



Panel Data Analysis of Harvested Area, Rice Price, Consumption, and Population in Determining Food Security in East Java

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Abstrak

Penelitian ini bertujuan untuk menganalisis dampak luas panen, harga beras, konsumsi beras, dan populasi terhadap ketahanan pangan di Provinsi Jawa Timur. Data yang digunakan adalah data panel sekunder dari 38 kabupaten/kota selama periode 2020–2024, dianalisis menggunakan regresi data panel dengan pendekatan Fixed Effect Model (FEM). Pemilihan model ditentukan melalui tes Chow dan Hausman, di mana tes Chow lebih menyukai FEM dan tes Hausman menunjukkan REM; namun, FEM dipertahankan untuk interpretasi yang lebih dalam karena kekuatan penjelasan dalam kelompok yang lebih kuat. Hasil estimasi menunjukkan bahwa luas panen (Coef = 0,0000721; $p < 0,01$), harga beras (Coef = 0,0009185; $p < 0,01$), dan populasi (Coef = 0,00001874; $p < 0,01$) memiliki pengaruh positif dan signifikan terhadap ketahanan pangan, sedangkan konsumsi beras tidak berdampak signifikan. Nilai dalam R^2 0,5272 menunjukkan bahwa model dapat menjelaskan 52,72% dari variasi ketahanan pangan di dalam wilayah. Temuan ini menekankan perlunya kebijakan pertanian adaptif regional dan perbaikan distribusi pangan spasial untuk meningkatkan ketahanan dan kinerja sistem pangan.

Kata kunci: Ketahanan pangan; Area yang dipanen; Harga beras; Konsumsi beras; Populasi.

Abstract

This study aims to analyze the effects of harvested area, rice prices, rice consumption, and population on food security in East Java Province. The data used are secondary panel data from 38 districts/cities over the 2020–2024 period, analyzed using panel data regression with the Fixed Effect Model (FEM) approach. Model selection was determined through Chow and Hausman tests, where the Chow test favored FEM and the Hausman test indicated REM; however, FEM was retained for deeper interpretation due to its stronger within-group explanatory power. The estimation results show that harvested area (coef = 0.0000721; $p < 0.01$), rice prices (coef = 0.0009185; $p < 0.01$), and population (coef = 0.00001874; $p < 0.01$) have a positive and significant effect on food security, while rice consumption has no significant impact. The within R^2 value of 0.5272 indicates that the model can explain 52.72% of the variation in food security within regions. These findings emphasize the need for regionally adaptive agricultural policies and spatial food distribution improvements to enhance resilience and food system performance.

Keywords: Food security; Harvested area; Rice price; Rice consumption; Population.

Abstrak

Penelitian ini bertujuan untuk menganalisis pengaruh luas panen, harga beras, konsumsi beras, dan jumlah penduduk terhadap ketahanan pangan di Provinsi Jawa Timur. Data yang digunakan adalah data panel sekunder dari 38 kabupaten/kota selama periode 2020–2024, dianalisis menggunakan regresi data panel dengan pendekatan Fixed Effect Model (FEM). Pemilihan model ditentukan melalui uji Chow dan Hausman, di mana uji Chow mendukung FEM dan uji Hausman menunjukkan REM; namun, FEM dipertahankan untuk interpretasi yang lebih dalam karena daya penjelas dalam

kelompoknya yang lebih kuat. Hasil estimasi menunjukkan bahwa luas panen (koef = 0,0000721; $p < 0,01$), harga beras (koef = 0,0009185; $p < 0,01$), dan jumlah penduduk (koef = 0,00001874; $p < 0,01$) berpengaruh positif dan signifikan terhadap ketahanan pangan, sedangkan konsumsi beras tidak berpengaruh signifikan. Nilai R^2 sebesar 0,5272 menunjukkan bahwa model tersebut dapat menjelaskan 52,72% variasi ketahanan pangan di suatu wilayah. Temuan ini menekankan perlunya kebijakan pertanian yang adaptif secara regional dan perbaikan distribusi pangan spasial untuk meningkatkan ketahanan dan kinerja sistem pangan.

