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Production Failure Risk Analysis and AHP-Based Decision Making For Mitigation Strategy Selection in Layer Poultry Farming

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Abstract. Layer poultry farming in Indonesia face recurring production failures with severe financial consequences. This research investigates PT RHA which recorded 30 to 35 percent decline in egg output during the Q1-Q2 2023. The study aims to: (1) financially quantify the production failures using the Cost of Failure, Value at Risk, and Risk-Adjusted Return on Capital and (2) prioritize mitigation strategies through the Analytic Hierarchy Process. The research adopts a mixed-methods explanatory case study design. Primary data were collected through semi-structured interviews and financial records from January 2021 through December 2024. The Cost of Failure analysis revealed that the total losses reached Rp 1,535,200,000. The VaR analysis produced a CvaR at 99 percent confidence of Rp 350,000,000, which was adopted as the recommended minimum capital buffer. Baseline RAROC stood at 21.4%, rising to 101.7% under the primary strategy. AHP analysis (CR =0.0099< 0.10) ranked the Preventive and Risk Elimination Strategy (A1) as optimal intervention with a composite score of 0.4843. This research demonstrates that integrating quantitative financial risk with AHP produces a defensible, evidence-based prioritisation framework for resource-constrained farm management. The findings may be applicable to similar layer operations across Indonesia and provide solid methodological framework agribusiness risk management studies.

Keywords: Analytic Hierarchy Process; Cost Of Failure; Layer Poultry Farming; Production Failure; Value At Risk.

1. INTRODUCTION

Layer farming is a agribusiness system that relies on the coordinated interaction of biological productivity, feed quality, financial stability, and strategic operational management. Many small-to medium-scale layer farms in Indonesia still operate traditionally, particularly regarding risk mitigation planning, they operate without structured and proper mechanisms to identify, analyze, and manage risk, especially those related to production failures. This sensitive environment presents numerous challenges that require consideration to ensure the health of birds and the quality of feed. Vaccination needs to happen on time to avoid disruptions, and provide a band-aid solution to issues that are, in theory, preventable. These issues are made worse with limited warning of the situation and the absence of response mechanisms (Brown 2008).

The primary issue faced in the field is the frequent occurrence of production breakdowns at both the micro and macro level, caused by unanticipated disease outbreaks, and poor feed and vaccine quality. Factors that disrupt the control of viral challenges such as Avian Influenza and Newcastle Disease on most farms include poorly designed immunization schedules. These operational breakdowns result in increased mortality and reduced egg quantity and quality, consequently increasing operational costs and reducing profits (Kidd et al., 2020). These operational vulnerabilities stem from a lack of structured risk analysis and

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forecasting mechanisms at the farm level. Most small-scale farms still adopt a reactive approach to production disruptions, rather than engaging in structured predictive planning. Without a performance-based risk management model, farm managers cannot accurately measure the financial impact of operational failures or prioritize evidence-based investments in preventive infrastructure (Marion et al.,2021).

In 2023, PT RHA's 40,000-bird laying hen farm underwent serious production disruptions during Q1 and Q2. During these periods, the farm was producing 30-35% of the average egg output. During the height of the production disruptions in Q2 2023, the farm was producing approximately 21,013 eggs in a day, a shortfall of 12,387 eggs, from a normal production output of approximately 33,400 eggs. Over the course of the disruption, the farm suffered a cumulative egg production shortfall of more than 1.84 million eggs. The daily mortality rate, which typically averages 0.04%, increased to 0.39%, which, during Q2, accounted for 1,404 confirmed bird loss. Additionally, the farm's feed conversion efficiency deteriorated from a baseline of 2.12 kilograms of feed per kilogram of eggs produced to 2.76 kilograms, indicating the farm's fell its profitability, due to a significant shortfall in its egg production. The production disruptions were the result of a combination of three factors. First, the farm suffered instability in the immune system of the birds, caused by poor management of the cold chain and delayed vaccination, resulting in bursts of viral infections. Second, the poor quality of feed and the lack of nutrition, caused primarily by the low protein levels in the feed, impacted the farm adversely by negatively affecting the size of the eggs as well as performance and productivity of the birds, while continuously worsening the feed conversion ratios. It can be said the feed given did not meet the chickens' nutritional needs, resulting in overeating. Third, there was no risk monitoring system that would allow the company to identify imminent threats. As a result of the shortcomings in both systems, the issues grew beyond control, and significant losses were incurred before they could be recognized and addressed.

