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Risk Perception Management and Development Challenges in Micro and Small-Scale Dairy Cattle Farming in West Java

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ABSTRACT

This study addresses the increasing risks faced by dairy farming systems, driven by climate change, supply chain disruptions, price volatility, and productivity constraints. It examines the differences in risk perception, business development challenges, and financing scheme intentions among micro and small-scale dairy farmers. A cross-sectional survey was conducted using convenience sampling involving 200 dairy farmers from Bogor (46 micro and 52 small farms) and Bandung (67 micro and 35 small farms) in Indonesia. Risk perception was measured using Likert scales and analyzed using a risk matrix approach to generate risk priority numbers. Differences across farmer segments were assessed using the Kruskal–Wallis test. Business development challenges were assessed using the Friedman ranking and post hoc Wilcoxon tests, while financing intentions were analyzed using multinomial logistic regression. The findings revealed that the most critical risks across all segments were feed price increases, climate change, and infectious diseases (including mastitis). Significant differences in risk perception were observed for the following six variables: feed price, heifer procurement, input availability, milk market absorption, production (mastitis) and infection (foot and mouth disease, bovine viral diarrhoea) disease risk. Despite variations in challenge prioritization, capital constraints and heifer availability consistently appear to be primary barriers to business expansion. Farmers showed optimism regarding prospects (86%), yet face structural limitations in scaling their operations. Financing intentions showed moderate interest in affordable credit (56%), profit-sharing schemes (51.5%), and livestock insurance (65.5%). The multinomial logistic regression results indicate that insurance intention, age, and sex significantly influence financing preferences. This study contributes to the literature by integrating risk matrix analysis, challenge prioritization, and financing behavior modeling to reveal heterogeneous risk perceptions and financial preferences among smallholder dairy farmers in tropical contexts.

Keywords: business development challenges; business scale; financing behavior; livestock insurance; risk perception

INTRODUCTION

Micro and small-scale dairy farming systems face increasingly complex risks, along with limited access to financial resources, which constrain business development. At the national level, domestic milk production currently satisfies only approximately 22% of the total milk demand, and projections indicate a slight annual decline of approximately 0.17% between 2022 and 2026 (MOA, 2022). This trend poses considerable challenges to food security and highlights the urgency of improving dairy sector productivity.

Food security remains a global priority and is defined as the condition in which all individuals have consistent physical and economic access to sufficient, safe, and nutritious foods to support an active and healthy life (Peng & Berry, 2019; Pérez-Escamilla, 2024). It is commonly conceptualized using four pillars: availability, access, utilization, and stability (FAO, 2006). Milk plays a strategic role as a source of animal protein. Therefore, enhancing domestic milk production is essential. However, government initiatives, such as increasing cattle populations through large-scale imports, introduce additional risks that necessitate effective mitigation strategies, including collaboration with smallholder farmers and cooperatives.

Agricultural risks in dairy farming can be broadly categorized into environmental, price, supply, and quality risks (Marimin & Maghfiroh, 2010). Environmental risks are particularly critical because climate change directly affects feed availability, feed quality, livestock health, and productivity (Astuti *et al*., 2024; Gauly & Ammer, 2020; Igbal *et al*., 2024). Empirical studies indicate that heat stress can reduce milk yield

by up to 13% and negatively affect milk composition (Zolotarov *et al*., 2023), with projected productivity losses reaching 30% by 2050 (Hutchins *et al*., 2025). In addition, disease outbreaks of foot-and-mouth disease (FMD), lumpy skin disease (LSD), bovine viral diarrhea (BVD), and mastitis continue to pose serious threats to livestock systems. In Indonesia, FMD is expected to have a significant impact in 2022 (Asmara *et al*., 2025).

Price risks arise from fluctuations in input and output markets, including feed, milk, and heifer procurement costs. High input and unstable output prices can significantly reduce farm profitability, potentially leading farmers to exit dairy production. Low milk prices can lead to the sale of dairy cattle for beef production (Gazzarin *et al*., 2025).

Supply risks are associated with the availability of critical inputs, such as breeding stock, feed, and veterinary services. Quality risks are related to the failure of milk products to meet market standards, affecting their acceptance by processors and cooperatives. Artificial insemination programs in Indonesia, as part of the heifer supply efforts, have been considered successful in reducing beef imports (Firman *et al*., 2023).

In addition to risk exposure, dairy farmers face financial and non-financial constraints in business development. Although limited access to capital remains a dominant issue (Lamkowsky *et al*., 2024), challenges related to feed, labor, stalls, and breeding stock are equally important. Moreover, farmers' readiness to anticipate risks determines the sustainability of their livestock businesses (Shantharaju *et al*., 2024). Previous studies have examined risk perception (Roessali *et al*., 2022), constraints (Kallioniemi *et al*., 2024; Karki *et al*., 2025), and investment behavior in dairy farming (Fertő *et al*., 2021); however, they often treat farmers as a homogeneous group and overlook differences across business scales and geographic contexts.