Kata Kunci: Ketahanan pangan; Luas panen; Harga beras; Konsumsi beras; Jumlah penduduk.

1. Introduction

Food security is a strategic issue that is a primary focus of national development, particularly in an agrarian country like Indonesia. Food is not only seen as a basic human need but also as a crucial factor in supporting a country's economic, social, and political stability (Rumawas *et al.*, 2021). According to Law Number 18 of 2012 concerning Food, food security is defined as the condition of meeting food needs for the nation down to the individual level, as reflected in the availability of sufficient, safe, nutritious, equitable, and affordable food to lead a healthy, active, and productive life in a sustainable manner. This definition emphasizes that food security encompasses not only the quantity and quality of food availability, but also the accessibility and sustainability of the food system itself.

In the Indonesian context, rice remains the primary food commodity most widely consumed by the public. The high level of dependence on rice makes this commodity a key indicator for assessing national food security. Therefore, factors influencing rice availability and affordability, such as harvested area, rice price, consumption levels, and population growth, require a comprehensive analysis to ensure targeted policy strategies (Collins *et al.*, 2021).

One of the provinces that plays a central role in the national food security system is East Java. This region is known as one of Indonesia's main food barns, contributing significantly to national rice production. In 2024, for example, East Java achieved positive performance in the agricultural sector, recording a rice harvest area of approximately 1.2 million hectares and producing approximately 6.5 million tons of dry milled grain (GKG) (Arifin, 2021).

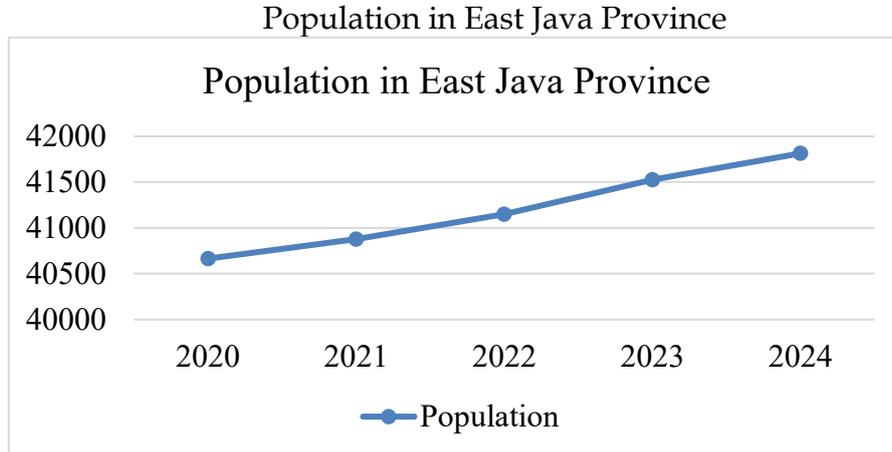
Table 1.
Rice Production and Harvested Area in East Java Province

Year	Rice production (tons)	harvested area (hectares)
2020	9.944.538	1.754.380
2021	9.789.587	1.747.481
2022	9.526.515	1.693.211
2023	9.710.661	1.685.560
2024	9.226.340	1.616.235

Based on BPS data (2020–2024), rice production in East Java decreased from 9,944,538 tons in 2020 to 9,226,340 tons in 2024. This decrease in production is in line

with the decrease in harvested area from 1,754,380 hectares to 1,616,235 hectares during the same period. The most significant decrease occurred in 2023–2024, amounting to 69,325 hectares, or 4.11%. The decrease in harvested area is largely due to the conversion of agricultural land to non-productive land such as residential and industrial areas, which is driven by population growth and infrastructure development (Azizah *et al.*, 2024).

Figure 1.



Population growth in East Java also places additional pressure on food security. The province's population will increase from 40.6 million in 2020 to 41.8 million in 2024. This population increase results in increased demand for food, particularly rice, the staple food of the majority of Indonesians. This growth also drives land conversion and increases consumption, exacerbating the imbalance between food availability and demand.

On the other hand, rice consumption in East Java in the last five years has shown an increasing trend, from 72,474,691 tons in 2020 to 76,022,795 tons in 2023, before decreasing slightly to 74,985,502 tons in 2024.

