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The Impact of Crop Failure Risk and Harvest Area on Rice Production in Takalar Regency

Chalid Hi Idris[1], Mohammad Natsir[2*], Nurdin[3], Syafiuddin[4], Amruddin[5], Sri Mardiyati[6]

[1,2,3,4,5,6]Master of Agribusiness Study Program, Postgraduate Program,Universitas Muhammadiyah Makassar

Correspondent Author: mohammad.natsir@unismuh.ac.id

Abstract

Rice is a strategic commodity that supports national food security. However, increasing rice production is often hampered by land degradation and the threat of crop failure due to climate anomalies. This study aims to analyze the risk levels of rice production and the risk of crop failure, as well as the influence of harvested area and the risk of crop failure on rice production in Takalar Regency. This study uses secondary annual time series data for the period 1990–2025. The risk level is measured using the Coefficient of Variation (CV) method, while the influence between variables is analyzed using multiple linear regression. The results of this study indicate that the average risk level of rice production reaches 17.32%, categorized as low, while the risk of crop failure is 63.84%, categorized as medium. The results of the regression analysis indicate that harvested area has a positive and highly significant effect on rice production, namely that if the harvested area of rice increases by 1%, rice production increases by 0.9163%. Meanwhile, the risk of crop failure has a negative impact on rice production, but not significantly, due to the existence of spatial buffers and effective institutional mitigation. Policies to protect sustainable food crop land and restore soil fertility are recommended to prevent the threat of future production stagnation.

Keywords: Harvested Area; Production; Puso; Rice; Risk.

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INTRODUCTION

Rice is one of Indonesia's primary food commodities, playing a strategic role in national food security, macroeconomic stability, and inflation control (Ministry of Agriculture, 2019; BPS, 2025). Given its vital function, the sustainability of rice farming is a primary focus of agricultural development. However, the rice agribusiness sector consistently faces two opposing structural challenges: the demand for continuous increases in aggregate production and the threat of natural resource degradation and extreme climate anomalies.

Takalar Regency, as one of the rice production centers in South Sulawesi, plays a crucial role in supporting regional food supply. Within the framework of agricultural production economics, output (production) is largely determined by the extent of productive land harvested (harvested area) and technological efficiency at the farm level (Modjo et al., 2025). Harvested area is a tangible indicator of the area planted successfully surviving various abiotic and biotic shocks until the final generative phase.

On the other hand, the agricultural sector is characterized by high uncertainty. The threat of total crop failure, or puso (crop failure), whether due to drought (El Niño), flooding (La Niña), or an explosion in plant pest populations (OPT) is a major disincentive that can immediately undermine production (Hardaker et al., 2015). Although the risk of crop failure theoretically has a linear impact on production decline, several empirical studies have shown that institutional and technological interventions can mitigate this shock, preventing a massive impact at the macro scale (Pratama & Khasanah, 2025).

This study aims to analyze the level of production risk and the risk of crop failure; and to empirically test the effect of harvested area and crop failure risk on total rice production in Takalar Regency over the past three decades.

RESEARCH METHODS

This research was conducted in Takalar Regency. It employed a quantitative explanatory design utilizing secondary annual time series data over a 36-year period (1990–2025). Data were sourced from the Central Statistics Agency (BPS), the Ministry of Agriculture, and the local Agriculture Service.

Risk analysis is conducted to determine the probability of production deviations and crop failures from normal expectations. The measurement tool used is the Coefficient of Variation (CV), with the mathematical formula:

$$CV = \frac{SD}{\bar{X}} \times 100\%$$

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Where SD is the standard deviation, and $\bar{X}$ is the average value (mean).

According to Amin and Prihantini (2021), risk classification is divided into three intervals: low (0–33.33%), medium (33.34–66.66%), and high (>66.67%).

To answer the hypothesis of the influence of harvested area (X_1) and crop failure risk (X_2) on rice production (Y), an ordinary least squares (OLS) regression model was used. The regression equation was transformed into natural logarithm (Ln) form to align the data scale and obtain elasticity values. The basic equation is:

$$lnY = \beta_0 + \beta_1 lnX_1 + \beta_2 lnX_2 + \varepsilon$$

Statistical tests included the F-test (simultaneous effect), the t-test (partial effect), and the coefficient of determination (R^2).

