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Risk Behavior of Shallot Farmers in Highland and Lowland Regions of Java, Indonesia

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Abstract: Shallot farming in Indonesia has significant risks, primarily due to production variability and price instability. These risks deter farmers from adopting strategies involving higher risk tolerance levels. Risk aversion varies across individuals, leading to differences in decision-making processes. The study examines income risk levels in shallot farming. It explores farmers' behaviors in response to these risks in two distinct regions: the highlands of Karanganyar Regency, Central Java, and the lowlands of Bantul Regency, Daerah Istimewa Yogyakarta. A total of 200 shallot farmers were randomly selected for structured interviews to assess their risk behavior and the factors influencing it. The analysis reveals that shallot farming entails a high degree of income risk, and the highland areas exhibit a greater coefficient of variation (0.574) compared to the lowlands (0.544). Approximately 65% of highland farmers and 80% of lowland farmers were observed to be risk-averse concerning their shallot farming activities. Key factors influencing risk behavior include land size, household size, farming experience, age, frequency of crop failure, education, income, and farming location. Notably, farming experience, education, household size, and income positively impact risk behavior, increasing farmers' likelihood of adopting risk-taking strategies. The primary source of income risk was production variability, exacerbated by staggered planting schedules. This study highlights the importance of synchronizing planting schedules and strengthening farmer group networks to improve planning, marketing, input procurement, and knowledge exchange. The findings also provide a foundation for policymakers to design regulations that optimize planting times and mitigate income risks in shallot farming.

Keywords: Shallot; Farmers' behavior; Risk; Farming

1. Introduction

Agriculture is a cornerstone of Indonesia's national and regional economies, encompassing crops, horticulture, planting, livestock, and fisheries. Among horticultural crops, shallots are the most extensively cultivated horticultural vegetable crop by farmers in Indonesia and are considered a strategic national commodity (Manik et al., 2023). As a primary condiment in Indonesian cuisine, shallots hold high economic value, making them a key agricultural product (Sigalingging et al., 2023; Wandschneider et al., 2013). From 2019 to 2023, shallot production in Indonesia was in surplus, with an increase in the export quantity of approximately 9,470 tons in 2023 (Center for Agricultural Data & Information Systems, 2024). According to Badan Pangan Nasional (2024), shallots contribute the highest production of the horticultural vegetable category at 13.59%, with export potential to South Asian countries such as Thailand amounting to 6,000 tons, and Malaysia, totaling 612.8 tons in 2023. The exports to Malaysia continuously increased (Badan Pangan Nasional, 2024). Despite the significance, the development of shallot farming faces technical, socio-economic, and policy challenges (Saptana et al., 2021). Furthermore, most farmers exhibit risk aversion due to their low risk management capacity (Annisa & Agustina, 2024).

Indonesia reached 2.14 million tons of shallots in 2023, a production increase of 8.15% from the previous year (Center for Agricultural Data & Information Systems, 2023). Despite this rise, demand for shallots continues to grow due to population increases and the expanding food processing industry. However, the seasonal nature of shallot production results in frequent price fluctuations, as supply does not always meet demand (Center for

Agricultural Data & Information Systems, 2022). Statistics Indonesia reported that shallots were the largest contributor to food inflation in May 2023, with an inflation rate of 7.29%, contributing 0.03% to national inflation (Silvia, 2023). This inflation was caused by production fluctuations in key growing areas (Basuki et al., 2021; Puspitasari et al., 2019).

Harvest quality and quantity differ across regions, influenced by local shallot varieties that must adapt to varying climates, soil types, and topographies (Atman et al., 2021; Yeshiwas et al., 2023). Compared to 2022, Indonesia's national productivity for shallots reached 10.74, or an increase of 0.22% tons per hectare in 2023 (Center for Agricultural Data & Information Systems, 2023). However, this remains low compared to leading producers like China, where productivity reaches 38.43 tons/ha. The Ministry of Agriculture forecasts that shallot productivity will continue to rise from 2025 to 2027, reaching 11.149 tons/ha, 11.330 tons/ha, and 115 tons/ha, respectively, with an average annual increase of 1.42% from 2023 to 2027 (Center for Agricultural Data & Information Systems, 2023). Shallots are widely grown in key provinces such as Central Java, West Java, East Java, West Sumatra, West Nusa Tenggara, and South Sulawesi (Center for Agricultural Data & Information Systems, 2022). Although not a primary production center, Yogyakarta produces a significant number of shallots, particularly in the Bantul Regency (Radar Jogja, 2023). In this area, shallots are cultivated on shallow sandy soils, have a lack of fertility, and are severely prone to erosion (Sutardi et al., 2022).