2. THEORICAL AND LITERATURE REVIEW

Production Risk and Cost of Failure in Poultry Farming

Production risk in layer poultry farming refers to the probability that actual performance outcome measured by Hen-Day Production (HDP), mortality rate, and Feed Conversion Ratio (FCR), deviate from expected levels due to disease, input quality failures, or management breakdowns (Hardaker et al., 2015). Layer poultry farming is a prime example of the agribusiness industry that operates within a great deal of uncertainty. This is due to the

biological nature of the inputs, the quality of inputs, and the discipline of the operator. In this case, the production risk is related to all of the ways in which actual production can fall short of expectations. This can happen due to the breakout of a disease, the quality of feed, environmental stressors, and poor management. The aforementioned factors have been identified in past research to cause the disruptions in supply and stagnation of progress of small- to medium-sized layer farms. The greatest impact is the disruption of supply, which causes a drop in eggs and an increase in the loss of life of the flock (Hardaker et al., 2015; Kaplan and Mikes, 2012). Previous studies indicate that disease-related disruptions and input inconsistency remain the dominant sources of risk in small- and medium-scale layer farms, often leading to significant declines in egg production and increased mortality (Hardaker et al., 2015; Kaplan and Mikes, 2012).

The Cost of Failure framework derives from Juran and Godfrey's (1999) quality management theory, which identifies prevention costs, appraisal costs, and failure costs. Within agriculture, Cost of Failure the visible losses (e.g. the loss of revenue from production, the presence of dead livestock, and downgraded products) and the invisible (e.g. the systemic costs surrounding a crisis which include, but are not limited to, the emergency vet fees, the feed losses due to a fall in the feed conversion ratio, and the costs of informal emergency loans). The studies by Hardaker et al. (2015) and Sharif et al. (2025) argue that informal farm accounting consistently undervalues indirect costs, which entails a systematic underinvestment in preventive action, as farm managers lack the necessary insight to understand the full extent of the costs of failure. In this study, Cost of Failure provides a retrospective assessment of the losses incurred in 2023 for the purpose of generating quantitative data to support AHP criteria, while also providing a prospective assessment for purposes of identifying future losses.

Value at Risk and RAROC in Agricultural Context

Value at Risk (VaR) measures, at a specific confidence level (Jorion, 2007), the worst expected loss a company would experience over a given time frame. Odening and Hinrichs (2003) showed that when income from livestock is distributed in a fat-tailed, non-normally distributed way, Monte Carlo simulations should be used in place of conventional parametric techniques, particularly when precision in the tails of the distributions is of utmost importance. Bell et al. (2021) furthered this understanding with the entire farm system, demonstrating that Conditional Value at Risk, or Expected Shortfall, offers a more complete perspective on catastrophic tail risk by averaging the loss in the worst specified percent of scenarios and providing the loss value that would be exceeded in the majority of scenarios. In this study, the Value at Risk analysis of PT RHA's 48-month net cash flow series is intended to set a financial

boundary to reduce the AHP criterion concerning financial loss. Simultaneously, the Value at Risk production thresholds establish the Hen-Day Production alert levels.

Value at Risk models based on simulation as opposed to parametric methods are essential in biological production systems due to the fact that the severity of disease outbreaks is the result of a multitude of processes, causing production losses with fat tails, which are more severe than what is predicted by most common distributions. Each application of the parametric Value at Risk to a biological production system would result in a systematic underestimation of the worst-case loss, which is the figure that should be the most significant driver of the capital buffer decision (Anderson et al., 2009).

Risk-Adjusted Return on Capital was originally developed for bank risk management and subsequently formalised by Crouhy, Galai and Mark (2014) as a unified performance metric that integrates operating profitability with economic capital requirements. Its core insight is that a business should not evaluate investment alternatives purely on the basis of expected return but rather on the basis of the return earned per unit of risk-weighted capital deployed. In banking, this prevents the appearance of high returns masking excessive risk-taking; in agricultural contexts, it prevents farm managers from selecting cheap interventions that deliver small improvements when a more expensive intervention would deliver a dramatically superior risk-adjusted outcome (Hubbard, 2020).