This study addresses this gap by investigating how micro and small-scale dairy farmers in Bogor and Bandung differ in their (1) risk perceptions, (2) development challenge priorities, and (3) intentions toward financing and insurance instruments. By incorporating segmentation based on scale and location, this study provides a more nuanced understanding of the heterogeneity in risk and financial behavior.

We tested three hypotheses: (1) Risk perceptions differ significantly across locations (Bogor vs. Bandung) and farm scales (micro vs. small). Specifically, environmental and feed risks are high in Bandung and among micro-scale farmers, price risk is low in Bandung, and quality risk is low among small-scale farmers, whereas veterinary input risks (medicines, vitamins, and vaccines) do not differ significantly owing to cooperative support. (2) The ranking of business development challenges differs significantly across locations and farm scales. Capital was the primary priority across all segments following the FMD outbreak, whereas stalls had the lowest priority. Feed-related challenges are high in Bandung, and among micro-scale farmers, labor constraints are low on micro-scale farms, and partnership-based herd expansion schemes are more workable for small-scale farmers. (3) Farmers' intentions toward financial schemes differ significantly based on their sociodemographic and behavioral characteristics. Younger, female, and more educated farmers are more likely to prefer credit- and profit-sharing schemes. Small-scale farmers prefer affordable credit, whereas micros-cale farmers prefer profit-sharing. Farmers in Bogor prefer profit sharing, whereas those in Bandung prefer credit and insurance. High income and financial literacy increase the likelihood of choosing credit, whereas risk aversion reduces preference for external financing. Farmers with insurance intentions are more likely to adopt credit schemes.

These findings are expected to inform policymakers, cooperatives, and financial institutions in designing targeted risk management and financing programs. This study contributes to the literature by integrating risk assessment, challenge prioritization, and financing intention modeling, thereby offering new empirical evidence on the diversity of decision-making among smallholder dairy farmers in tropical regions.

METHODS

Data Collection

This study employed a cross-sectional quantitative design. Respondents were micro and small-scale dairy farmers affiliated with cooperatives or livestock associations in Bogor and Bandung, Indonesia. Bogor and Bandung were chosen based on their natural factors, history, and the development of collection and processing infrastructure that supports dairy cattle development. The estimated number of national dairy cows is 485,000, with the total number of cows in West Java reaching 99,000 (20%) (BPS, 2025). There are 16 primary dairy milk cooperatives in West Java that are members of the Indonesian Milk Cooperative Association (GKSI) and equipped with milk processing units.

Farm size was classified according to Ministerial Regulation No. 14/2020, which categorizes farms with fewer than five lactating cows as microscale, those with 5–45 lactating cows as small scale, 46–850 lactating cows as medium scale, and >850 lactating cows as large scale. In this study, micro-scale (<5 lactating cows) and small-scale (≥5 lactating cows) farms were categorized.

A purposive sampling approach was applied to ensure representation across locations and business scales. A total of 200 respondents were distributed across four segments: Bogor Micro (BOM; n = 46), Bogor Small (BOS; n = 52), Bandung Micro (BAM; n = 67), and Bandung Small (BAS; n = 35).

Data were collected between May and August 2025 through face-to-face interviews using structured questionnaires administered by trained enumerators. The questionnaire included sections on demographic characteristics, risk perception, financial literacy, and risk propensity. Financial literacy was assessed using an adapted OECD framework (OECD, 2022), whereas risk propensity was measured using a scale developed by Meertens and Lion (2008). Ethical approval was

obtained from the Ethics Committee of IPB University (No. 1662/IT3.KEPMSM-IPB/SK/2025), and informed consent was obtained from all participants.

Data Analysis

This study focuses on three main outcomes: (1) risk priority number (RPN), (2) ranking of business development challenges, and (3) intention toward financing schemes. Risk perception was evaluated using two dimensions, frequency (occurrence) and impact (severity), each measured on a five-point Likert scale. The RPN was calculated as the product of occurrence and severity, adapted from Hopkin (2017). High RPN values indicate a high perceived risk.

Risk variables were grouped into four categories: environmental, price, supply, and quality. The analysis included 14 specific risk variables: the impact of climate change (R1), security/theft (R2), livestock deaths (R3), high heifer price (R4), low milk selling price (R5), high feed prices (R6), feeding shortages (R7), difficulty in procuring heifers (R8), difficulty in procuring medicines, vitamins, and vaccines (R9), low quantity (amount) of milk (R10), quality of milk (R11), milk not absorbed/ purchased (R12), production disease (mastitis) (R13), and environmental infectious diseases (FMD) (R14)

The questionnaire related to risk perception was evaluated for validity and reliability. Content validity was evaluated by experts, and internal consistency reliability was evaluated using Cronbach's alpha (Taherdoost, 2016). Two experts in risk management and agribusiness evaluated the questionnaire's content validity. Reliability testing using Cronbach's alpha revealed coefficients of 0.704 and 0.908 for the occurrence and severity scales, respectively, indicating good internal consistency. Missing data points were replaced with mean integer values.