RESULTS AND DISCUSSION

Crop Failure Risk and Rice Production Risk in Takalar Regency

In rice farming, risk is the probability of deviation between expected results and actual results. Based on this research methodology, risk levels are measured using the Coefficient of Variation (CV) analysis tool. The CV value is obtained by dividing the standard deviation by the mean, which is then classified into three levels: low (0% – 33.33%), medium (33.34% – 66.66%), and high (66.67% – 100%). Historical data from 1990–2025 (Table 1) shows a stark contrast between production volatility and the threat of crop failure (puso) in Takalar Regency.

Stability in the Low Category: Based on the collected data, the average rice production in Takalar Regency over a 36-year period reached 107,513.08 tons per year, with a standard deviation of 18,618.77. This calculation yields a Coefficient of Variation (CV) of 17.32%. Based on established criteria, the aggregate risk level of rice production in this region falls into the low category.

A Coefficient of Variation (CV) of only 17.32% indicates that rice production performance in Takalar Regency is very stable with minimal extreme fluctuations from year to year. This low production risk indicates that the cultivation system implemented by farmers has demonstrated good adaptation to microenvironmental changes. Determining factors supporting this stability include a reliable irrigation system, the use of New Superior Varieties (VUB) that are resistant to biotic/abiotic stresses, and consistent extension support (Suharyanto et al., 2024). This production stability is vital, given that the agricultural sector is a major contributor to Takalar Regency's GRDP and employs approximately 27.52% of the local workforce.

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On the other hand, land loss data reveals a different reality. The risk of crop failure, defined as the area of rice fields experiencing crop failure due to natural factors or pests, averages 4,045.35 hectares per year, with a very large standard deviation of 2,582.58. This results in a Coefficient of Variation (CV) of 63.84%.

A Coefficient of Variation (CV) of 63.84% places the risk of crop failure in the moderate category, but its position is at the upper limit, almost touching the high category (>66.67%). The standard deviation, which reaches more than half the average value, indicates that crop failure in Takalar Regency is highly volatile, sporadic, and unpredictable.

Table 1. Rice Failure Risk and Rice Production Risk in Takalar Regency (1990-2025)

Uraian	Produksi	Puso
Rata-rata	107.513,08	4,045.35
Standar Deviasi	18.618,77	2,582.58
Koefisien Variasi (CV) (%)	17,32	63.84

Source: Secondary data analysis, 2026.

The average crop failure rate of 4,045.35 hectares is no small figure. Assuming production costs per hectare reach tens of millions of rupiah, the annual economic losses at the farmer level are substantial. High volatility (CV 63.84%) is strongly correlated with the frequency of global climate anomalies such as El Niño (causing extreme drought) and La Niña (causing flash floods), as well as pest outbreaks such as brown planthoppers (BPH) and rats (Mutisari et al., 2025). In normal climate years, crop failure losses can likely be kept below 2,000 hectares. However, when extreme climate cycles occur, crop failure can skyrocket beyond 6,000 hectares in a single growing season.

The Impact of Harvest Area and Crop Failure Risk on Rice Production

This study aims to analyze and empirically test the causal relationship between harvested area and the level of vulnerability to crop failure (failure risk) on total aggregate rice production in Takalar Regency. The econometric approach used to unravel the complexity of this relationship is multiple linear regression analysis applied to 36 years of time series data (1990–2025).

Based on the summary statistical output, an empirical regression model representing these dynamics is formulated as the natural logarithm (ln) function equation as follows:

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$$\ln Y = 2.398 + 0.916 \ln X_1 + -0.0217 \ln X_2 + e$$

The credibility of a regression model is largely determined by how well the independent variables explain the variance of the dependent variable. The analysis results show an R-square value of 0.82067. This figure indicates that 82.07% of the total variation in rice production in Takalar Regency can be comprehensively explained by fluctuations in harvested area and the dynamics of crop failure risk, while the remaining 17.93% is explained by variables outside the regression model (such as fertilizer dosage, seed variety, or labor).

The strength of this model is confirmed by the results of the simultaneous F-test. The F-statistic value was recorded at 75.5118 with a significance level (Significance F) of 0.0000000. Because this probability value is well below the error tolerance threshold (α = 0.05), it can be concluded that, simultaneously, harvested area and crop failure risk have a very significant effect on rice production levels. This aligns with the initial hypothesis that assumed the simultaneous intervention of these two variables.

In partial deconstruction (t-test), harvested area emerged as the primary determinant driving the production curve. The Harvested Area variable (X_1) has a positive regression coefficient of 0.9162766 with a P-value of 0.000000. The statistical fact that the P-value is less than 0.05 proves that harvested area has a positive and highly significant effect on rice production in Takalar Regency, thus accepting the first hypothesis.

