Sulawesi and to develop appropriate mitigation strategies using the House of Risk (HOR) methodology. Data were collected through field observations, expert interviews, and questionnaires involving veterinarians, halal supervisors, qurban committees, and slaughtering operators. The results identified 23 risk events and 17 risk agents. HOR Phase 1 analysis revealed six critical risk agents, with the highest Aggregate Risk Potential (ARP) values being A14 (2,754), A6 (2,232), and A7 (1,784). HOR Phase 2 generated 12 preventive actions, where PA12 achieved the highest Total Effectiveness (68,490), followed by PA7 (42,282) and PA4 (40,320). The proposed mitigation model integrates risk identification, monitoring, supervision, sanitation control, and workforce development to improve halal compliance, food safety, environmental management, and operational sustainability. The findings provide practical guidance for implementing sustainable risk management systems in qurban animal slaughtering operations.*

Keywords: *House of Risk; Risk Mitigation; Halal Compliance; Food Safety; Sustainable Operations.*

I. PENDAHULUAN

Qurban animal slaughtering represents one of the largest annual livestock-processing activities in Indonesia (Riyadi, 2026). According to the Indonesian Ministry of Religious Affairs, approximately 2.16 million qurban animals were slaughtered during Eid al-Adha 2024, comprising cattle, goats, and sheep. The increasing volume of slaughtering activities raises concerns regarding food safety, hygiene, environmental pollution, and worker safety (Putri et al., 2023). Poorly managed slaughtering operations may result in meat contamination, quality deterioration, and inefficient distribution, highlighting the importance of proactive risk management practices (Kristanto & Kurniawati, 2023; Utama et al., 2025).

Despite existing regulations, many qurban slaughtering sites still operate with limited facilities and inadequate sanitation controls (Khan et al., 2022). Data from the Directorate General of Livestock and Animal Health Services indicate that more than 30% of temporary slaughtering locations require improvements in hygiene and waste-management practices (Khan et al., 2021a). In addition, veterinary inspections frequently identify deficiencies in ante-mortem examinations and meat-handling procedures (Khan et al., 2021b). These shortcomings increase the risk of cross-contamination, occupational accidents, and non-compliance with halal and food safety standards during peak slaughtering periods (Khan et al., 2023).

South Sulawesi is among Indonesia's important livestock-producing provinces, supporting both commercial and religious slaughtering activities (Lahmar & Al Qaruty, 2026). Statistics Indonesia (BPS) reported that the province possessed approximately 1.5

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million cattle and over 900 thousand goats in recent years. During Eid al-Adha, thousands of animals are processed across Makassar, Gowa, Maros, and neighboring districts (Khan et al., 2024). The involvement of livestock suppliers, veterinarians, slaughtering committees, volunteers, and consumers creates a complex operational system with numerous potential sources of risk and process disruption (Masudin et al., 2024).

Risk management studies in livestock and food-processing industries have increasingly adopted the House of Risk (HOR) method (Riana et al., 2025). Research conducted in poultry slaughterhouses identified 28 risk events and 23 risk agents, successfully prioritizing 12 critical risks for mitigation (Astutik et al., 2024). Other studies in halal food supply chains reported risk reductions exceeding 30% after implementing HOR-based mitigation strategies (Purnomo et al., 2021; Ulfah, 2022). Furthermore, HOR has been applied in agricultural distribution and meat-processing systems to improve operational reliability, demonstrating its effectiveness in prioritizing preventive actions and reducing Aggregate Risk Potential values (Padhil et al., 2021; Suaib et al., 2024).

Although HOR has been extensively applied in manufacturing, food processing, and supply chain management, its application to qurban animal slaughtering operations remains limited (Kusrini et al., 2022; Muthmainnah et al., 2021; Perdana et al., 2020). Previous studies generally focused on halal compliance, animal welfare, or meat quality without integrating comprehensive operational risk mitigation. Moreover, the unique characteristics of qurban activities, such as temporary facilities, volunteer workers, concentrated slaughtering schedules, and high operational uncertainty, have received little attention. Therefore, this study proposes a specialized HOR-based risk mitigation model tailored to sustainable qurban slaughtering operations (Malik et al., 2024; Winarso & Jufriyanto, 2020).

This study aims to identify risk events and risk agents affecting qurban animal slaughtering operations in South Sulawesi and to develop appropriate mitigation strategies using House of Risk Phases 1 and 2. The proposed model prioritizes critical risks and determines effective preventive actions to improve operational performance. The findings are expected to support safer slaughtering practices, enhance meat quality, strengthen halal compliance, and improve environmental management. Furthermore, the model may assist policymakers and qurban committees in implementing sustainable risk management systems.