The risks faced by farmers were primarily related to production and price fluctuations. These two risks are significant factors in determining the success of shallot farming. Production risks arise from extreme weather conditions, such as droughts or floods, which can cause crop failure (Ghozali & Wibowo, 2019). Price risks, both in terms of output and input, are influenced by market structures and production levels. During peak harvest seasons, an oversupply of shallots causes prices to drop, while input prices rise during planting seasons. Consequently, shallot farming is vulnerable to production and price fluctuation risks, leading to income instability for farmers (Prabowo et al., 2023; Salmiah et al., 2020).

Farm income directly impacts household income, with risk reduction being far more effective in stabilizing income than increasing farm earnings alone (Chen et al., 2019). Risk reduction strategies in shallot farming can include advancing agricultural industrialization, enhancing the professional status of farmers, improving rural public services, and increasing government policy support (Biagini & Severini, 2022). However, these risks often make farmers hesitant to take additional risks (Lawalata et al., 2017). Individual risk aversion leads to differences in decision-making (Erny et al., 2019). Farmers typically become risk-averse in their behavior to handle potential adverse risks. Farmers assume that securing small profits rather than increasing risks is preferable (Annisa & Agustina, 2024).

Shallot farming is often handed down through generations, resulting in adherence to traditional practices and risk-averse tendencies (Annisa & Agustina, 2024). Socio-economic factors, such as land size, age of the farmer, education, household size, experience of farming, income, and frequency of past failures, also influence farmers' behavior toward risk (Iqbal et al., 2016). Small-scale farmers are often more reluctant to take risks due to financial and environmental uncertainties, which are prevalent in highland and lowland areas (Marthen et al., 2023; Mwaijande et al., 2023). Nevertheless, the challenges encountered by farmers in the highland and lowland regions are distinct. Shallot farming in highland areas is more vulnerable to pests, diseases, and climate variability, including fluctuations in rainfall patterns and temperature (Adiyoga, 2018; Gofar et al., 2023). In contrast, lowland areas are more prone to land erosion and soil salinization (Samuel et al., 2023; Sutardi et al., 2022; World Bank, 2021). The variation of challenges between highland and lowland areas creates disparities in shallot farm productivity, income, and sustainability, leading to varying levels of risk.

This study aims to analyze shallot farming income risks and farmers' behavior in response to these risks and to analyze the determinants of that behavior. The study addresses gaps in previous research by offering a comparative analysis of shallot farming in highland and lowland regions, which primarily examined the associated risk without considering land type variation. The findings are expected to elucidate the challenges and hazards encountered by farmers, thereby aiding in the formulation of targeted policies to enhance farmers' welfare.

2. Methodology

2.1 Research Location

The research locations were purposively selected to represent the highland (Karanganyar Regency, Central Java) and the lowland (Bantul Regency, Yogyakarta). Both areas were major production centers for shallots and significantly contributed to the supply of shallots both within and outside their regions. Karanganyar, especially the Blumbang sub-district, represented highland areas where most farmers cultivated shallots on mountain slopes characterized by fertile soil, a sequential farming system, and river water irrigation. This sub-district is 1,200 meters above sea level, with an average annual rainfall of 1,506 to 2,722 millimeters and daily temperatures ranging from 9℃ to 23℃ (Statistics of Karanganyar Regency, 2024). Bantul regency, especially the Sanden sub-district, was chosen to represent the lowland area where most farmers cultivated shallots in sandy soil characterized by shallow soil, low productivity, low nutrients, and groundwater irrigation prone to erosion. This subdistrict is located 10 meters above sea level (MASL), with an annual mean precipitation of 90.76 millimeters and an average temperature of 30°C (Government of Bantul Regency, 2024).

2.2 Procedure of Sampling and Data Collection

The population of shallot farmers in Karanganyar was 425, while in Bantul, it was 376. Selected respondents were chosen to employ simple random sampling, comprising 100 shallot farmers from each region, resulting in 200 respondents. Data was collected using a questionnaire designed based on literature reviews and preliminary observation to obtain information from data from the latest planting season (May-July 2024). Observations were also conducted during the data collection period from August to September 2024 to improve the results. The questionnaire included the respondents' characteristics, like age, education level, household size, duration of farming experience, and land size. Additionally, data on farming practices were gathered, including all inputs—such as quantity and price—labor and other expenses incurred in the shallot farming process.