Table 2.

Rice Consumption and Rice Prices in East Java Province

Year	Rice Consumption (tons)	Rice Price (rupiah)
2020	72.474.691	9.698
2021	75.593.715	9.455
2022	75.719.312	8.823
2023	76.022.795	10.628
2024	74.985.502	11.745

This high consumption rate indicates that the population still relies heavily on rice as its primary source of daily calories. Per capita consumption reaches 150 kg per year, far above the FAO standard of 120 kg (Dinas Pertanian Jawa Timur, 2023).

Based on data from the Information System for Availability and Price Development of Staple Foods in East Java (2025), the price of rice decreased from Rp9,698 per kilogram in 2020 to Rp8,823 in 2022. However, since 2023, the price of rice has experienced a significant increase, reaching Rp10,628 per kilogram and continuing to rise to Rp11,745 in 2024. This increase in rice prices has put pressure on people's purchasing power, especially low-income groups who rely on rice as their main source of food. Sharp price fluctuations can exacerbate food vulnerability by

reducing people's access to adequate and affordable staple foods (Khasanah dan Gunanto, 2024)

Fluctuating rice prices, declining harvested area, increasing consumption, and population growth highlight the multidimensional challenges of maintaining food security in East Java Province. If not addressed with an integrated, data-driven policy approach, this situation could have serious implications for regional and national economic stability. Therefore, empirical analysis is crucial to identify the extent to which each factor impacts food security.

The selection of variables in this study is based on previous literature reviews that highlight harvested area, rice price, rice consumption, and population as key factors in determining food security (Rahim et al., 2024; Khasanah & Gunanto, 2024). Harvested area and rice price reflect availability, while consumption and population reflect demand and pressures on the food system (Hadi et al., 2023). The simultaneous use of all four variables allows for a more comprehensive analysis of food security dynamics.

However, there are still gaps in previous research, which generally focused on only one or two variables or used a cross-sectional approach. Therefore, this study combines all four variables in a single panel data regression model covering five years (2020–2024) and involving 38 districts/ cities in East Java Province. This analysis aims to provide a more holistic and spatial-temporal understanding of the province's food security situation.

The main objective of this study is to empirically analyze the influence of several key factors on food security in East Java Province. The specific objectives of this study include: (1) examining the influence of harvested area on food security; (2) evaluating the impact of rice prices on food security; (3) analyzing the relationship between rice consumption levels and food security; and (4) assessing the influence of population size on food security. It is hoped that the results of this study can provide relevant policy recommendations for local governments in maintaining the stability of food production and distribution, preventing food crises, and increasing the efficiency and sustainability of agricultural resource management in East Java Province.

2. Research Methods

This study uses a quantitative approach with panel data regression to analyze the influence of harvested area, rice prices, rice consumption, and population on food security in East Java Province. This province was chosen because it contributes significantly to national rice production while also facing challenges related to consumption and high population growth.

The data used is secondary data. Secondary data was obtained from various official agencies, including the Central Statistics Agency (BPS), the National Food Agency, and the Ministry of Trade's Food Price Information System. The collected data is panel data, combining time series (2020–2024) and cross-sectional dimensions (38 districts/ cities in East Java Province). The data was obtained through a literature review, namely by searching and processing official publication documents, statistical reports, and digital archives from government agencies. All data used has been validated and converted into uniform units for use in the regression model. The data used in this study consists of:

Table 3.
 Research Data Sources

No.	Variable	Period	Data Source
1.	Food Security in East Java	2020-2024	National Food Agency
2.	Harvested Area in East Java	2020-2024	BPS
3.	Rice prices in East Java	2020-2024	Information System on Availability and Price Development of Staple Foods in East Java
4.	Rice consumption in East Java	2020-2024	BPS
5.	Population in East Java	2020-2024	BPS

The dependent variable in this study is food security, measured using the Food Security Index (IKP) from the National Food Agency. The IKP encompasses the dimensions of food availability, affordability, and stability at the district/city level. Independent variables include harvested area (X1), rice price (X2), rice consumption (X3), and population (X4).