II. METODE PENELITIAN

This study employed a risk management approach to identify, assess, and mitigate risks in qurban animal slaughtering operations in South Sulawesi. The research framework integrates the House of Risk (HOR) Phase 1 and Phase 2 methods to systematically identify risk events, determine their causes, prioritize critical risk agents, and formulate effective mitigation strategies. The final stage involved developing a risk mitigation model to support sustainable, safe, and reliable qurban slaughtering operations.

Data Collection

Data were collected through observations, interviews, and expert questionnaires involving veterinarians, halal supervisors, qurban committees, and slaughtering operators. Primary data included risk events, risk agents, severity, occurrence, and mitigation alternatives, while secondary data were obtained from regulations, operational guidelines, livestock statistics, and relevant scientific literature.

House of Risk Phase 1 (HOR 1)

HOR Phase 1 was used to identify and prioritize risk agents in qurban animal slaughtering operations. Risk events, causes, severity, occurrence, and correlation values were evaluated to calculate Aggregate Risk Potential (ARP) and determine priority risk agents for mitigation.

$$ARP_j = O_j \sum_{i=1}^{m} (S_i \times R_{ij})$$

Where:

- ARP_j = Aggregate Risk Potential of risk agent j
- O_j = Occurrence rating of risk agent j
- S_i = Severity rating of risk event i
- R_{ij} = Correlation value between risk event

i and risk agent j

The risk agents were then ranked according to their ARP values. Pareto analysis was employed to identify priority risk agents requiring immediate mitigation actions.

House of Risk Phase 2 (HOR 2)

HOR Phase 2 was used to prioritize preventive actions for critical risk agents identified in HOR Phase 1. The effectiveness of each action was evaluated using correlation values, and Total Effectiveness (TE) was calculated to determine the most effective mitigation strategies.

$$TE_k = \sum_{j=1}^{n} (AR\ P_j \times E_{jk})$$

Where:

- TE_k = Total effectiveness of preventive action k
- ARP_j = Aggregate Risk Potential of risk agent j
- E_{jk} = Relationship value between risk agent j and preventive action k

Each preventive action was subsequently assessed based on its Degree of Difficulty (Dk), considering implementation cost, required resources, and operational complexity. The Effectiveness-to-Difficulty Ratio (ETD) was calculated using Equation (3):

$$ETD_k = \frac{TE_k}{D_k}$$

Preventive actions with the highest ETD values were selected as priority mitigation strategies.

Development of Risk Mitigation Model

A House of Risk-based mitigation model was developed by integrating priority risk agents and preventive actions. The model supports risk control in qurban animal slaughtering operations and serves as a decision-support tool to improve food safety, halal compliance, occupational safety, environmental management, and operational sustainability.

III. HASIL DAN PEMBAHASAN

This section presents the findings obtained from the House of Risk (HOR) analysis. The discussion covers risk event identification, risk agent assessment, prioritization of critical risks, evaluation of mitigation actions, and development of a sustainable risk mitigation model for qurban animal slaughtering operations in South Sulawesi.

Identification of Risk Events in Qurban Animal Slaughtering Operations

Risk events were identified throughout qurban animal slaughtering operations in South Sulawesi, covering animal reception, inspection, slaughtering, carcass handling, meat distribution, sanitation, and waste management. The identification process aimed to determine operational risks affecting food safety, halal compliance, occupational safety, environmental sustainability, and overall operational performance.

Table 1. Identified Risk Events and Severity Ratings

Code	Risk Event Description	Severity (Si)
E1	Animal arrives in unhealthy condition	8
E2	Incomplete animal health inspection	8
E3	Failure to detect zoonotic diseases	9
E4	Lack of animal identification records	6
E5	Delay in slaughtering schedule	6
E6	Insufficient number of trained slaughterers	8
E7	Non-compliance with halal slaughtering procedures	10
E8	Improper animal handling before slaughter	8
E9	Animal stress affecting meat quality	7
E10	Failure of slaughtering equipment	7
E11	Improper bleeding process	8
E12	Cross-contamination during slaughtering	9
E13	Contamination from slaughtering tools	8
E14	Inadequate personal hygiene of workers	8
E15	Improper carcass handling	8
E16	Contamination during meat cutting process	9
E17	Delayed meat distribution	6
E18	Improper meat packaging and handling	7
E19	Unequal distribution of qurban meat	5
E20	Accumulation of slaughtering waste	8
E21	Environmental pollution from blood and wastewater	9
E22	Occupational accidents during slaughtering operations	9
E23	Inadequate post-slaughter sanitation and disinfection	8

As shown in Table 1, twenty-three risk events were identified in qurban animal slaughtering operations. The most critical events were halal non-compliance (E7; severity = 10), cross-contamination (E12 and E16; severity = 9), environmental pollution (E21; severity = 9), and occupational accidents (E22; severity = 9), indicating the need for priority mitigation and further HOR Phase 1 analysis.