2.3 Analytical Technique

Data processing employed inductive techniques, focusing on facts and events, and conclusions were drawn according to empirical proof from the research locations. The data was evaluated employing descriptive methods, combining qualitative and quantitative perspectives. The measurement of income risk levels in farming was analyzed using the coefficient of variation (Erny et al., 2019), formulated as follows:

$$KV = \frac{\sigma}{\bar{X}} \tag{1}$$

where, KV was the variation coefficient, σ was the income standard deviation, and $\bar{X}$ was the mean income. A small coefficient of variation means low variability in the average values within the distribution, reflecting that the income risk faced is relatively low.

The quadratic utility function model was applied to examine farmers' risk-related behavior, which allows for evaluating decisions under risk conditions in their farming practices. This attempt also considers farmers' preferences and the diminishing marginal utility of income:

$$U = b_0 + b_1 I + b_2 I^2 \tag{2}$$

where, U was the utility value, I was the income at the equilibrium of the alternative choice presented, b_0 was the intercept, b_1 was the coefficient of regression, and b_2 was the coefficient reflecting risk preferences.

Based on the principle of Bernoulli's and the Neumann-Morgenstern with the enhancement by the neutral probabilities (50:50), the equilibrium value can be understood as the balance between outcomes under uncertain conditions and those under certain conditions. This value is called the certainty equivalent (CE), which denotes the income received in shallot farming. Each farmer possesses a distinct CE value, resulting in individualized utility curves attributable to disparities in income received. Multiple linear regression was utilized to evaluate the determinants of farmers' risk behavior (Sriyadi & Yekti, 2021). The model can be expressed as:

$$b_2 = \alpha_0 + \sum_{i=1}^{7} \alpha_i X_i + dD + \mu \tag{3}$$

where, b_2 is the coefficient of risk preference, X_1 is the land size (hectares), X_2 is the age (years), X_3 is the education (years), X_4 is the farming experience (years), X_5 is the household size (people), X_6 is the frequency of failures (times), X_7 is the income (IDR/year), D is the dummy location (0 = lowland and 1 =highland), d is the dummy coefficient, α_0 is the intercept, α_i is the regression coefficients for each independent variable, and μ is the error term.

The model analysis was tested using Ordinary Least Squares (OLS) and conducted in two steps: classical assumption test and model adequacy testing (Gujarati, 2012; Winkelmann, 2008). The classical assumption included multicollinearity and heteroscedasticity, as the data used are point-in-time or cross-sectional (Gujarati, 2012). OLS analysis can be applied if the examined model adheres to classical assumptions. The multicollinearity and heteroskedasticity indicate that the model should be refined accordingly.

(a) Multicollinearity testing

Multicollinearity testing is conducted using a correlation matrix among independent variables. Multicollinearity exists if the correlation coefficient exceeds 0.8000 (Winkelmann, 2008). It must be addressed before conducting heteroscedasticity testing and corrections if multicollinearity exists.

(b) Heteroscedasticity testing

Detection of heteroscedasticity can be conducted through several methods, encompassing the Harvey, Glesjer, Koenker, and Breusch-Pagan tests. If a test detects heteroskedasticity, the model must be modified, and the analysis should subsequently be conducted using the Feasible Generalized Least Squares (FGLS) method (Gujarati, 2012).

To address heteroscedasticity, four models can be utilized:

(a) Depvar model: h_t: $(X_t b)^2 \alpha^2$

(b) Mult model: h_t: $exp\ (Z_t \alpha)$

(c) Stdlin model: h_t: $(Z_t \alpha)^2$

(d) Varlin model: h_t: $Z_t \alpha$

Among these four heteroscedasticity correction models, one model was selected as the most suitable for identifying the determinants of risk preference coefficient.

3. Results and Discussion

3.1 Risk Analysis of Shallot Farming

Shallot farming income risk across highland and lowland regions was evaluated through the coefficient of variation (Table 1).

Table 1. Summary statistics of shallot farming income by region

Farm Income	Highland	Lowland
Lowest income (IDR)	65,750,000	61,750,000
Highest income (IDR)	135,000,000	115,500,000
Average (kg)	113,755,210	105,790,750
Standard deviation	65,250,533	57,550,500
Coefficient of variation	0.574	0.544

The results show that the income variation for shallot farming in both highland and lowland was relatively high, at 0.574 and 0.544, respectively. The lowest income from shallot farming in the highlands was IDR 65,750,000 per hectare, while the highest was IDR 135,000,000/ha. Meanwhile, the lowest income from shallot farming in the lowland area was IDR 61,750,000/ha, and the highest was IDR 115,500,000/ha.