Given that RPN data are ordinal and not fully homogeneous, differences across segments were evaluated using the nonparametric Kruskal–Wallis test. Risk visualization was conducted using a risk matrix processed using Microsoft Excel for Microsoft 365 MSO (Version 2509 Build 16.0.19231.20138) 64-bit. Business development challenges (capital, feed, labor, stalls, and heifers) were analyzed using the Friedman test to identify ranking differences, followed by a post hoc Wilcoxon test.

Financing intentions, categorized as no intention, profit-sharing, credit, or a combination of both, were analyzed using multinomial logistic regression. The model estimates the probability of selecting each financing option relative to the reference category (no external financing). Multinomial regression was applied to test preferences for financial schemes using IBM® SPSS® Statistics Version 25. The basic model refers to Agresti (2013): multinomial regression $\pi_j(x) = P(Y=j \mid x)$ with $\sum_j \pi_j(x) = 1$, and the J categories of Y as a multinomial variate with probabilities ($\pi_1(x), \ldots \pi_j(x)$), as follows, and the proposed variables are presented in Table 1.

$$Log \frac{\pi_j(x)}{\pi_J(x)} = \alpha_j + \beta_j^T \quad J = 1, J-1$$

Where: $\pi_j(x)$ is the probability of choosing a financing option j; $\pi_J(x)$ is the probability of the reference category j (no external financing); α_j is the intercept for the category j; β_j^T is the vector of regression coefficients (weights) for category j, which determines the effect of the independent variables on the odds.

RESULTS

Respondent Characteristics

The results of the chi-square test indicate that demographic characteristics are similar across the four segments, with no significant differences in age, education, financial literacy, or risk propensity. Most dairy farmers had low levels of education (up to junior high school; average 71%) and limited financial literacy (less literate average 38% and non-literate average 29%), while the majority exhibited risk-taking behaviors (average 71.5%; Table 2).

A notable exception is sex composition: Bandung microscale farmers are predominantly female, whereas the other segments are male-dominated (61.2%). This suggests a sex-specific role distribution in small-scale dairy operations.

Most farmers (86%) expressed optimism about the future of dairy farming. However, financing preferences varied across segments. While the overall differences across segments were not statistically significant, Bogor

Table 1. Multinomial logit variables for financial scheme preferences

Variables	Description
Dependent variables	
Y	0 = no intention for external funding; 1 = intention for profit sharing; 2 = intention for credit; 3 = intention for both profit sharing and credit
Independent variables	
X1 Age	0 = <= 40 years; 1 = > 40 years
X2 Sex	0 = man 1 = woman
X3 Education	0 = low (until junior high school); 1 = high (higher than junior high school)
X4 Business scale	0 = micro; 1 = small
X5 Location	0 = Bogor; 1 = Bandung
X6 Intention to insurance	0 = no intention; 1 = intention
X7 Financial literacy	1 = illiterate; 2 = less literate; 3 = sufficient; 4 = well literate
X8 Risk propensity	0 = risk avoider; 1 = risk taker

farmers showed a stronger inclination toward profit-sharing schemes (chi-square test, p = 0.001), whereas Bandung farmers demonstrated relatively higher interest in insurance.

Based on a comparison between the average number of lactating cows and the total number of cows, the most productive segments were BAS (66%), BOS (62%), BAM (59%), and BOM (24%). Bandung (both micro and small-scale segments) is more productive and stable than Bogor in terms of price volatility. However, BAM is more vulnerable in terms of margin (revenue–cost; Table 3).

Risk Analysis

Across all segments, the three highest-perceived risks were feed price increases (11.64), climate change (8.76), and infectious diseases (7.00; Table 4). Feed price risk is characterized by both high frequency and high impact, making it the most critical concern. Climate change is perceived as frequent but moderately impactful, whereas infectious diseases are perceived as less frequent but highly severe. Risk visualization was conducted using scatterplots of occurrence and severity and grouped into three categories: high, medium, and low risk (Figure 1).

Table 2. Characteristics of dairy farmers in Bogor micro, Bogor small, Bandung micro, and Bandung small segments