Identification and Assessment of Risk Agents

Risk agent identification was conducted to determine the root causes of risk events in qurban animal slaughtering operations. A total of 17 risk agents were identified and evaluated based on occurrence levels to assess their contribution to operational disruptions, halal non-compliance, food safety issues, environmental impacts, and occupational safety risks through expert assessments and field observations.

Table 2. Risk Agents and Occurrence Ratings

Code	Risk Agent Description	Occurrence (Oj)
A1	Lack of operator training and competency	8
A2	Insufficient understanding of halal slaughtering procedures	8
A3	Weak supervision during slaughtering operations	7
A4	Inadequate ante-mortem inspection procedures	7
A5	Limited veterinary personnel availability	6
A6	Poor sanitation monitoring system	8
A7	Inadequate cleaning and disinfection practices	8
A8	Lack of personal protective equipment (PPE) compliance	7
A9	Improper animal handling before slaughtering	7
A10	High animal density during qurban activities	8
A11	Failure of slaughtering equipment and tools	6
A12	Insufficient waste management facilities	8
A13	Poor wastewater disposal practices	8
A14	Lack of standard operating procedure (SOP) implementation	9
A15	Inadequate coordination among qurban committees	7
A16	Limited operational budget and resources	6
A17	Absence of periodic training and evaluation programs	8

As shown in Table 2, 17 risk agents were identified as major sources of operational risk. The highest occurrence rating was observed for A14 (score = 9), while A1, A2, A6, A12, and A17 each received occurrence scores of 8. These findings indicate that managerial, human resource, sanitation, and environmental factors are the dominant contributors to risk in qurban animal slaughtering operations.

Prioritization of Critical Risk Agents Using House of Risk Phase 1

House of Risk Phase 1 analysis was conducted to determine the priority risk agents contributing to operational risks in qurban animal slaughtering activities. The analysis integrated severity ratings, occurrence ratings, and correlation values to calculate Aggregate Risk Potential (ARP) and identify critical risk sources.

Table 3. House of Risk Phase 1 Matrix

Risk Events	A1	A2	A3	A4	A5	A6	A7	A8	A9	A10	A11	A12	A13	A14	A15	A16	A17	Severity (Si)
E1	1	0	0	9	9	0	0	0	3	1	0	0	0	3	0	0	1	8
E2	1	0	3	9	9	0	0	0	1	1	0	0	0	3	0	0	1	8
E3	1	0	3	9	9	1	0	0	0	1	0	0	0	3	0	0	1	9
E4	0	0	3	9	1	0	0	0	0	0	0	0	0	9	1	0	0	6
E5	3	1	3	0	0	0	0	0	1	9	1	0	0	9	9	3	3	6
E6	9	3	1	0	0	0	0	1	0	3	0	0	0	9	3	1	9	8
E7	3	9	1	0	0	0	0	0	1	0	0	0	0	9	1	0	3	10
E8	1	3	1	0	0	0	0	0	9	9	0	0	0	3	1	0	1	8
E9	1	1	0	0	0	0	0	0	9	9	0	0	0	3	0	0	1	7
E10	1	0	0	0	0	0	1	1	0	0	9	0	0	3	0	3	1	7
E11	3	9	0	0	0	0	1	1	0	0	3	0	0	9	0	0	3	8
E12	3	1	3	0	0	9	9	3	0	0	1	0	0	9	1	0	1	9
E13	1	1	1	0	0	9	9	1	0	0	3	0	0	9	0	0	1	8
E14	3	1	1	0	0	9	9	9	0	0	0	0	0	9	1	0	1	8
E15	3	1	1	0	0	9	3	1	0	0	1	0	0	9	0	0	1	8
E16	1	1	1	0	0	9	9	3	0	0	1	0	0	9	0	0	1	9
E17	1	0	3	0	0	0	0	0	0	1	0	0	0	9	9	3	1	6
E18	1	1	3	0	0	3	3	0	0	0	0	0	0	9	1	0	1	7
E19	0	0	3	0	0	0	0	0	0	1	0	0	0	9	9	0	0	5
E20	0	0	1	0	0	3	1	0	0	0	0	9	9	3	1	3	0	8
E21	0	0	1	0	0	3	1	0	0	0	0	9	9	3	0	3	0	9
E22	9	1	1	0	0	1	0	9	1	0	3	0	0	3	0	0	3	9
E23	1	0	3	0	0	9	9	1	0	0	0	0	0	9	0	0	3	8
Occurrence (Oj)	8	8	7	7	6	8	8	7	7	8	6	8	8	9	7	6	8	
ARP	1,416	1,512	1,029	1,106	864,000	2,232	1,784	1,001	798,000	1,128	522,000	1,368	1,224	2,754	1,092	624,000	1,008	
Ranking	4	3	10	8	14	2	5	11	15	6	17	7	9	1	12	16	13	