These discoveries are coherent with previous studies emphasizing the relatively high-risk level of shallot farming (Setyowati et al., 2023). Moreover, Mazwan et al. (2020) found that the level of risk was relatively low. The difference stems from their study conducted during the dry season, when the likelihood of pest and disease attacks is lower. Moreover, shallot farmers in highlands and lowlands face higher risks due to differing regional characteristics.

The study also reveals that shallot farming in the highlands tends to have higher risks than lowland farming. Tajidan et al. (2022) research supports this finding that highland farming is riskier than lowland farming. However, it contradicts the study by Hindarti & Saputro (2022), which suggests that shallot farming in highlands carries lower risks. These differences are attributed to varying capabilities and farming technologies employed in the respective study areas.

Shallot farming risks can be seen from both income and production risks. Production variations primarily cause the greater income risk faced by shallot farmers. The lowest variation of production in the highlands was 8,750 kg/ha, with the highest at 13,750 kg/ha. In the lowland, the smallest variation of production was 7,500 kg/ha, and the greatest was 12,750 kg/ha. On the other hand, the lowest price variation for shallots in the highlands was IDR 17,000 /kg, with the highest at IDR 20,500 /kg. In the lowlands, the smallest price variation was IDR 16,750 /kg, and the greatest was IDR 19,750 /kg.

The variation in production comes from planting at different periods, leading to differences in growth and production. Planting time differences also result in varied production outcomes (Tesfaye et al., 2018). Additionally, weather and climate heavily affected the shallot growth. For instance, farmers planting during the mid of the rainy season experience higher rainfall, which affects production by increasing the potential for pest and disease attacks (Hatfield et al., 2011). Conversely, farmers who sow at the onset of the rainy season tend to achieve better production outcomes when rainfall is lower.

The shallot production variation drives income variation, as differences in quality lead to price differences (Mastrobuoni et al., 2014), ultimately affecting the income farmers receive. The study also indicated that shallot farming in the highlands carries higher risks than in the lowland area due to the highland farmers not planting shallots concurrently, unlike lowland farmers who are organized within farmer groups. Furthermore, highland areas prone to cold and misty climates caused the growth of fungi and led to a decline in production. The climate rendered shallots in highland areas more vulnerable to pests and diseases that favor cool and humid conditions.

3.2 Farmers' Behavior Towards Risk

Farmers' behavior towards shallot farming risk was analyzed using a quadratic utility function. The function for every farmer was estimated based on the principle of Bernoulli-Morgenstern, which was advanced by the neutral probability (50:50).

According to the utility function, highland shallot farming had the lowest determination coefficient (R^2), 0.967, and the highest was 0.995. This indicates that variations of income explain 96.70% of the value of utility variation for shallot farming, while the remaining 3.30% is credited to other components not included in the model. For those with the highest R^2, the variation in utility values is explained by variations in shallot farming income by 99.50%, while 0.50% is due to other factors not included in the model. The analysis shows that the lowest calculated F-value was 65.555, and the highest was 1,232.100, indicating that income variations strongly influence farmers' risk behavior in shallot farming.

In the lowland region, the analysis of shallot farming showed R^2 values ranging from 0.950 to 0.985. This indicates that 95% of the variation in utility values is explained by income variations, with the remaining 5% credited to other factors not included in the model. For farmers with the highest R^2, the values of utility variation are explained by income variations of 98.50%, with 1.50% due to other factors not included in the model. The lowest F-value was 55.525, while the highest was 1,003.500.

Table 2. Farmers' behavior distribution toward shallot farming risks

Behavior	Highland Shallot		Lowland Shallot	
	Freq.	Percent (%)	Freq.	Percent (%)
Risk averse	65	65	80	80
Risk neutral	25	25	15	15
Risk taker	10	10	5	5
(R^2) lowest	0.967		0.950	
(R^2) highest	0.995		0.985	
F-count lowest	65.555		55.525	
F-count highest	1,232.100		1,003.100	

Table 2 shows that out of 100 farmers engaged in shallot farming in a highland area, 65% of the coefficient is negative and statistically significant (b_2), indicating that farmers were risk-averse to shallot farming. Another 20% had a negative coefficient, and 5% had a positive but insignificant risk coefficient, signifying that these farmers were risk-neutral. Lastly, 10% of farmers were found to be risk-takers in shallot farming. The result indicates that most shallot farmers in the highlands exhibited risk-averse behavior toward shallot farming.