Variables	Bogor micro (n=46), s(%)	Bogor small (n=52), s(%)	Bandung micro (n=67), s(%)	Bandung small (n=35), s(%)	Total (n=200), s(%)	Chi-square test
Age						
<= 40 years	20 (43.5)	24 (46.2)	37 (55.2)	13 (37.1)	94 (47)	0.33
> 40 years	26 (56.5)	28 (53.8)	30 (44.8)	22 (62.9)	106 (53)	
Sex						
Man	38 (82.6)	43 (82.7)	26 (38.8)	19 (54.3)	126(63)	0**
Woman	8 (17.4)	9 (17.3)	41 (61.2)	16 (45.7)	74 (37)	
Education						
Until junior high school	30 (65.2)	33 (63.5)	55 (82.1)	24 (68.6)	142 (71)	0.09
Higher than junior high school	16 (34.8)	19 (36.5)	12 (17.9)	11 (31.4)	58 (29)	
Financial literacy						
Illiterate	14 (30.4)	20 (38.5)	19 (28.4)	5 (14.3)	58 (29)	
Less literate	21 (45.7)	15 (28.8)	26 (38.8)	14 (40)	76 (38)	0.167
Sufficient	9 (19.6)	12 (23.1)	19 (28.4)	10 (28.6)	50 (25)	
Well literate	2 (4.3)	5 (9.6)	3 (4.5)	6 (17.1)	16 (8)	
Risk propensity						
Risk averse	8 (17.4)	14(26.9)	26 (38.8)	9 (25.7)	57 (28.5)	0.09
Risk taker	38 (82.6)	38 (73.1)	41 (61.2)	26 (74.3)	143 (71.5)	
Insurance intention						
No intention	13 (28.3)	22 (42.3)	23 (34.3)	11 (31.4)	69 (34.5)	0.50
Intention	33 (71.7)	30 (57.7)	44 (65.7)	24 (68.6)	131 (65.5)	
Livestock death experience						
Never	9 (19.6)	8 1(5.4)	12 (17.9)	2(5.7)	31 (15.5)	0.33
Once	37 (80.4)	44 (84.6)	55 (82.1)	33 (94.3)	169 (84.5)	
Livestock theft						
Never	45 (97.8)	52 (100)	61 (91)	35 (100)	193 (96.5)	0.03*
Once	1 (2.2)	0 (0)	6 (9)	0 (0)	7 (3.5)	
Dairy farming prospects						
Better	42 (91.3)	44 (84.6)	56(83.6)	30(85.7)	172(86)	0.33
Same or worse	4(8,7)	8(15.4)	11(16.4)	5(14.3)	28(14)	
Financing intention (1)						
Profit-sharing						
No intention	18 (39.1)	16 (30.8)	43 (64.2)	20 (57.1)	97 (48.5)	0.001**
Intention	28 (60.9)	36 (69.2)	24 (35.8)	15 (42.9)	103 (51.5)	
Credit						
No intention	18 (39.1)	21 (40.4)	32 (47.8)	17 (48.6)	88 (44)	0.71
Intention	28 (60.9)	31 (59.6)	35 (52.2)	18 (51.4)	112 (56)	
Financing intention (2)						
No intention	13 (28.3)	13 (25)	22 (32.8)	12 (34.3)	60 (30)	
Profit-sharing	5 (10.9)	8 (15.4)	11 (16.4)	4 (11.42)	28 (14)	0.92
Credit	7 (15.2)	12 (23.1)	12 (17.9)	6 (17.1)	37 (18.5)	
Profit-sharing and credit	21 (45.7)	19 (36.5)	22 (32.8)	13 (37.1)	75 (37.5)	

Note: **Sig. (p<0.01), *Sig. (p<0.05), Financing (2) was used as a dependent variable in the multinomial logistic regression.

Table 3. Productivity and milk price volatility in Bogor micro, Bogor small, Bandung micro, and Bandung small segments

Variables	Bogor micro (n=46)		Bogor small (n=52)		Bandung micro (n=67)		Bandung small (n= 35)	
	Mean	St.Dev	Mean	St.Dev	Mean	St.Dev	Mean	St.Dev
Number of cows (head)	8.4	6.4	23.5	33.6	3.9	2.3	11.4	7.5
Number of lactating cows (head)	2.0	1.2	14.5	16.0	2.3	1.0	7.5	3.5
Maximal quantity of milk (Liter/head/day)	18.1	5.6	19.4	8.9	20.2	5.7	20.4	5.2
Average quantity of milk (Liter/head/day)	13.3	4.8	11.5	4.2	15.5	5.2	15.3	3.8
Minimal quantity of milk (Liter/head/day)	8.5	4.7	6.0	3.8	9.3	5.0	9.1	4.8
Maximal price of milk (IDR/Liter)	9142	2453	8577	1294	8424	2342	7711	885
Average price of milk (IDR/Liter)	7800	1475	7675	825	7673	1257	7263	451
Minimum price of milk (IDR/Liter)	6833	863	7043	1041	7167	714	6977	747
Average revenue (IDR million/month)	3.85	3.21	7.53	12.30	3.88	3.77	8.40	7.01
Average cost (IDR Million /Month)	2.93	1.15	5.72	9.20	3.60	1.97	5.19	3.25

Note: IDR (Indonesian Rupiah).

Table 4. Average values of occurrence (O), severity (S), and risk priority number (RPN) for 14 risk variables (R1–R14), and results of the Kruskal–Wallis H test for differences in RPN across Bogor micro (n=46), Bogor small (52), Bandung micro (67), and Bandung small (n=35) segments