The analytical tool used in this study is panel data regression processed using STATA software. Panel data regression analysis allows researchers to combine time (time series) and cross-sectional dimensions in a single analytical model.

There are three estimation model approaches commonly used in panel data analysis, namely the Common Effect Model (CEM), Fixed Effect Model (FEM), and Random Effect Model (REM) (Rahim *et al.*, 2024). Model selection is based on the results of the Chow Test and the Hausman Test.

To ensure the validity and reliability of the panel regression model used, several classical assumption tests were carried out, namely the Multicollinearity Test, Heteroscedasticity Test, Residual Normality Test, and Model Specification Test (Linearity).

Model Specifications

The panel regression model used is explicitly written as follows:

$$Y_{it} = \alpha + \beta_1 X_{1it} + \beta_2 X_{2it} + \beta_3 X_{3it} + \beta_4 X_{4it} + u_i + \varepsilon_{it}$$

Information :

- α : Food Security Index
- X_1 : Harvested area
- X_2 : Rice price
- X_3 : Rice consumption
- X_4 : Population
- u_i : Fixed effects of each district/city
- ε_{it} : Error

Although the Hausman Test results indicate that the Random Effects Model (REM) is suitable for use, this study uses the Fixed Effects Model (FEM) because it is more capable of explaining temporal variation within fixed entities and capturing the specific characteristics of each district/city. This is considered more relevant to the research context, which focuses on food security in a specific region.

3. Results and Discussion

Determination of Panel Data Regression Model

a. Chow test

$$F(37, 148) = 4.91$$

$$\text{Prob} > F = 0.0000$$

The Chow test is a testing method used to determine the best model between the Common Effect Model (CEM) and the Fixed Effect Model (FEM) in panel data analysis (Hutagalung & Darnius, 2022). The purpose of this test is to determine whether there is a significant difference between the observed cross-section units. The test results show a value of $F(37, 148) = 4.91$ with $\text{Prob} > F = 0.0000$, which means H_0 is rejected. This means that the FEM model is better than the CEM because there are significant individual effects between panel units, so they cannot be ignored.

The Chow Test results justify that the FEM model is more appropriate for use in this study. The use of the FEM model allows the study to account for specific differences between panel units that contribute to data variation.

b. Hausman test

Table 4.
Hausman test results

Variabel	(b) FE	(B) RE	(b-B) Selisih	S.E.
LP	0,0000721	0,0000702	0,0000019	0,0000083
HB	0,0009185	0,0009122	0,0000063	0,0000112
KB	-0,00000025	-0,00000024	-0,00000001	0,00000005
JP	0,00001874	0,00001803	0,00000071	0,0000013
chi² (4) = 4,22				
Prob > chi² = 0,2389				

The Hausman test is an important test in panel data regression analysis that compares the consistency between two models. The Hausman test compares whether the FEM or REM model is more appropriate (Basuki & Prawoto, 2023). The test results show a chi^2 value of 4.22 with $\text{Prob} > \text{chi}^2 = 0.2389$, thus H_0 is accepted. This means that the REM model is more appropriate because no correlation was found between the individual effects and the independent variables.

These results indicate no significant difference between the Fixed Effect and Random Effect models. Because the Prob value $> \text{chi}^2$ is greater than 0.05, the more appropriate model to use is the Random Effect Model (REM). REM is considered more appropriate because it assumes that individual variation does not significantly influence the relationship between the independent and dependent variables.

Results of Classical Assumptions

a) Multicollinearity (VIF)

Table 5.
 Multicollinearity results

Variabel	VIF	1/VIF
X2	1,22	0,819
X1	1,18	0,849
X4	1,10	0,910
X3	1,08	0,926
Mean VIF	1,15	

The results of the multicollinearity test using the Variance Inflation Factor (VIF) show that all independent variables have VIF values below 10, with the highest value being 1.22 (for the rice price/X2 variable) and an average VIF value of 1.15. This indicates that there are no symptoms of multicollinearity among the independent variables in the model. Thus, the independent variables used are independent of each other and are suitable for inclusion in the panel regression model.