Analytic Hierarchy Process in Farm Decision-Making

The Analytic Hierarchy Process (AHP) is a decision-making framework created by Thomas Saaty in 1980 to help with complex problems involving multiple, interrelated criteria. According to Saaty's scenario, human judgments tend to be most both accurate and reliable when individuals provide two-element comparisons; therefore, the framework prefers judgments in this manner rather than by considering the entire set of alternatives and assigning absolute rankings. The AHP framework decomposes a decision into three levels to make complex decision problem structures more manageable and more easily solvable (Saaty, 1980). AHP's first, highest-level element is the goal of the decision to be made, the second level consists of evaluation criteria, and the final level represents the set of alternatives to be considered.

Within the context of poultry farming and animal production, the literature attests to the validation of the AHP as a decision support tool. Gilal et al. (2025) used AHP to evaluate and prioritize the mitigation of risks in various dimensions of poultry farming and illustrated that the AHP is capable of documenting the consensus of experts in situations characterized by biological uncertainties and when qualitative and/or quantitative data are scarce. Asih et al.

(2025) examined the use of AHP and Fuzzy AHP in the context of sustainability decision-making for poultry slaughterhouses in Indonesia, and concluded that the use of AHP as a conventional approach was sufficient to generate a priority list that was acceptable to the stakeholders, and therefore proposed that the AHP approach be adopted. Agustine et al. (2023) employed AHP to evaluate the priorities of farmers in smallholder livestock in the Indonesian context and demonstrated that the AHP is capable of documenting the consensus of experts in the presence of diverse educational and experiential backgrounds through the formation of priorities that are consistent, and when the respondents do not provide quantitative data.

One important limitation of AHP that merits acknowledgement in this context is its assumption of independence among criteria. In the present application, there are plausible interdependencies between financial loss reduction and implementation feasibility, because strategies that cost more to implement may reduce financial losses more substantially in the long run. Saaty (2001) developed the Analytic Network Process as an extension of AHP specifically to handle such interdependencies, but given the farm-level data availability and the practical orientation of this research, standard AHP is retained as the primary decision tool while the possibility of interdependence effects is acknowledged as a boundary condition on the interpretation of results.

3. RESEARCH METHODS

This study uses a mixed-methods, explanatory case-study design which combines stakeholder engagement and quantitative financial modeling to understand production failures in small-scale layer poultry farming. This study relies on pragmatism to understand the complex, multi-dimensional smallholder farming risks, as neither quantitative nor qualitative modeling and thinking can capture these risks in their entirety (Creswell and Plano Clark, 2018). By applying the empirical financial modeling, complemented by direct observation and expert interviews, this study creates a viable and methodologically sound risk management framework for agribusiness.

According to Yin (2018), this study is a type of applied-explanatory case study. It is explanatory because it intends to explain the processes and mechanisms that transform operational failings (cold chain failures, outbreaks of illness, feeding inconsistency, poor vaccination practices, etc.) into high-value financial risk and/or loss. It is applied because the primary outcome of this study is to produce actionable solutions to improve the risk-adjusted returns and decrease the downside risk for the management of PT RHA. This study has five integrated steps which are shown in Figure 1.

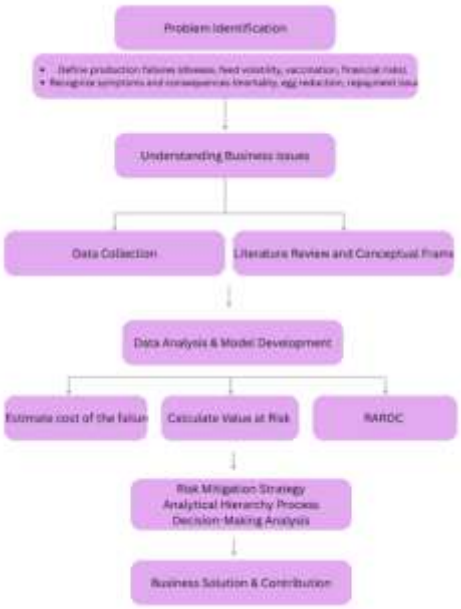


Figure 1. Five Integrated Steps

The analytical architecture of this study integrates five methodological components into a coherent, sequential pipeline: data preparation and classification, Cost of Failure estimation, Value at Risk modelling, Risk-Adjusted Return on Capital measurement, and Analytic Hierarchy Process prioritisation. Each component generates outputs that directly feed the next stage, ensuring analytical consistency and progressive refinement from raw operational data to strategic recommendations.