In the lowland area, among 100 farmers, 80% of the coefficient is negative and statistically significant (b_2), indicating risk-averse behavior. Meanwhile, 10% had a negative coefficient, and 5% had a positive but insignificant risk coefficient, reflecting risk-neutral behavior. The remaining 5% were found to be risk-takers in shallot farming. These findings indicate that shallot farmers in the lowlands also exhibited risk-averse behavior. Overall, the shallot farmers in both areas tend to avoid risks or are risk-averse.

These findings, where most farmers reject risk, align with the study by Lawalata et al. (2017). Factors such as small land ownership, high price fluctuations, and uncertain weather conditions drive farmers to engage in traditional cultivation methods, minimizing inputs to reduce production costs. The economic dilemmas faced by farming households also contribute to the higher percentage of risk-averse farmers. Additionally, since these farmers are close to subsistence levels and frequently experience weather uncertainties, they lack the opportunity to maximize profit. calculations in cultivating. This behavior of prioritizing failure avoidance is called "safety first," which characterizes most farmers.

Farmers' motivation to achieve higher income through shallot farming is quite high, as shallots are a quick-yielding and valuable commodity. However, the high risks in this farming prevent most farmers from engaging in large-scale production. Risks, such as pest and disease outbreaks and price fluctuations, pose challenges, especially for farmers with limited capital. Few farmers have started cultivating shallots on a bigger scale because they have more capital and are willing to take speculative risks. On the other hand, small-scale farmers are forced to sell their entire harvest during harvest time, regardless of whether prices are high or low, as they lack the budget reserves to meet their daily needs. Larger-scale farmers, however, have the flexibility to store their harvest if prices are low and sell only when prices are high, as they have sufficient funds to cover their living expenses.

The results showed that lowland farmers exhibited greater reluctance towards the risks associated with shallot farming than those in the highlands. This disparity stems from lowland farmers having an average of 12 years of experience, whereas highland farmers predominantly have over 30 years of shallot cultivation experience. The lack of experience exacerbates farmers' aversion to risk. The other factor is attributed to the socio-economic condition, wherein the annual income of lowland farmers was IDR 30,750,000, considerably lower than that of highland farmers, which was IDR 45,450,000. The decline in income leads to increased risk aversion among farmers. Shallot farmers in highland regions commonly adopted sequential cropping, whereas those in lowland areas applied a monoculture farming system. Sequential cropping is one of the risk managements (Glaze-Corcoran et al., 2020; Huss et al., 2022). Additionally, seasonal appropriateness must be considered to optimize production (Tesfaye et al., 2018). The planting times in highland and lowland areas differ. The ideal planting season for shallots in the highland area is from June to August, while in the lowland area, it is from August to October.

3.3 Socio-economic Determinants Affecting Farmers' Behavior Towards Risk

Eight variables are suspected of influencing farmers' behavior toward risks in shallot farming. The factors affecting the behavior of farmers regarding shallot farming risks were analyzed employing a multiple linear regression model (Table 3). This study uses the risk coefficient derived from the analysis of the quadratic utility function as the dependent variable. Meanwhile, land size, farming experience, age, household size, frequency of failure, education, income, and dummy location representing the cultivation location were determined as the independent variables.

The results showed that age, education, and income significantly influence the coefficient of risk in measuring the risk of farmers' behavior (Table 3). These results were supported by some studies that stated that older age tends to reduce farmers' willingness to take risks. At the same time, higher education levels influence farmers' openness to receiving new information related to various risk sources, which can help them manage risks more effectively (Akhtar et al., 2018; Ullah et al., 2015).

Table 3. Regression analysis results of shallot behavior of farmers toward risk

Independent Variables	Regression Coefficient	T-count
Intercept	0.743E-04***	12.250
Land size (X_1)	-0.784E-9NS	-0.854
Age (X_2)	-0.326E-06*	-2.561
Education (X_3)	0.785E-07**	2.764
Farming experience (X_4)	0.367E-06NS	1.763
Household size (X_5)	0.574E-07NS	1.092
Frequency of failure (X_6)	-0.422E-05NS	-0.675
Income (X_7)	0.367E-04**	2.786
Dummy location (D)	0.576E-05***	3.767
Determinant coefficient (R^2)	0.895	
F-count	8.713***	
DW	1.811	

Note: *** means significant at α 1%; ** means significant at α 5%; * means significant at α 10%; and NS means not significant.