Table 3 shows the relationship between 23 risk events and 17 risk agents in the HOR Phase 1 matrix. Strong correlations (value = 9) were identified between E7–A2/A14, E12/E16–A6/A14, and E20/E21–A12. These results indicate that SOP implementation, sanitation monitoring, and waste management are the most influential factors affecting operational risk occurrence.

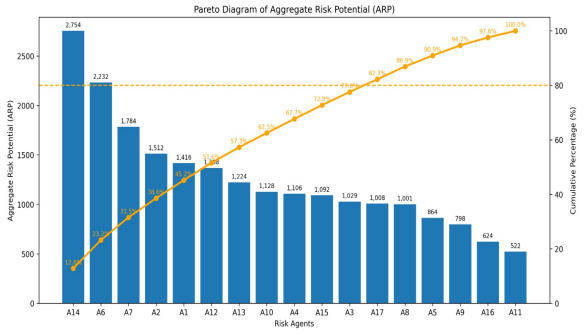

Figure 1. Pareto Diagram of ARP of Risk Agents in Qurban Animal Slaughtering Operations

Figure 2 shows the Pareto analysis of 17 risk agents. The highest ARP values were obtained by A14 (2,754), A6 (2,232), and A7 (1,784). The cumulative percentage reached 82.83% at the sixth risk agent, indicating that A14, A6, A7, A2, A1, and A12 are the priority risk agents requiring mitigation to improve operational safety, halal compliance, and sustainability.

Development and Evaluation of Preventive Actions Using House of Risk Phase 2

House of Risk Phase 2 was applied to develop 12 preventive actions for mitigating 6 priority risk agents. The analysis evaluated mitigation effectiveness to improve safety, halal compliance, environmental performance, and operational sustainability in qurban animal slaughtering operations.

Table 5. Preventive Action List for Priority Risk Agents

Code	Preventive Action Description	Risk Agent
PA1	Develop and standardize qurban slaughtering SOPs	A14
PA2	Conduct periodic SOP socialization and implementation audits	A14
PA3	Establish sanitation monitoring and inspection teams	A6
PA4	Implement sanitation checklists before, during, and after slaughtering activities	A6, A7
PA5	Improve cleaning and disinfection procedures for facilities and equipment	A7
PA6	Provide halal slaughtering training for slaughtering operators	A2, A1
PA7	Conduct regular halal compliance supervision and evaluation	A2, A14
PA8	Organize competency-based training programs for workers	A1
PA9	Implement periodic competency assessment and certification programs	A1
PA10	Improve slaughtering waste collection and segregation systems	A12
PA11	Develop environmentally friendly waste and wastewater treatment facilities	A12
PA12	Establish an integrated monitoring system for operational, sanitation, and environmental performance	A14, A6, A7, A12

Table 5 presents 12 preventive actions developed to mitigate 6 priority risk agents identified in HOR Phase 1. The actions emphasize SOP implementation, sanitation control, halal compliance, workforce competency, and waste management as the dominant sources of operational risk.