Quantitative data spanning January 2021 to December 2024, constituting 48 monthly observations, were extracted from PT RHA's internal management information system. The dataset encompasses monthly egg production volumes by grade, daily flock population and mortality records, hen-day production percentages, feed conversion ratios, veterinary and medication expenditures, vaccination and cold-chain compliance logs, egg selling prices, and monthly financial statements including revenue, variable costs, and short-term debt obligations.

4. RESULTS AND DISCUSSION

Production Failure: The Scale of the Problem

The production failure in 2023 at PT RHA did not stem from a single issue. There are three separate problems hit the farm simultaneously. The first problem is the chickens lost their protection against disease because the vaccine had deteriorated due to cold storage and poor handling before it was even injected. Second, the feed supplied by the primary vendor

contained inconsistent protein levels, which made the chickens weaker and less able to lay eggs, resulting in uneven egg production. Third, both problems went undetected for a long time, leading to the collapse within six months, because the farm lacked a system to detect early warning signs. If any of these three problems had occurred on its own, the farm might have been able to overcome it. The true damage come from all three problems striking simultaneously, compounding each other, and worsening each week without a structured response. Worse still, the full financial cost of the collapse was never properly calculated at the time, because the farm lacked accounting system to track each type of loss.

Table 1. Production Performance Indicators PT RHA: Baseline versus Failure versus Recovery (2022-2023)

Indicator	Baseline 2022	Q1-2023	Q2-2023 (Peak)	Q3-2023 (Recovery)	Unit
Hen-Day Production	83.5%	64.2%	**57.1%**	74.8%	%
Daily Egg Output	33,400	25,680	**21,013**	28,594	Eggs/day
Mortality Rate	0.04%	0.22%	**0.39%**	0.09%	%/day
Feed Conversion Ratio	2.12	2.51	**2.76**	2.29	kg/kg
Egg Shortfall	—	−709,800	**−1,132,290**	−430,560	Eggs/qtr

Source: PT RHA internal operational records

This data show that Hen-Day Production dropped from a base level of 83.5% to a low of 57.1% in the Q2-2023, a decline of 26.4 percentage points. Daily egg production fell from 33,400 to 21,013 eggs. The cumulative egg deficit over two quarters affected by this failure exceeded 1.84 million eggs. The mortality rate reached 0.39% per day, nearly ten times the normal rate and resulting in the loss of 1.404 birds in Q2-2023 alone. The feed conversion ratio worsened from 2.12 to 2.76 simultaneously, creating a double pressure of higher feed costs per unit of production just as total production fell sharply.

Cost of Failure: Quantifying the Damage

The Cost of Failure framework coverts the production performance gaps into comprehensive financial values, capturing both direct losses reflected in income statements and the indirect costs that accumulates because of the crisis. Without these comprehensive measures, farms cannot make evidence-based investment decisions regarding prevention efforts, as the business viability of each intervention must be evaluated based on the total cost

of the problem being treated, not just the portion of that cost listed in standard accounting records.

The CoF formula is:

CoF = Direct Failure Costs + Indirect Failure Costs

Table 2. Cost of Failure Estimation PT RHA, Q1 and Q2 2023

Cost Component	Q1-2023 (IDR)	Q2-2023 (IDR)
Direct Costs	**Rp 397,300,000**	**Rp 652,700,000**
Lost egg revenue	Rp 284,000,000	Rp 453,000,000
Bird mortality replacement	Rp 79,200,000	Rp 140,400,000
Downgraded egg losses	Rp 34,100,000	Rp 59,300,000
Indirect Costs	**Rp 197,700,000**	**Rp 287,500,000**
Emergency veterinary & diagnostic	Rp 51,200,000	Rp 64,500,000
Medication & biosecurity supplies	Rp 38,400,000	Rp 56,100,000
Feed conversion inefficiency loss	Rp 65,800,000	Rp 104,200,000
Emergency financing (informal 24%/yr)	Rp 24,300,000	Rp 38,700,000
Additional labour	Rp 18,000,000	Rp 24,000,000
TOTAL CoF	**Rp 595,000,000**	**Rp 940,200,000**

Source: PT RHA operational records. Egg price: Rp. 1.800/egg; pullet replacement: Rp 100,000/bird; informal leading rate: approximately 24% per year. Methodology follows Juran and Godfrey (1999) and Hardaker et al (2015).