No	Variables	Overall			BOM			BOS			BAM			BAS			Diff. Test	
		O	S	RPN	O	S	RPN	O	S	RPN	O	S	RPN	O	S	RPN	Kruskal–Wallis	Asymp. Sig
R1	Impact of climate change	3.20	2.74	8.76	2.89	2.63	7.61	3.42	2.63	8.99	3.13	2.73	8.56	3.40	3.06	10.39	7.12	0.068
R2	Security/theft	1.07	1.78	1.89	1.07	1.78	1.90	1.08	1.51	1.63	1.07	1.72	1.84	1.03	2.29	2.35	6.59	0.086
R3	Livestock deaths	1.94	2.99	5.81	1.67	2.91	4.88	1.92	2.96	5.69	2.07	2.94	6.10	2.06	3.26	6.70	5.22	0.157
R4	High heifers' price	2.72	2.51	6.82	2.65	2.61	6.92	2.60	2.16	5.60	2.90	2.42	7.00	2.66	3.06	8.12	4.97	0.173
R5	Low milk selling price	1.94	2.19	4.23	2.22	2.28	5.06	1.79	2.10	3.75	2.01	2.10	4.24	1.63	2.34	3.82	2.59	0.459
R6	High feed prices	3.59	3.25	11.64	3.37	3.15	10.62	3.37	2.84	9.57	4.04	3.49	14.13	3.31	3.49	11.55	11.54	0.009**
R7	Feeding scarcity	2.53	2.58	6.51	2.28	2.50	5.71	2.33	2.31	5.38	2.85	2.67	7.62	2.51	2.89	7.26	6.92	0.074
R8	Heifers procuring difficulty	1.74	1.87	3.25	1.76	2.02	3.56	1.52	1.63	2.47	1.67	1.75	2.92	2.17	2.26	4.90	14.92	0.002**
R9	Medicines/vitamins/vaccines procuring	1.12	1.65	1.84	1.11	1.80	2.00	1.13	1.49	1.69	1.07	1.51	1.62	1.17	1.94	.28	8.06	0.045*
R10	Quantity (amount) of milk is less	2.58	2.59	6.66	2.63	2.78	7.32	2.56	2.45	6.27	2.54	2.30	5.83	2.60	3.09	8.02	3.35	0.340
R11	Quality of milk is below standard	1.85	2.08	3.84	1.91	2.22	4.24	1.79	1.82	3.26	1.81	2.06	3.72	1.91	2.31	4.43	2.54	0.468
R12	Milk not absorbed/purchased	1.10	1.69	1.85	1.33	1.83	2.42	1.10	1.51	1.65	1.00	1.48	1.48	1.00	2.14	2.14	10.10	0.018*
R13	Production disease (Mastitis)	2.11	2.44	5.14	2.09	2.43	5.08	2.06	2.06	4.24	2.01	2.36	4.75	2.37	3.17	7.52	13.56	0.004**
R14	Environmental infectious diseases (FMD, LSD, BVD)	1.70	4.13	7.00	1.48	3.54	5.24	2.00	3.47	6.94	1.55	4.70	7.30	1.80	4.77	8.59	15.14	0.002**

Note: BOM (Bogor micro), BOS (Bogor small), BAM (Bandung micro), BAS (Bandung small) **Sig. (p<0.01), *Sig. (p<0.05).

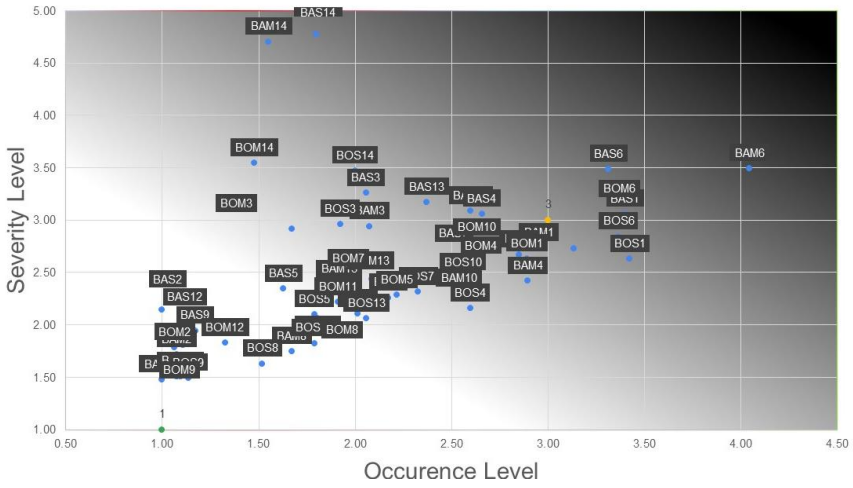

Figure 1. Risk map of 14 risk variables in Bogor micro, Bogor small, Bandung micro, and Bandung small segments of dairy farmers based on occurrence and severity levels. Note: Dark color = high risk; intermediate shading = medium risk; light color = low risk. BOM (Bogor micro), BOS (Bogor small), BAM (Bandung micro), BAS (Bandung small). Risks: (1) Impact of climate/weather change; (2) security/theft; (3) livestock death; (4) heifer price; (5) low selling price of milk; (6) feed price; (7) feed shortage; (8) heifer procurement; (9) procurement of medicines, vitamins, and vaccines; (10) low quantity (amount) of milk; (11) below-standard milk quality; (12) milk not absorbed/purchased; (13) production diseases (mastitis); (14) environmental infectious diseases (foot-and-mouth disease, lumpy skin disease, BVD).