Table 6. House of Risk (HOR) Phase 2 Matrix

Risk Agent	Preventive Action												ARP
	PA1	PA2	PA3	PA4	PA5	PA6	PA7	PA8	PA9	PA10	PA11	PA12	
A14	9	9	0	0	0	0	9	0	0	0	0	9	2,754
A6	0	0	9	9	3	0	0	0	0	0	0	9	2,232
A7	0	0	3	9	9	0	0	0	0	0	0	9	1,784
A2	1	1	0	0	0	9	9	3	1	0	0	1	1,512
A1	1	1	0	0	0	9	3	9	9	0	0	1	1,416
A12	0	0	0	0	0	0	0	0	0	9	9	9	1,368
TE	27,774	27,774	25,344	40,32	22,752	26,352	42,282	17,28	14,448	12,312	12,312	68,49	
D	3	3	3	4	3	3	4	2	2	3	5	5	
ETD	9,258	9,258	8,448	10,08	7,584	8,784	10,571	8,64	7,224	4,104	2,462	13,698	
Ranking	4	5	8	2	10	6	1	7	11	9	12	3	

Table 6 shows the effectiveness relationship between priority risk agents and preventive actions. The Total Effectiveness (TE) values indicate the ability of each preventive action to mitigate multiple risk agents simultaneously. Higher TE values represent greater contributions toward operational risk reduction and improved system performance.

Prioritization of Risk Mitigation Strategies

Risk mitigation strategies were prioritized using the Effectiveness-to-Difficulty Ratio (ETD). Based on 12 preventive actions, higher ETD values indicate more effective and feasible

mitigation measures for reducing operational risks in qurban animal slaughtering activities.

Table 6. ETD-Based Ranking of Preventive Actions

Rank	Preventive Action Code	TE	D	ETD
1	PA7	42,282	4	10,571
2	PA4	40,32	4	10,08
3	PA12	68,49	5	13,698
4	PA1	27,774	3	9,258
5	PA2	27,774	3	9,258
6	PA6	26,352	3	8,784
7	PA8	17,28	2	8,64
8	PA3	25,344	3	8,448
9	PA10	12,312	3	4,104
10	PA5	22,752	3	7,584
11	PA9	14,448	2	7,224
12	PA11	12,312	5	2,462

As presented in Table 8, PA7 achieved the highest ETD value (10,571), followed by PA4 (10,080), indicating that halal compliance supervision and sanitation control are the most effective mitigation strategies. These findings are consistent with previous studies showing that supervision systems and sanitation management significantly reduce operational risks and improve process reliability in food and slaughtering operations (Purnomo et al., 2021; Ulfah, 2022).

Meanwhile, PA12 generated the highest TE value (68,490) but required greater implementation effort (D = 5). In contrast, PA1 and PA2 achieved ETD values of 9,258, demonstrating the importance of SOP implementation and compliance audits. Similar findings have been reported by previous HOR-based studies, which emphasized that standardized procedures, monitoring systems, and workforce development are critical factors for improving operational performance and risk reduction (Natalia et al., 2020; Padhil et al., 2021).

Proposed Risk Mitigation Model for Sustainable Qurban Animal Slaughtering Operations

The proposed model integrates the results of HOR Phase 1 and Phase 2, including 23 risk events, 17 risk agents, 6 priority risk agents, and 12 preventive actions. The framework supports halal compliance, food safety, occupational safety, environmental sustainability, and operational reliability in qurban animal slaughtering activities.

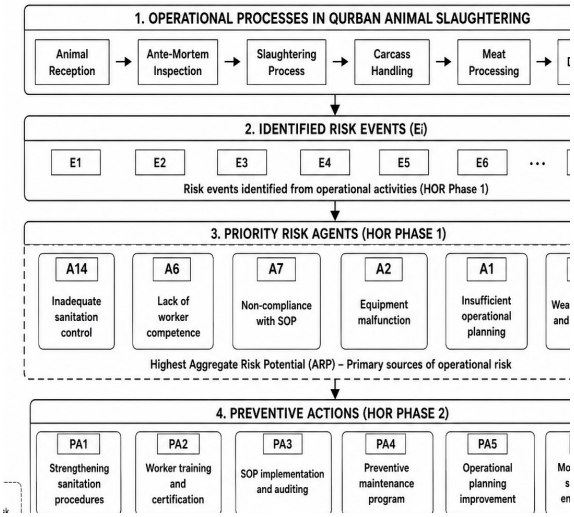

Figure 2. Proposed House of Risk-Based Risk Mitigation Model for Sustainable Qurban Animal Slaughtering Operations

Figure 3 presents the HOR-based conceptual framework integrating 23 risk events, 17 risk agents, and 6 priority risk agents. Similar integrated risk frameworks have been reported by (Hasanah et al., 2025; Indrasari et al., 2024; Suaib et al., 2024).