This calculation show that total Cost of Failure amounted to Rp 1,535,200,000. Direct cost accounted for 68% of the total, dominated by a loss of egg revenue amounting to Rp 737 million. Indirect cost contributed 32% with the most diagnostically significant item being Rp 63 million paid as interest on emergency loans at an interest rate of approximately 24% per year. This table represents the financial cost of structural unpreparedness, that is money paid not because of the disease itself, but due to lack of cash reserves to cover the revenue shortfall without having to rely on high-cost informal credit. The fact that Failure Cost in the second quarter were 58% higher than in the first quarter even though the farm had already experienced an initial failure in Q1 provides that the most compelling financial argument for preventive action rather that reactive management, as leaving the root cause untreated will worsen losses with each passing quarter.

VaR and RAROC: Risk Exposure and Return Assessment

Value at Risk provides the forward-looking dimension of the risk analysis, estimating the probability distribution of future losses rather than measuring historical losses already incurred. Three normality tests were applied to the Net Cash Flow distribution. The Shapiro-Wilk test (W = 0.6242, p below 0.001), Jarque-Bera test (JB = 30.89, p below 0.001), and Kolmogorov-Smirnov test (D = 0.3290, p below 0.001) all decisively reject normality. The

distribution is left-skewed with a heavy tail, consistent with the heavy-tailed farm distribution income distribution documented by Odening and Hinrichs (2003). Therefore, the primary method to be used is Monte Carlo simulation using the student's t-distribution with 5 degrees of freedom. The VaR formula:

$$\mathbf{VaR(\alpha) = inf\{ l \in \mathbb{R} : P(Loss > l) \leq 1 - \alpha \}}$$

$$\mathbf{CVaR(\alpha) = E[Loss \mid Loss > VaR(\alpha)]}$$

Source: Jorion, P. (2007). Value at Risk: The New Benchmark for Managing Financial Risk. McGraw-Hill.

Table 3. VaR and CVaR Results

VaR Metric	CL 90%	CL 95%	CL 99%
NCF Historical Simulation VaR	Rp 198.0M	Rp 230.5M	Rp 300.7M
NCF Monte Carlo VaR (fat-tail)	Rp 117.6M	Rp 188.9M	Rp 377.7M
NCF Monte Carlo CVaR (Exp. Shortfall)	Rp 231.1M	Rp 313.2M	**Rp 350 M ★**
HDP Production Alert Threshold	~72% HDP	~62% HDP	~40% HDP

Source: Historical Simulation, Parametric, and Monte Carlo VaR computed from 48-month NCF dataset. References: Jorion (2007); Odening and Hinrichs (2003); Bell et al. (2021).

The analysis shows that, based on a Monte Carlo simulation, PT RHA should maintain a reserve fund of at least IDR 350,000,000 as an emergency reserve to protect the farm from financial crises. This figure represents the worst-case scenario for losses the farm could face in extreme circumstances. This figure directly determines the size of the emergency fund recommended for Strategy A3.

The analysis also generates an early warning trigger for the farm: when Daily Chicken Production (HDP) drops by 62%, the farm should treat this as an orange alert and immediately act. This threshold is integrated into the A2 monitoring dashboard. Together, these two results demonstrate how risk analysis has shifted from abstract statistics to a concrete, everyday management tool: one tells managers how much cash to set aside, and the other tells them exactly when to sound the alarm (Bell et al., 2021). The RAROC formula:

$$\mathbf{RAROC = RANI \div Economic\ Capital\ (EC)}$$

$$\mathbf{RANI = Annual\ Operating\ Profit - Expected\ Annual\ Loss\ (CoF)}$$

$$\mathbf{Economic\ Capital\ (EC) = Annualised\ 99\%\ Monte\ Carlo\ VaR}$$

Source: Crouhy, Galai & Mark (2014). The Essentials of Risk Management.

Table 4. RAROC Analysis Baseline versus A1 and All Alternatives.