High risk. Variables that fall into the high-risk category include infectious diseases R14 (BAS14, BAM14, BOM14, and BOS14), feed prices R6 (BAM6, BAS6, BOM6, and BOS6), and climate change R1 (BOM1, BAM1, BAS1, and BOS1).

Medium and low risk. Several variables with a moderate risk of occurrence and severity have the potential to become high risk, such as livestock deaths (BOM3, BOS3, BAM3, and BAS3), which, although rare, have a major impact on livestock businesses, as well as high purchase prices for heifers (BOM4, BOS4, BAM4, and BAS4), feeding shortages (BAM7 and BAS7), low milk quantity (BAS10 and BOM10), and production diseases (BAS13). Low-risk factors included security/theft (R2), low milk-selling prices (R5), difficulty in procuring heifers (R8), difficulty in procuring medicines, vitamins, and vaccines (R9), the risk of milk not being purchased (R12), and below-standard milk quality (R11).

Segment-specific differences revealed that Bandung farmers exhibited high overall perceived risks, particularly for feed prices and disease-related variables. Microscale farmers in Bandung are particularly vulnerable because of their dependence on purchased feed and limited land availability. Statistical testing confirmed significant differences across six risk variables: feed prices (R6), heifer procurement (R8), procurement of medicines, vitamins, and vaccines (R9), milk market absorption (R12), and disease risks—production (mastitis) (R13) and infection (FMD; R14; Figure 2).

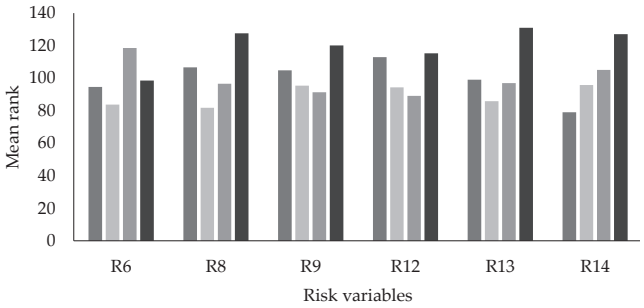

Figure 2. Comparison of significant differences in mean ranks of six risk perception variables among Bogor micro (n=46), Bogor small (n=52), Bandung micro (n=67), and Bandung small (n=35) segments. Note: R6 (Feed prices), R8 (Heifers procuring difficulty), R9 (Medicines/ vitamins/ vaccines procuring difficulties), R12 (The quality of milk is below standard), R13 (Milk not absorbed/purchased), R14 (Production disease (Mastitis). ■ Bogor micro; ■ Bogor small; ■ Bandung micro; ■ Bandung small.

Business Development Challenges

Based on the Friedman and post hoc Wilcoxon tests, the ranking analysis shows that business development constraints differ across segments, although a consistent pattern emerges (Table 5). Capital and heifer availability were the top priorities across all groups, indicating structural constraints on herd expansion.

Secondary challenges include labor, feed, and stalls, with variations depending on location and scale. For example, farmers in Bandung face greater constraints on stall expansion owing to limited land. Feed challenges are more pronounced in Bandung because of the country's reliance on external supplies. Overall, farmers prioritized financial capacity as a key enabler of business growth.

Financing Intentions

Farmers showed moderate to high interest in external financing instruments: credit (56%), profit sharing (51.5%), and insurance (65.5%) (Table 2). However, profit sharing is less preferred in the Bandung micro and Bandung small (Figure 3). The multinomial logistic regression results indicate that (1) insurance intention is a strong predictor of financing behavior; farmers who are unwilling to adopt insurance are also less likely to engage in external financing. Profit sharing had a negative influence ($\beta = -1.088$, $p<0.05$); the odds ratio of 0.34 implies that the likelihood of adopting profit-sharing financing decreased by approximately 66% among farmers without insurance intention. Similarly, a combination of profit sharing and credit also had a negative influence ($\beta = -0.943$, $p<0.05$), with an odds ratio of 0.39, suggesting that the probability of adopting both financing instruments decreased by approximately 61% among farmers without insurance intention. (2) Sex significantly influenced profit-sharing adoption, with male farmers more likely to choose this scheme ($\beta = 1.143$, $p<0.10$), and an odds ratio of 3.14 indicating that male farmers were more than three times more likely to adopt profit-sharing financing than female farmers, holding other factors constant. (3) Age marginally but significantly influenced financing options ($\beta = -0.623$, $p<0.10$), indicating that younger farmers may be less likely to adopt combined schemes. (4) Other variables, such as education and financial literacy, were not statistically significant but showed directional tendencies. The model demonstrates moderate explanatory power (Nagelkerke $R^2 = 0.16$), suggesting that additional behavioral or contextual factors may influence financing decisions (Table 6).

Table 5. Priority of business development challenges based on the Friedman test and the Wilcoxon test across Bogor micro (n=46), Bogor small (n=52), Bandung micro (n=67), and Bandung small (n=35) segments

Segment	Priority 1	Priority 2	Priority 3	Priority 4
Bogor micro	Capital	Heifers	Labour	Feed ≈ Stalls
Bogor small	Capital	Heifers ≈ Stalls	Feed ≈ Labor	
Bandung micro	Capital	Heifers ≈ Labor	Stalls	Feed
Bandung small	Capital	Heifers	Feed ≈ Stalls ≈ Labor	

Note: ≈ indicates no difference in ranking priority.