The framework incorporates 12 preventive actions developed through HOR Phase 2 to reduce operational risks and improve halal compliance, food safety, and sustainability. These findings are consistent with studies by (Padhil et al., 2022; Perdana et al., 2020), which emphasize proactive mitigation and continuous improvement for sustainable operational performance.

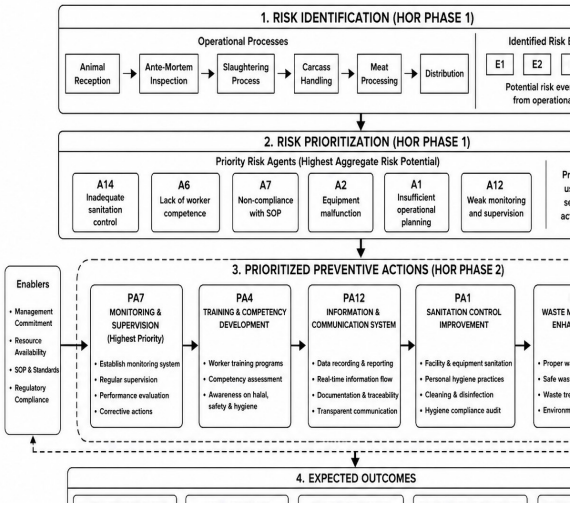

Figure 4. Integrated Risk Mitigation Model for Sustainable Qurban Slaughtering Operations

Figure 4 presents an integrated risk mitigation model derived from HOR Phase 1 and Phase 2, incorporating 6 priority risk agents and 12 preventive actions. The model systematically links risk identification, prioritization, and mitigation processes. Similar integrated approaches have been reported by (Muthmainnah et al., 2021; Perdana et al., 2020).

The model emphasizes five priority preventive actions (PA7, PA4, PA12, PA1, and PA2) as key strategies for reducing operational risks. Supported by management commitment and continuous monitoring, these actions are expected to improve halal assurance, food safety, environmental sustainability, and operational performance. These findings are consistent with previous studies by (Kusrini et al., 2022; Muthmainnah et al., 2021), which highlighted proactive mitigation as a critical factor in achieving sustainable operational systems.

Table 9. Managerial Implementation Framework for Sustainable Qurban Animal Slaughtering Operations

Stage	Main Activities	Responsible Stakeholders	Expected Outcomes
Planning	Develop SOPs, allocate resources, establish sanitation and halal compliance programs	Qurban Committee, Halal Supervisors, Local Government	Standardized operational procedures and implementation readiness
Implementation	Execute preventive actions, conduct training, implement sanitation checklists, and monitor compliance	Slaughtering Operators, Veterinarians, Halal Supervisors	Reduced occurrence of priority risk agents and improved operational control
Evaluation	Perform operational audits, halal compliance assessments, sanitation inspections, and performance reviews	Internal Auditors, Veterinarians, Halal Supervisors	Identification of operational gaps and corrective action requirements
Continuous Improvement	Update SOPs, improve facilities, enhance training programs, and strengthen monitoring systems	Management Team, Local Government, Stakeholders	Sustainable operational performance and continuous risk reduction

Table 9 presents a managerial implementation framework consisting of four stages: planning, implementation, evaluation, and continuous improvement. Each stage involves specific stakeholders and activities aimed at mitigating the six priority risk agents identified through HOR analysis. Similar managerial frameworks have been widely applied in risk management studies to improve operational effectiveness and sustainability (Fole, 2023; Kusrini et al., 2022).

The framework facilitates the systematic execution of 12 preventive actions, strengthens halal compliance, food safety, sanitation management, and continuous monitoring systems. Through stakeholder collaboration and periodic performance evaluation, the framework supports sustainable operational improvement and risk reduction. These findings are consistent with previous studies emphasizing the importance of structured implementation and continuous improvement in achieving sustainable operational performance (Malik et al., 2024; Winarso & Jufriyanto, 2020).