RAROC Component	Baseline (Current)	Under A1 (Preventive)
Annual Operating Profit	Rp 2,180M	Rp 2,640M
Expected Annual Loss (Cost of Failure)	Rp 1,535M	Rp 798M
Risk-Adjusted Net Income (Profit minus Loss)	Rp 645M	Rp 1,842M
Economic Capital (99% Monte Carlo VaR x 8)	Rp 3,008M	Rp 1,812M
RAROC = Risk-Adjusted Net Income divided by Economic Capital	26.8%	127.1%
RAROC Comparison -- All Alternatives	Baseline: 26.8%	A1: 127.1%| A2: 80.0% | A3: 66.6%

Source: RAROC computed from Cost of Failure estimates and Value at Risk results. Methodology: Crouhy, Galai and Mark (2014). RAROC under A2 and A3 computed separately using alternative-specific loss reduction estimates.

Baseline RAROC = 26.8%, confirming a critically weak risk-return position in which the expected annual CoF consumes 70% of operating profit. Under preventive strategy, Risk-Adjusted Return on Capital improves to 127.1%, a gain of 80.3 percentage points that represents the highest improvement of any alternative, far exceeding the 24% informal lending rate benchmark and delivering returns that are commensurate with the risk the investment addresses. A2 delivers 80.0% and A3 delivers 66.6%, both substantially improved over the baseline and above the cost-of-capital benchmark, but significantly below A1.

AHP Results: Criteria Weights and Strategy Ranking

The Analytic Hierarchy Process is the primary decision-making instrument of this research and the analytical highlight of this chapter. Cost of Failure, Value at Risk, and Risk-Adjusted Return on Capital were designed to generate the quantitative evidence base that this AHP requires. The AHP now synthesises that financial evidence with the structured expert judgments of eight PT RHA stakeholders to produce a single, defensible strategy priority ranking.

Table 5. Aggregated Pairwise Comparison Matrix and Criteria Weight

Code	Criterion	Weight	Evidence Basis
C1	**Failure Probability Reduction**	**44.0%**	CoF shows 68% of Rp 1.54B in losses are directly preventable; all 8 stakeholders unanimously ranked prevention as top priority
C2	**Financial Loss Reduction**	**26.6%**	Rp 63M informal loan interest demonstrates the financial cost of unpreparedness; total CoF of Rp 1.54B drives C2 weight
C3	**Speed & Effectiveness of Response**	**15.2%**	Absence of early warning allowed both 2021 and 2023 failures to escalate undetected; VaR-derived HDP thresholds operationalise C3
C4	**Implementation Feasibility**	**8.9%**	Resource constraints at PT RHA require strategies feasible within existing budget and staff capability
C5	**Recovery & Adaptive Capacity**	**5.4%**	CVaR 99% = Rp 350 M establishes the quantitative target for financial reserve capacity
CR = 0.0099 ✓ (<0.10)	**λmax = 5.0437**	All consistency checks passed — judgments are logically consistent (Saaty, 2008)	

Source: AHP questionnaire, Part A, geometric mean of 8 respondents. CR = 0.0099 < 0.10 (Saaty, 2008)

The calculated weights confirmed clear and consistent stakeholder priorities. C1, Failure Prevention, received the highest weighting of 44.0%, followed by C2 Financial Loss

Reduction at 26.6%, C3 Response Speed at 15.2%, C4 Feasibility at 8.9%, and C5 Recovery at 5.4%. The Consistency Ratio of 0.0099, well below the 0.10 threshold, demonstrated logical consistency across the assessment suite. C1's weighting of 44.0% directly reflects the Cost of Failure finding that 68% of the Rp 1.54 billion loss was caused by preventable production failures. Respondents who were briefed on this evidence uniformly ranked prevention as the highest priority, demonstrating the importance of evidence-based AHP because the presence of financial evidence transforms expert intuition into consistent and quantitatively justified criterion weights.

Table 6. AHP Final Priority Ranking.