The analysis results show that the correlation coefficients among the independent variables are relatively small, indicating no multicollinearity issues. However, there is a problem with heteroskedasticity. To eliminate the impact of heteroskedasticity, several models were used: DEPVAR (heteroskedasticity correction using the dependent variable), MULT (correction using a multiplicative model), STDLIN (correction where the standard deviation is a linear function of exogenous variables), and VARLIN (correction where the variance is a linear function of exogenous variables) are used.

The analysis of the heteroskedasticity model produced an R^2 of 0.895 (Table 4), meaning that 89.50% of farmer behavior toward risk is described by variations in land size, age, education, farming experience, household size, frequency of failure over the preceding five years, income, and dummy location. The persisting 10.50% is determined by other variables not involved in the model. The likelihood ratio (LR) result of 24.346 is higher than the chi-square (χ^2 table) value of 20.090, indicating that farmer behavior toward risk is affected by socio-economic attributes, including land size, age, education, experience, household size, frequency of failure in the past five years, income, and dummy location.

Table 4. Regression analysis results of shallot farmers' behavior towards risk after eliminating the heteroscedasticity effect

Variable	Reg. Coef.	Heteroscedasticity-Free Regression Coef.			
	OLS	DEPVAR	MULT	STDLIN	VARLIN
Intercept	0.743E-04*** (12.250)	0.628E-04*** (14.443)	0.754E-04NS (0.964)	0.741E-04NS (0.878)	0.321E-05*** (3.469)
Land size (X_1)	-0.784E-9NS (-0.854)	-0.5266E-9*** (-11.325)	-0.625E-9* (-1.987)	-0.526E-9NS (-1.437)	-0.356E-9NS (-0.311)
Age (X_2)	-0.326E-06* (-2.561)	-0.371E-06*** (-11.343)	-0.316E-08NS (-1.252)	-0.443E-08NS (-0.785)	-0.156E-07* (-1.731)

Education (X_3)	0.785E-07** (2.764)	0.476E-07*** (12.191)	0.302E-07*** (2.822)	0.215E-07^{NS} (1.356)	0.511E-07*** (2.878)
Farming experience (X_4)	0.367E-06^{NS} (1.763)	0.346E-06*** (7.687)	0.327E-08^{NS} (0.732)	0.535E-08^{NS} (1.235)	0.545E-08^{NS} (0.347)
Household size (X_5)	0.574E-07^{NS} (1.092)	0.835E-07*** (9.434)	0.736E-07^{NS} (0.658)	0.334E-07^{NS} (0.422)	0.872E-07^{NS} (1.456)
Frequency of failure (X_6)	-0.422E-05^{NS} (-0.675)	-0.223E-05*** (-9.101)	-0.724E-08^{NS} (-0.763)	-0.134E-08^{NS} (-0.125)	-0.346E-06* (-1.867)
Income (X_7)	0.367E-04** (2.786)	0.322E-9** (10.655)	0.611E-08*** (3.520)	0.765E-08^{NS} (1.176)	0.564E-08* (1.678)
Dummy (D)	-0.576E-05*** (-3.767)	-0.546E-05*** (-6.665)	-0.567E-05*** (-3.332)	-0.754E-05*** (-2.965)	-0.756E-05*** (-2.754)
R^2	0.895	0.895	0.895	0.895	0.895
F-count/LR	8.713***	24.346***	24.346***	24.346***	24.346***

Among the four models used to address heteroskedasticity, the DEPVAR model was the best, as it had the most significant independent variables. This model was chosen to identify the determinants of farmers' risk behavior. The DEPVAR model reveals that all independent variables significantly affect the dependent variable.

(a) Land size

The land size owned by shallot farmers in the highlands and lowlands is relatively small. The average land size cultivated by farmers in the highlands is 0.1960 hectares, while in the lowlands, it is 0.2050 hectares. The land area has a negative and significant regression coefficient, signifying that with larger land ownership, farmers tend to become more risk-averse when all other factors are constant (ceteris paribus). This result was coherent with the study by Sriyadi & Yekti (2021), which found that larger landholdings render farmers more reluctant to take risks. This result contradicts the findings of Pujiharto & Wahyuni (2017), which indicated that larger landholdings increase farmer income, thereby positioning farmers as risk-takers. The uncertainty factors in the hardness of shallot farming are principally risky. If even a small land size carries risks, a larger land size would present even greater risks of failure. Apart from uncertainty, this risk of failure is also caused by unpredictable weather conditions due to climate anomalies, such as planting shallots during the dry season when unexpected rains occur. Shallots are highly sensitive to rain (Marpaung & Rosliani, 2019), and an increase in soil moisture due to rain causes basal rot in shallots (Karenina et al., 2023), impacting crop production and growth.