IV. CONCLUSION

This study applied the House of Risk (HOR) methodology to identify, assess, and mitigate risks associated with qurban animal slaughtering operations in South Sulawesi. The results identified 23 risk events and 17 risk agents distributed throughout the operational process. HOR Phase 1 analysis revealed six critical risk agents, namely A14 (ARP = 2,754), A6 (ARP = 2,232), A7 (ARP = 1,784), A2 (ARP = 1,512), A1 (ARP = 1,416), and A12 (ARP = 1,368), which collectively represented the dominant sources of operational risk. Furthermore, HOR Phase 2 generated 12 preventive actions, with PA12 (TE = 68,490), PA7 (TE = 42,282), and PA4 (TE = 40,320) identified as the most effective mitigation strategies. The proposed risk mitigation model integrates risk identification, prevention, monitoring, and continuous improvement to enhance halal compliance, food safety, environmental management, occupational safety, and operational sustainability. For future implementation, qurban committees, veterinary authorities, and local governments are encouraged to prioritize SOP

enforcement, sanitation monitoring, halal compliance supervision, workforce competency development, and integrated monitoring systems. Future studies may incorporate quantitative performance indicators and digital monitoring technologies to further strengthen sustainable risk management practices in qurban animal slaughtering operations.

REFERENCES

Astutik, W., Mujaddid, J. K., Fole, A., & Yanasim, N. (2024). Enhancing Risk Mitigation Strategies In Innovative Poultry Slaughterhouses: A House Of Risk Method Approach. *Scientifica: Jurnal Ilmiah Sains Dan Teknologi*, *2*(11), 1–21. https://jurnal.kolibi.org/index.php/scientica/article/view/3644

Fole, A. (2023). Perancangan Strategi Mitigasi Risiko Pada Proses Bisnis CV. JAT Mengunakan Metode House of Risk. *Journal of Industrial Engineering Innovation*, *1*(02), 54–64. https://doi.org/10.58227/jiei.v1i02.109

Hasanah, S. U., Santosa, P. I., & Ferdiana, R. (2025). House of Risk Phase 1: A Tool for Identifying and Prioritizing Software Development Risk Agents. *2025 International Conference on Advancement in Data Science, E-Learning and Information System (ICADEIS)*, 1–6. https://doi.org/10.1109/ICADEIS65852.2025.10933042

Indrasari, L. D., Komari, A., Tripariyanto, A. Y., Santosa, H. B., Siswanto, E., Vitasmoro, P., Pradana, J. A., & Salsabilah, V. K. (2024). *Design of sustainable green supply chain management using house of risk*. 120009. https://doi.org/10.1063/5.0212379

Khan, S., Haleem, A., & Khan, M. I. (2021a). Assessment of risk in the management of Halal supply chain using fuzzy BWM method. *Supply Chain Forum: An International Journal*, *22*(1), 57–73. https://doi.org/10.1080/16258312.2020.1788905

Khan, S., Haleem, A., & Khan, M. I. (2021b). Risk management in Halal supply chain: an integrated fuzzy Delphi and DEMATEL approach. *Journal of Modelling in Management*, *16*(1), 172–214. https://doi.org/10.1108/JM2-09-2019-0228

Khan, S., Haleem, A., & Khan, M. I. (2023). Risk assessment model for halal supply chain using an integrated approach of IFN and D number. *Arab Gulf Journal of Scientific Research*, *41*(3), 338–358. https://doi.org/10.1108/AGJSR-09-2022-0160

Khan, S., Haleem, A., & Khan, M. I. (2024). A risk assessment framework using neutrosophic theory for the halal supply chain under an uncertain environment. *Arab Gulf Journal of Scientific Research*, *42*(3), 852–870. https://doi.org/10.1108/AGJSR-12-2022-0312

Khan, S., Khan, M. I., Haleem, A., & Jami, A. R. (2022). Prioritising the risks in Halal food supply chain: an MCDM approach. *Journal of Islamic Marketing*, *13*(1), 45–65. https://doi.org/10.1108/JIMA-10-2018-0206

Kristanto, D., & Kurniawati, D. A. (2023). Development of halal supply chain risk management framework for frozen food industries. *Journal of Islamic Marketing*, *14*(12), 3033–3052. https://doi.org/10.1108/JIMA-04-2022-0112

Kusrini, E., Safitri, K. N., & Fole, A. (2022). Mitigasi Resiko di Distribusi Sustainable Supply Chain Management Menggunakan Metode House Of Risk (HOR). *Integrasi: Jurnal Ilmiah Teknik Industri*, *7*(1), 14–23. https://doi.org/10.32502/js.v7i1.4348

Lahmar, A., & Al Qaruty, R. (2026). Mitigating risks in the halal supply chain: a bibliometric review of the role of technologies. *Journal of Islamic Marketing*, 1–26. https://doi.org/10.1108/JIMA-07-2025-0412

Malik, R., Safutra, N. I., Fole, A., & Pangestu, F. A. (2024). Improving Resilience in Water Distribution Systems: An Application of the House of Risk Method at PDAM Gowa Unit Tompobulu. *Jurnal Sistem Teknik Industri*, *26*(2), 199–209. https://doi.org/10.32734/jsti.v26i2.16171