Mathematically, every 1% increase in harvested area, ceteris paribus (assuming other variables remain constant), will boost total rice production by 0.916%. This finding confirms a fundamental principle in agricultural economics: the larger the area that can be safely harvested by farmers, the greater the volume of unhusked rice output that ends up in the regional food barn. This increase aligns with historical trends in which Takalar Regency has continuously strived to optimize its cropping index (IP) amidst land constraints.

Table 2. The Impact of Harvest Area and Crop Failure Risk on Rice Production in Takalar Regency

Variable	Coefficient	Error Standards	t-Statistic	Prob.
Constant	2.39818***	0.840942	2.851779	0.007445

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Harvest Area	**0.91628*** **	**0.081381**	**11.259045**	**0.000000**
Crop Failure Risk	-0.021698ns	0.023654	-0.917290	0.365647
R-squared	**0.8207**			
F-statistic	75.5118			
Prob. (F-statistic)	**0.0000**			
Information: ***significant at α = 1% ns: non-significant				

Source: Secondary data analysis, 2026.

The most interesting and counterintuitive finding in this analysis lies in the crop failure risk variable (X_2). The regression results show a negative regression coefficient of -0.0216976. This negative sign is theoretically appropriate, as it indicates an inverse relationship: the higher the intensity of crop failure, the more likely rice production will contract or decline.

However, from a statistical probability perspective, the P-value for the crop failure risk variable is 0.36564654. Because this probability figure far exceeds the critical limit of 0.05 (5%), the academic conclusion is that crop failure risk does not have a statistically significant effect on aggregate rice production in Takalar Regency. Therefore, the second hypothesis, which predicted a negative and significant effect, must be rejected.

This insignificance of crop failure risk presents a paradox. Why are crop failure disasters due to floods, droughts, or pest attacks, which often harm individual farmers, considered insignificant by regional macro statistics to reduce regional food supplies?

This paradox can be explained through the concept of the Macroscale Spatial Compensation Effect (Pratama & Khasanah, 2025). In the aggregate context of a district-level area, the total harvested rice area reaches tens of thousands of hectares annually. Meanwhile, although fluctuations in crop failure (the coefficient of variation) may be high due to sporadic climate events in a given year, the absolute percentage of hectares of land completely destroyed is very small (marginal) compared to the "ocean" of rice fields that were safely harvested.

When a group of farmers in one village experiences a total crop loss (puso), the deficit in grain volume in that small area is quickly "covered" or compensated for by a bumper harvest in other villages or supporting sub-districts. As a result, in the year-end

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GRDP calculation at the district level, the "wound" caused by puso is unable to create a shock deep enough to disrupt the stability of the total production graph. This spatial resilience is what causes variable X_2 to lose its significance in the aggregate regression model.

Although statistics indicate the risk of crop failure is insignificant on a macro scale, local governments are strictly prohibited from becoming myopic about the micro-scale suffering on the ground. For individual farming households whose rice fields are swept away by tidal flooding or consumed by planthoppers, crop failure is a catastrophic economic loss that wipes out operational capital (seeds, fertilizer, labor wages) with no return on investment (Mutisari et al., 2025).

Therefore, future agricultural policy in Takalar Regency must rely on dual interventions. On the one hand, to ensure the significance of the regression of harvested area remains intact, the government must tighten Regional Spatial Planning (RTRW) regulations to curb the rate of conversion or conversion of Protected Rice Fields (LSD) into residential areas. On the other hand, to protect farmers from the stochastic threat of micro-crop failure, relevant agencies need to expand the social safety net through subsidizing premiums for Rice Farming Insurance (AUTP) (Ministry of Agriculture, 2024), as well as revitalizing irrigation infrastructure in zones vulnerable to abiotic stress.

CONCLUSION

In Takalar Regency, the aggregate risk of rice production is low (CV=17.32%), indicating that crop yield stability is well maintained. Conversely, fluctuations in the area of crop failure (the risk of crop failure) are extreme and fall into the medium-high category (CV=63.84%) due to sporadic vulnerability to climate anomalies, pests, and diseases. Harvested rice area has a positive and highly significant impact as a primary driver of rice production. Conversely, the risk of crop failure is not significantly macroeconomic due to the spatial compensation effect (a failure in one area is offset by a bumper harvest in another), although its impact is highly detrimental to individual farmers.

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