This risk of failure is also attributed to declining soil fertility and pests. It was found that some farmland in the highlands has become saturated, characterized by compacted soil that has difficulty absorbing water. Initially, such land could still be planted with shallots, and they would grow. However, the plants wilt over time and eventually die, with their bulbs rotting. Several experts declare that the occurrence is attributed to overutilization of inorganic fertilizers and pesticides, which causes soil contamination by chemicals, making the soil dense, hard on the surface, and nutrient-deficient (Pahalvi et al., 2021; Prashar & Shah, 2016; Rashmi et al., 2020). Therefore, farmers are increasingly reluctant to cultivate shallots on larger plots of land.

(b) Age

The average shallot farmer in the highlands was 41 years old. The oldest farmer was 73 years of age, whereas the youngest was 29 years old. The average age of shallot farmers in the lowland is 44 years, with the oldest being 78 and the youngest being 31 years. Age has a negative and significant regression coefficient, meaning the older farmer tends to become more risk-averse. In contrast, younger farmers are inclined to be less risk-averse in ceteris paribus conditions. Fahad et al. (2018) support this finding by asserting that younger farmers exhibit a greater propensity for risk-taking than their older counterparts. Lawalata et al. (2017) also state that older farmers are more averse to risk.

However, the study by Pujiharto & Wahyuni (2017) found that age does not have a significant effect, which means that age is contrarily relative to the risk coefficient. This is understandable because older farmers with more experience and skills are inclined to be more traditional and quickly get tired. Younger farmers, while less experienced and skilled, tend to perform more gradually to improve and are physically stronger. This developing personality tends to make younger farmers more willing to take risks.

This behavior is evident in some younger farmers who are starting to change their production factors, such as fertilizer. Young farmers are beginning to change from using inorganic fertilizers to using organic fertilizers and reducing inorganic pesticides. They only use chemical pesticides when necessary, for example, when a pest or disease outbreak occurs. Traditionally, farmers have become accustomed to spraying chemical pesticides weekly, regardless of whether there are pests.

(c) Education

The average formal education of shallot farmers in the highland area is 18 years, ranging from 15 to 23 years, while in the lowland area, it averages 17 years, ranging from 14 to 23 years. Therefore, most farmers have attained a high school diploma or completed vocational training. Education exhibits a positive and significant regression coefficient, implying that increased educational attainment correlates with a greater propensity for risk-taking among farmers. This is because higher education generally broadens knowledge and improves access to information on various sources of risk, allowing farmers to develop better risk mitigation strategies (Saqib et al., 2016).

(d) Farming experience

The experience of shallot farmers in the highlands spans from 8 to 55 years, averaging 30 years, whereas in the lowlands, it spans from 5 to 15 years, and the average is 12 years. The experience variable's regression coefficient is positive and significant, revealing that an expansion in experience substantially elevates the risk coefficient under ceteris paribus conditions. Consequently, as farmers acquire greater expertise in shallot cultivation, their risk aversion decreases.

Farmers' knowledge and skills in shallot farming are derived from inherited experience and observations of their surroundings. This enables experienced farmers to handle their farms more efficiently (Saqib et al., 2016). Experienced farmers possess expertise and are cognizant of the potential ramifications of their decisions, particularly concerning pricing and production. For example, before deciding to plant shallots, some farmers in farmer groups consider their past experiences and may conduct surveys in other regions where similar crops are grown. This is important because if other areas are also cultivating the same crop, it is almost certain that prices will drop at harvest time. Lessons from past failures are valuable, and experienced farmers work to prevent similar failures from occurring.

(e) Household size

The household size among highland shallot farmers is from one to four, with an average of two members per family, while in the lowlands, the number ranges from one to four, with an average of three members per family. The variable for the household size had a positive and significant elasticity, signifying that when household size is increased, it leads to a greater willingness to take risks. This is because the household size supports labor availability, essential in shallot farming. Most shallot farmers depend significantly on familial labor for any job encompassing nursery, soil cultivation, planting, weeding, fertilization, irrigation, harvesting, and post-harvest processing. Additionally, this research shows that larger families impose increased demands on the head of the household to exert greater effort to attain higher yields to fulfil the family's necessities. This serves as a motivation for farmers to take on more risks.