Masudin, I., Zuliana, P. E., Utama, D. M., & Restuputri, D. P. (2024). Assessment and risk mitigation on halal meat supply chain

using fuzzy best-worst method (BWM) and risk mitigation number (RMN). *Journal of Islamic Marketing*, *15*(3), 842–865. https://doi.org/10.1108/JIMA-08-2022-0240

Muthmainnah, S., Immawan, T., & Herdianzah, Y. (2021). IMPLEMENTATION OF THE HOUSE OF RISK IN THE SUPPLY CHAIN OF MANUFACTURING SMEs. *Journal of Industrial Engineering Management*, *6*(2), 40–50. https://doi.org/10.33536/jiem.v6i2.904

Natalia, C., Br. Hutapea, Y. F. T., Oktavia, C. W., & Hidayat, T. P. (2020). Interpretive Structural Modeling and House of Risk Implementation for Risk Association Analysis and Determination of Risk Mitigation Strategy. *Jurnal Ilmiah Teknik Industri*, *19*(1), 10–21. https://doi.org/10.23917/jiti.v19i1.9014

Padhil, A., Chairany, N., Ahmad, A., Ramli, H., & Malik, R. (2021). SUPPLY CHAIN RISK ANALYSIS IN KUB – IK MATARAM MACOA WITH HOUSE OF RISK (HOR). *Journal of Industrial Engineering Management*, *6*(2), 51–60. https://doi.org/10.33536/jiem.v6i2.942

Padhil, A., Fachry Hafid, M., & Dwi Wahyuni, A. P. (2022). Risk Analysis of Water Distribution in PDAM City of Makassar Using the House of Risk (HOR) Method. *American Journal of Mechanical and Industrial Engineering*, *7*(4), 63–69. https://doi.org/10.11648/j.ajmie.20220704.12

Perdana, S., Usman, R., & Arifiya, N. (2020). Analysis of supply chain risk mitigation strategies in the Bogor compressor company with the house of risk method. *IOP Conference Series: Materials Science and Engineering*, *852*(1). https://doi.org/10.1088/1757-899X/852/1/012094

Purnomo, B. H., Suryadharma, B., & Al-hakim, R. G. (2021). Risk Mitigation Analysis in a Supply Chain of Coffee Using House of Risk Method. *Industria: Jurnal Teknologi Dan Manajemen Agroindustri*, *10*(2), 111–124. https://doi.org/10.21776/ub.industria.2021.010.02.3

Putri, I., Kusrini, E., & Paripurna, Y. (2023). *Risk management of the Halal supply chain: A literature review*. 040003. https://doi.org/10.1063/5.0168344

Riana, R. I., Immawan, T., & Herdianzah, Y. (2025). Supply Chain Risk Management for Waste Management Strategy Using House of Risk. *Metode : Jurnal Teknik Industri*, *11*(1), 138–147. https://doi.org/10.33506/mt.v11i1.4149

Riyadi, S. (2026). Qurban as an instrument of Islamic social finance for sustainable social development in Indonesia. *ECOBIZTECH: Journal of Economics, Business, and Technology*, *1*(2), 134–150. https://doi.org/10.65881/ecobiztech.v1i2.74

Suaib, R. A. H., Mansur, A., Basuki, D. E., & Aulia, B. P. R. (2024). Risk Mitigation Design for Supply Chain Activities in Printing Industry with House of Risk Method. *Jurnal Sains Dan Teknologi Industri*, *21*(2), 293. https://doi.org/10.24014/sitekin.v21i2.29853

Ulfah, M. (2022). Mitigasi risiko rantai pasok industri kue menggunakan house of risk. *Journal Industrial Servicess*, *8*(1), 63–70. https://doi.org/10.36055/jiss.v8i1.14315

Utama, D. M., Dewi, S. K., & Antika, M. D. (2025). A new framework for risks mitigation halal food supply chain: a case study in Indonesia. *International Journal of System Assurance Engineering and Management*, *16*(8), 2800–2816. https://doi.org/10.1007/s13198-025-02836-y

Winarso, K., & Jufriyanto, M. (2020). Rework Reduction and Quality Cost Analysis of Furniture Production Processes Using the House of Risk (HOR). *Journal of Physics: Conference Series*, *1569*(3). https://doi.org/10.1088/1742-6596/1569/3/032022