b) Heteroscedasticity

Breusch-Pagan / Cook-Weisberg test for heteroskedasticity

Ho: Constant variance

$\chi^2(1) = 1.37$

Prob > $\chi^2 = 0.2411$

The Breusch-Pagan/Cook-Weisberg test was used to detect heteroscedasticity in the regression model. The test results showed a chi-square value of 1.37 with a probability of 0.2411. Because the probability value is greater than the 0.05 significance level, the decision was made to fail to reject the null hypothesis (H_0), stating that the residual variance is constant. Thus, the model does not contain heteroscedasticity symptoms, which means the model meets the assumption of homoscedasticity.

c) Residual Normality

Skewness/Kurtosis tests for Normality

adj $\chi^2(2) = 1.84$

Prob > $\chi^2 = 0.3985$

The normality test was performed using the Skewness/Kurtosis test. The test results showed an adjusted chi-square value of 1.84 with a probability of 0.3985. A probability value greater than 0.05 indicates that the model residuals are normally distributed. This is important because the assumption of residual normality is necessary for the validity of statistical inferences in regression models, such as hypothesis testing of regression coefficients.

d) Linearity

Ho: model has no omitted variables

$$F(3, 181) = 1.12$$

$$\text{Prob} > F = 0.3415$$

To test the linearity and specification of the model, the Ramsey RESET test was used with the null hypothesis that no relevant variables were omitted from the model (the model was fit). The test results showed an F-value of 1.12 with a probability of 0.3415. Because the probability value is greater than 0.05, the null hypothesis is not rejected. This means that the model does not experience misspecification, and the relationship between the independent and dependent variables in the model can be assumed to be linear.

Panel Data Regression Analysis

Table 6.

Panel Data Regression Analysis Results

Variabel	Koefisien	Std. Error	t- Statistik	Prob.	95% Confidence Interval
X1	0,0000721	0,0000213	3,387	0,001	0,0000301 – 0,0001141
X2	0,0009185	0,0003428	2,679	0,008	0,0002401 – 0,0015970
X3	- 0,0000002514	0,0000001441	-1,745	0,083	-0,000000536 – 0,000000033
X4	0,00001874	0,00000619	3,027	0,003	0,0000065 – 0,0000310
Konstanta	63,584032	3,418312	18,605	0,000	56,825200 – 70,342865

R² Within = 0,5272

R² Between = 0,4831

R² Overall = 0,5025

F-statistik (4,148) = 33,66 dengan p-value 0,0000 (model signifikan)

rho = 0,6761 → 67,61% variasi Y dijelaskan oleh perbedaan antar individu

The coefficient of determination (R-squared) in this regression is divided into three parts: within, between, and overall. The within R-squared value of 0.5272 indicates that 52.72% of the variation in Y within individuals (over time) can be explained by the independent variables. Meanwhile, the between R-squared value of 0.4831 indicates that 48.31% of the variation between individuals can be explained by the model. The overall R-squared value of 0.5025 indicates that half of the total variation in Y can be explained by X1 to X4. These values indicate that the model is quite strong in explaining the relationship between variables, especially in the within-dimension or time dynamics within the same entity.

The F-test results on the model show an F-value (4, 148) of 33.66 with a p-value of 0.0000, which means it is highly statistically significant. This means that simultaneously, variables X1, X2, X3, and X4 together have a significant effect on

variable Y. In other words, this regression model is suitable for use because the independent variables as a whole are able to explain changes in the dependent variable. These results strengthen the argument that the model has good predictive power and does not overfit the data. The very small probability also indicates that the possibility of error in rejecting the null hypothesis is very low, strengthening the validity of the analysis results.

The harvested area variable (X1) has a coefficient of 0.0000721 and is statistically significant at the 5% level ($p = 0.001$). This indicates that each unit increase in harvested area has the potential to increase food security by 0.0000721, assuming other variables remain constant. The 95% confidence interval, which ranges from 0.0000301 to 0.0001141, strengthens the belief in this positive effect. These findings clarify that agricultural land productivity is a crucial factor in supporting regional food security. Efforts to increase harvested area or optimize existing agricultural land can be a key strategy in maintaining food availability. This finding is supported by a study by Haryanto et al. (2020), which shows that agricultural expansion and intensification play a significant role in strengthening regional food security.