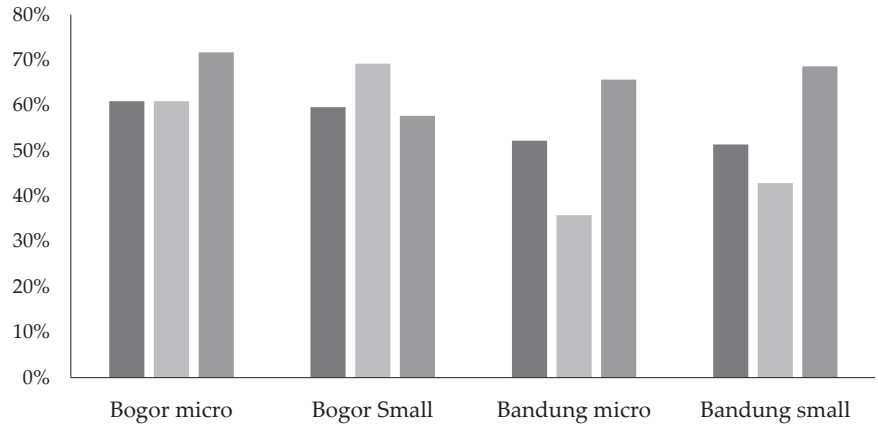

Figure 3. Comparison of financial instrument intentions related to business development among Bogor micro (n=46), Bogor small (n=52), Bandung micro (n=67), and Bandung small (n=35) segments. ■ Intention to Credit; ■ Intention to Profit-sharing; ■ Intention to insurance.

Table 6. Multinomial logistic regression for financing preferences of dairy farmers for profit sharing, credit, and combined financing (n = 200)

Variables	Profit sharing		Credit		Both financing	
	Coef. (SE)	Odds Ratio	Coef. (SE)	Odds Ratio	Coef. (SE)	Odds Ratio
Intercept	-0.47 (1.12)	–	-1.73 (1.03)	–	0.25 (0.83)	–
Financial literacy	-0.16(0.28)	0.86	0.10 (0.24)	1.1	0.19 (0.20)	1.21
Sex (Male)	1.14* (0.58)	3.14	0.41 (0.49)	1.51	0.07 (0.41)	1.07
Age <= 40	0.13 (0.50)	1.14	0.69 (0.44)	2.0	-0.62* (0.38)	0.54
Education (≤ junior high school)	-0.51 (0.53)	0.6	0.59 (0.52)	1.8	0.01 (0.43)	1.01
Insurance intention (No intention)	-1.09** (0.53)	0.34	-0.33 (0.44)	0.72	-0.94** (0.38)	0.39
Location (Bogor)	-0.27 (0.52)	0.76	0.31 (0.49)	1.37	0.42 (0.41)	1.52
Business scale (micro)	-0.02 (0.50)	0.98	-0.31 (0.45)	0.73	0.08 (0.38)	1.09
Risk preference (risk averse)	0.09 (0.52)	1.09	0.43 (0.47)	1.53	-0.49 (0.43)	0.61
Pseudo R^2						
Model fit	Value					
Cox & Snell	0.15					
Nagelkerke	0.16					
McFadden	0.07					

Note: Reference category: No intention of external funding. *p<0.10,**p<0.05,***p<0.01

DISCUSSION

This study provided three main insights. First, the risk perception of dairy farmers was dominated by feed prices, climate change, and infectious diseases. These findings are consistent with those of previous studies highlighting the vulnerability of livestock systems to environmental and market uncertainties. However, this study extends the literature by demonstrating that risk perception varies significantly across segments, particularly between locations and farm scales.

This study reinforces previous research findings that the input value composition of dairy cattle farming for the purchase of concentrate feed reached 90%, which was mostly commercial feed, whereas forage feed that can be grown independently accounted for only 7.8% (Atmakusuma *et al*., 2019). However, milk prices from cooperatives still cover high feed prices. Climate change, particularly during the dry season, affects animal welfare by altering feed availability, livestock health (Cahyadi *et al*., 2019), and milk productivity (Abbas *et al*., 2019). Climate change also increases the risk of disease (Ayal *et al*., 2017).

Risks, such as death and mastitis, are considered rare but can result in losses for farmers. Farmers generally consult or invite veterinarians assigned by cooperatives or government agencies. Milk quantity can be improved by improving feed quality. Feed difficulties can be overcome by sourcing feed from outside the region, which results in high feed prices. Collaborations with the tofu industry are also possible. Dairy heifers are generally the result of existing cattle or those obtained from fellow farmers; therefore, the risk is considered low. Farmers are also careful when adopting heifers or breeding cows from outside, especially regarding the quality and quantity of milk production. Cooperatives and livestock groups manage the availability of medicines, vaccines, and vitamins; therefore, the risk is considered to be low.