Rank	Strategy Alternative	Composite Score	Percentage	Key Justification
1st	**A1 Preventive and Risk Elimination**	**0.4843**	48.4%	Highest score on C1 (0.7416, weight 44.0%). Directly eliminates all 3 root causes of 2023 failure. RAROC: +80.3 pp to 101.7%. Prevents Rp 1.54B in total Cost of Failure. All 8 respondents confirm prevention as top priority (CR = 0.0099).
2nd	**A2 Monitoring and Control Optimisation**	**0.2594**	25.9%	Strongest on C3 response speed (0.6479) and C4 feasibility (0.5357). Best early-warning capability via Hen-Day Production dashboard. Conditional: implement after A1 is operational.
3rd	**A3 Financial Resilience and Recovery**	**0.2563**	25.6%	Strongest on C5 recovery (0.6706). Rp 350M reserve fund eliminates 24% emergency loan cost. Conditional: implement after A1 and A2 are operational and net cash flow is positive for 3 or more quarters.

The AHP results show a clear answer for the winner which is the best alternative for PT RHA, namely A1, Risk Prevention and Elimination Strategy is determined as the optimal mitigation strategy for PT RHA with a composite score of 0.4843, representing 48.4% of the total priority weight. A1 dominates because it achieves the highest score on C1, the criterion that has the largest weight of 44.0%, this figure shows the unanimous assessment of all eight stakeholders that preventing failure from occurring at the source is more valuable than any downstream detection or financial absorption mechanism. This result is clearly and strongly validated by all analysis results, namely the AHP expert assessment process, the Risk-Adjusted Return on Capital financial efficiency analysis, and the Cost of Failure loss calculation. The same and consistent results by all these analyses make this the most robust evidence-based decision result that is most suitable and can be implemented by PT RHA management.

Business Solution: A1 Preventive Strategy

The primary and only business solution strongly recommended for PT RHA to immediately implement is A1: Risk Prevention and Elimination Strategy. This is a risk mitigation strategy that must be implemented and prioritized by stakeholders. A1 consists of four integrated actions to address production failures and prevent future recurrence.

Action 1 is Vaccine Cold Chain Standardization, which includes installing certified temperature recording devices in all vaccine storage areas, developing written SOPs governing the entire vaccine handling process, and maintaining weekly compliance check records. The estimated investment required is approximately IDR 35 to 40 million.

Action 2 is Enhanced Biosecurity Protocols, which includes installing entry control points in all laying hen houses, including disinfectant foot washing basins, mandatory guest books, the use of necessary personal protective equipment, and vehicle disinfection lanes. This reduces the potential for pathogen entry, a mechanism confirmed as the primary entry route in both crises. The estimated investment for this action is IDR 80 to 90 million.

Action 3 is a Feed Supplier Quality Audit, which involves quarterly laboratory testing of protein content for each batch received and the procurement of at least two qualified backup suppliers to allow for rapid source substitution. The estimated investment for this activity is IDR 30 to 40 million.

Action 4 is a Structured Staff Training Program, which provides quarterly training for all field staff covering vaccination techniques, cold chain management, biosecurity compliance, and early disease recognition. The estimated investment is IDR 40 to 50 million.

Total investment for A1: IDR 210 million, phased over four months. The difference in AHP scores is crucial: A1's score is 0.4843, which is 87% higher than A2's 0.2594 and 89% higher than A3's 0.2563. This reflects the strong consensus of eight expert respondents covering all functional roles at PT RHA, based on documented financial evidence of Rp 1.54 billion.

5. CONCLUSION

This study demonstrates that integrating CoF, VaR, and RAROC with the Analytic Hierarchy Process yields a strong, evidence based decision-making framework for prioritizing risk mitigation in small-scale layer poultry farms. The framework applied at PT RHA quantifies the total cost of production failure in 2023 at 1.54 billion and uses this evidence as the basis for AHP criterion weights in financial reality, rather than relying entirely on expert opinion.

The AHP analysis, which refers to a paired-comparison questionnaire from eight expert stakeholders and was verified with a CR of 0.0099 < 0.10, identified the Risk Prevention and Elimination Strategy (A1: cold chain standardization, enhanced biosecurity, feed audits, and staff training) as the optimal first intervention with a composite score of 0.4843. These results were independently validated by RAROC analysis, which showed that A1 increased the risk-adjusted return from 21.4% (very weak) to 101.7%. The conditional recommendations provide a sequential decision path for further investment A2 (Monitoring & Control, IDR 95 million) as the second layer after A1 is operational, and A3 (Financial Resilience with a reserve fund of IDR 350 million and an investment of IDR 175 million) as the third layer after sustainable positive cash flow is achieved.

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