The rice price variable (X2) also shows a positive effect on food security with a coefficient of 0.0009185 and a p-value of 0.008, which is far below the significance threshold of 0.05. The confidence interval between 0.0002401 and 0.0015970 indicates the stability of the relationship. Increasing rice prices can reduce people's purchasing power and potentially reduce food security. However, in a regional context, these results indicate that increasing rice prices can reflect the increasing economic value of the agricultural sector, which can encourage increased production, distribution efficiency, and provide economic incentives for farmers to increase productivity. This can also increase investment in the agricultural sector. These findings are in line with the results of research by Siregar & Nasution (2019), which stated that price stability and incentives are important in increasing production and food security.

The rice consumption variable (X3) has a negative coefficient of -0.0000002514 and is not statistically significant ($p = 0.083$). The confidence interval extends from -0.000000536 to 0.000000033, including the value of zero, indicating that the effect of rice consumption on food security cannot be conclusively determined. These results indicate that per capita rice consumption does not necessarily have a direct impact on food security in this region. It is possible that other factors, such as food distribution, logistical efficiency, or dependence on other producing regions, are more dominant in influencing food security than consumption levels themselves. In line with FAO (2021), consumption does not always reflect food security if food distribution is uneven or people begin to shift to non-rice consumption patterns.

The population variable (X4) shows a significant and positive effect on food security with a coefficient of 0.00001874 ($p = 0.003$). The confidence interval between 0.0000065 and 0.0000310 indicates the stability of the estimated effect. In general, an increase in population in a region can drive increased demand for food, but if balanced with growth in production, distribution, and adequate infrastructure, then the increase in population can actually be a driving force for the food security system.

In the context of East Java, population growth accompanied by strengthening the agricultural sector and food distribution shows a synergistic relationship with food security, in accordance with the theory of development economics (Todaro & Smith, 2020).

Overall, the results of this study indicate that improving food security in East Java Province needs to be directed at optimizing harvested area, regulating rice prices to support producer welfare while maintaining affordability for consumers, and managing population growth accompanied by strengthening food distribution and production systems. Although rice consumption does not have a statistically significant effect, this variable remains relevant in long-term planning, particularly within a cross-sectoral policy framework that considers changing consumer consumption patterns.

Food security is not solely determined by production, price, consumption, or demographics. Vulnerability factors such as uneven food distribution, climate fluctuations, and price volatility also play a crucial role and must be anticipated in policy formulation. Uneven distribution can lead to shortages in certain areas even if overall stocks are sufficient. Meanwhile, climate disruptions such as El Niño, changes in rainfall patterns, and seasonal natural disasters can disrupt planting and harvest cycles. High price volatility also creates uncertainty for food sector actors, both producers and consumers. Therefore, the food security strategy in East Java must be holistic, focusing not only on increasing production but also encompassing strengthening distribution systems, price stabilization, developing agricultural systems that are adaptive to climate change, and improving the quality and coverage of food consumption data comprehensively to support more responsive and sustainable policies.

4. Conclusion

Based on panel data regression analysis with the best Fixed Effect Model (FEM), this study found that harvested area, rice prices, and population had a positive and significant effect on food security in East Java Province, while rice consumption had no significant effect. This finding indicates that increasing land productivity, stable rice prices that benefit producers, and strategically managing population growth are key factors in strengthening regional food security. Policy implications that can be taken include strengthening agricultural intensification programs based on narrow land by the district/city level of the Agriculture Service, as well as controlling rice distribution and prices through the National Food Agency with regional implementation scale.

More adaptive local data-driven policies are needed to address regional dynamics, such as the implementation of spatial prediction systems to identify areas vulnerable to food insecurity, regular mapping of food security risks, and strengthening technological interventions such as digitizing the rice supply chain and utilizing satellite data to monitor harvested areas. Local governments, along with technical

agencies and research institutions, need to collaborate in implementing this approach to support sustainable, evidence-based food security.

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