(f) Frequency of failure

Seasonal uncertainty, unstable prices, and high costs mainly cause the failure of shallot farming for several farmers. In the highlands, the frequency of failure in shallot farming over the past five years ranges from zero to two occurrences, with an average of 0.06 times. In the lowlands, the frequency ranges from zero to one occurrence, with an average of 0.04 times. The elasticity of the frequency of failure is negative and significant; that the higher the frequency of failure, the greater the tendency of farmers' reluctance to take risks. This finding aligns with previous research, which shows that the frequency of failure is contrarily relative to the risk coefficient, which means that the higher the failures, the greater the reluctance of farmers to take risks (Pujiharto & Wahyuni, 2017).

(g) Income

Farmers in the highlands earn between IDR 35,750,000 and IDR 105,500,000 annually from shallot farming, with an average income of IDR 45,450,000/year. In contrast, farmers in the lowlands have annual incomes ranging from IDR 20,000,000 to IDR 75,000,000, with an average of IDR 30,750,000/year. Most of the revenue for shallot farmers in the highlands comes from shallots, garlic, chili, cabbage, carrots, long beans, and mustard greens. In contrast, farmers in the lowlands mainly derive their income from shallots, rice, chili, cassava, and peanuts. The elasticity of farmers' annual income is positive and significant, meaning that a rise in income leads to a decline in the farmers' risk aversion. This study outcome is reasonable since the primary motivation for farmers in their agricultural endeavors is to achieve a high revenue. Additionally, shallot farming incurs high costs, necessitating substantial income. The study also found that farmers with plans for higher income or capital are willing to engage in larger-scale shallot farming. They are not afraid of facing the risk of failure because they have a reserved budget for living expenses. Higher income may suggest that farmers possess a greater capacity for risk-bearing and represent a method of diversification that eventually impacts their risk behavior (Akhtar et al., 2018).

(h) Dummy variables

Dummy variables are used to differentiate highland and lowland shallot farming. In this context, D = 1 represents shallots from the highland, while D = 0 represents those from the lowland. The dummy variable negatively affected the farmers, who took a significant risk. The result revealed that the reluctance of highland farmers to engage in shallot farming differs from that of lowland farmers, with highland reluctance being lower than that in lowland areas. According to the observation and survey, the plausible reason was that highland shallot farmers have longer farming experiences and higher income despite the higher risk in that location. Both factors assist farmers in enhancing risk mitigation management and resource allocation.

The analysis of shallot farming risks gives valuable insights that guide agricultural policies designed to mitigate these risks. The higher coefficient of variation in income for both highland (0.574) and lowland (0.544) signifies considerable income instability in shallot farming. This condition informs the relevant authorities to develop programs, such as crop insurance, which protect farmers from income losses caused by unforeseen events such as pest infestations or adverse weather conditions (Wei et al., 2021). Implementing such insurance schemes could incentivize farmers to pursue larger-scale production without fearing catastrophic financial losses. This program can potentially enhance readiness to adopt technology in three aspects: motivation, capacity, and opportunity. Moreover, professional extension programs are essential for educating farmers on risk management strategies like sequential cropping and diversification, which have proven effective in risk mitigation. The information about concurrent farming mitigates risk potential and can serve as a basis for the government to establish regulations pertaining to ideal shallot planting schedules. Integrating the roles of all stakeholders and consolidating policies are necessary (Maryono et al., 2024) since they help mitigate the risks of shallot farmers and improve their welfare.

4. Conclusion

Shallot farming, whether in highland areas (Karanganyar Regency) or lowland areas (Bantul Regency), carries a considerable income risk, with higher variability observed in highland areas than in lowland areas. The income risk was greater due to production variability, which is further influenced by the timing of shallot planting. Farmers who plant shallots at the ideal time tend to achieve optimal yields. Farmers in both the highland and the lowland showed a preference for risk aversion, indicating a tendency to avoid engaging in high-risk farming. Several socio-economic components significantly determine the farmers' behavior toward risk in shallot farming, comprising land size, farming experience, education, household size, age, frequency of failures over the past five years, income, and dummy location. Based on the results, it underscored the need for government policies that promote or formulate the appropriate planting times for shallots. This ideal time of planting could be disseminated through agricultural extension services. This program educated farmers about the optimal timing for planting shallots, which can help mitigate risks and improve overall production outcomes and farmers' well-being.

Data Availability

The data used to support the findings of this study are available from the corresponding author upon request.

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Conflicts of Interest

The authors declare no conflict of interest.

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