The evaluation of risk perception across the four segments revealed differences in six variables. Risk perception of feed prices was highest in the BAM

segment. Meanwhile, the risk perception of five variables—difficulties in procuring heifers, procuring medicines/vitamins/vaccines, milk not absorbed/purchased, production disease (mastitis), and environmental infectious diseases—was high in the BAS segment.

Risk perception may be affected by farmer demographics, although dairy farmers' characteristics were relatively similar to those of previous studies conducted in Central and West Java (Atmakusuma *et al*., 2019; Fadillah *et al*., 2023; Mukson *et al*., 2017). This implies that the younger generation's intention to engage in livestock farming remains limited, as they are generally influenced by their parents and continue farming owing to limited formal job opportunities. Owing to their limited formal education, dairy farmers tend to have low financial literacy and a tendency to take risks in livestock farming.

Another finding was the difference in the sex of farmers. In Bandung, micros-cale farmers are dominated by women, whereas other segments are dominated by men. In an earlier study, without differentiating by scale, men dominated the population in Bandung (Atmakusuma *et al*., 2019). This indicates that different scales can reveal sex roles in livestock farming. The dominance of female farmers among the micro-scale farmers in Bandung is presumably related to the location of the farm, which is generally behind the house, and to inherited businesses that can be managed by daughters without a high level of formal education.

Second, capital and heifer availability were identified as primary constraints on business development. This reflects the structural limitations in smallholder dairy systems, where expansion is constrained not only by financial access but also by input availability and infrastructure. Stall expansion in Bandung is relatively complex because the existing stalls are located in residential areas. Hence, expansion is limited to existing stall capacity, which was partially affected by the FMD outbreak in 2022. In Bogor, diverse locations are associated with limited feed management, resulting in lower output than in Bandung.

Third, financing behavior is heterogeneous and influenced by both demographic and behavioral factors. The strong relation between insurance intention and financing decisions suggests that risk management awareness plays a critical role in shaping financial behavior. The finding that dairy farmers are not interested in insurance suggests that they are also not interested in external funding. This may be caused by extreme liquidity shortages, leading to the rejection of both insurance and financing (because of fear of debt and interest payments) as a common coping strategy for smallholders (Shantharaju *et al*., 2024). They also face challenges owing to lower initial sales (Zawadzka *et al*., 2021). By contrast, in a previous study, dairy farmers who have access to financial institutions can effectively manage various risks (Özsayın, 2023), and credit bundled with insurance can have a significantly higher uptake rate (33%) than that of traditional credit (Ndegwa *et al*., 2020). This shows that Bandung and Bogor dairy farmers face gaps in accessing financial institutions, which affect their perceptions of risk management.

Compared with previous studies that treat farmers as homogeneous, this study highlights the importance of segmentation. For instance, Bandung farmers prioritize risk mitigation (insurance), whereas Bogor farmers prioritize growth-oriented financing (profit sharing). These differences imply that the "one-size-fits-all" policy approach is ineffective.

From a managerial perspective, cooperatives play a crucial role as intermediaries, providing access to loans and grants from other parties, such as the government, NGOs, and CSR initiatives from private companies (Resti *et al*., 2017), as well as insurance (Acharya *et al*., 2024; Geng *et al*., 2023; Zhong *et al*., 2022). They can consolidate feed procurement to reduce costs, facilitate access to financing and insurance, and provide financial literacy programs. From a policy perspective, integrating credit with insurance products (bundling) may increase adoption rates, as suggested by previous research.

CONCLUSION

This study demonstrates that micro and small-scale dairy farmers exhibit significant heterogeneity in risk perceptions, development priorities, and financing intentions. Farmers in Bandung face high operational risks, particularly those related to feed dependence and disease exposure, whereas Bogor farmers focus more on productivity-related concerns. Despite these differences, capital and heifer availability remain the primary constraints across all segments. Financial behavior also differs. Bogor farmers are more inclined toward profit-sharing schemes, whereas Bandung farmers show a stronger interest in insurance as a risk-mitigation strategy. These findings underscore the need for segment-specific policies and financial instruments tailored to local conditions and farmers' characteristics. Integrating risk-management tools with financing schemes can enhance the adoption and sustainability of dairy farming systems.

LIMITATIONS

This study had several limitations. First, risk perception is inherently subjective and may be influenced by recall bias. Second, the findings are limited to two regions with relatively developed dairy infrastructures, which may restrict generalisability. Third, the psychological and sociocultural factors that influence financial behavior were not explicitly examined. Finally, the use of ordinal data necessitated a nonparametric analysis, which may have lower statistical power than parametric approaches.

CONFLICT OF INTEREST

We certify that there are no conflicts of interest related to financial, personal, or other relationships with individuals or organizations associated with the material discussed in the manuscript.

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DECLARATION OF GENERATIVE AI AND AI-ASSISTED TECHNOLOGIES IN THE WRITING PROCESS

The author(s) used Mendeley Reference Manager and Grammarly to improve the accuracy of references and the quality of language during the preparation of this work. After using these tools/services, the author(s) reviewed and edited the content as needed and took full responsibility for the content of the publication.

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