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Research Article

Determinants of Indonesia's Food Security 2019–2023: A Panel Data Analysis

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Abstract: Food security is a critical pillar for ensuring socio-economic stability and achieving sustainable development. This study analyzes the influence of rice production, gross regional domestic product (GRDP) per capita, poverty rate, access to clean water, and the COVID-19 pandemic on Indonesia's food security during the 2019–2023 period. Using panel data regression with the Random Effects Model (REM), the results indicate that rice production, poverty, and access to clean water significantly affect food security. Interestingly, the COVID-19 dummy variable shows a significant positive effect (2020–2022), indicating improved food security during the pandemic years. These findings highlight the effectiveness of government responses, particularly through social protection and food distribution programs. The study provides insights for future policies that prioritize increasing domestic food production, poverty alleviation, and equitable access to clean water as strategies to strengthen sustainable food security.

Keywords: clean water, Covid-19, food security, panel data regression, poverty, rice production

1. INTRODUCTION

Food is the identity of a nation. It is not merely an economic commodity, but the fundamental foundation that drives human life, shapes civilization, and determines the direction of a country's development (Prabayanti et al., 2022). In the context of a developing country like Indonesia, food security is not only an ultimate development goal but also a critical instrument that supports the development process itself (Sen, 1989; Simatupang, 2007).

As defined by the FAO (1996), food security is a condition that not only involves the availability of food but also includes secure and nutritious access for every individual to lead an active and healthy life. This becomes crucial in the context of sustainable development, as the achievement of food security is directly related to the overall welfare of society. Law No. 18 of 2012 underscores that food security is not merely about the quantity and quality of food, but also involves diversity, equitable distribution, and affordability for all societal groups. From this perspective, food security serves as a vital prerequisite for reducing socio-economic inequality and improving the quality of life, which in turn supports inclusive and sustainable economic development (Hikmah & Pranata, 2023).

Food security has two interrelated strategic dimensions. First, it serves as a fundamental requirement to ensure access to adequate quantity and quality of food for all citizens to live

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healthy and productive lives. The right to adequate food has been universally recognized as a basic human right (FAO, 1998; Byron, 1988), and is nationally guaranteed by Law No. 18 of 2012 on Food. Second, food security is a foundation for the development of high-quality human resources. Individuals who are healthy and well-nourished have the capacity to learn, innovate, create knowledge, and become productive workers. In the long run, food security contributes to the creation of a stable, innovative, and competitive economic environment (Timmer, 1997).

Globally, food security has become a strategic issue highlighted by various international organizations such as FAO, WHO, and WFP. Food security is also a core agenda in the Sustainable Development Goals (SDGs), specifically Goal 2: Zero Hunger (Ainistikmalia et al., 2022). This emphasis underscores that food security now concerns not only availability, but also accessibility, affordability, food safety, and the sustainability of food systems (Azyan et al., 2023; Nisa, 2024). These aspects must operate synergistically to achieve sustainable food security (BPS, 2021).

However, the challenges faced are far from simple. Food security is a multidimensional issue influenced by social, economic, cultural, political, and environmental contexts. In policymaking, political dynamics often dominate the direction of interventions, despite the complexity of food issues requiring holistic and cross-sectoral approaches (Suryana, 2014; Tono et al., 2023).

Empirically, Indonesia still faces serious challenges in achieving equitable food security. According to the 2022 Global Food Security Index (GFSI), Indonesia ranked 63rd out of 113 countries. This ranking indicates that despite being an agrarian country, Indonesia still faces structural issues within its national food system. A clear reflection of weak food security is the persistently high prevalence of child stunting.

Based on data from the 2022 Indonesian Nutritional Status Survey (SSGI), the stunting prevalence stood at 21.6%. Although this figure shows a decline from the previous year (24.4%), it remains far from the national target of 14% by 2024 and exceeds the WHO threshold of 20% (MoH RI, 2023). This condition indicates that food security is not only about availability but also includes access to and the quality of nutritious food consumption.

As a monitoring and evaluation instrument, the National Food Agency has developed the Food Security Index (IKP). The classification of food security levels is based on IKP scores. Regions are categorized as highly food-insecure if the score is below 37.61; moderately food-insecure if the score ranges from 37.61 to 48.27; and low food-insecure for scores between 48.27 and 57.11. Meanwhile, regions with low food security are those scoring between 57.11 and 65.96; moderate food security between 65.96 and 74.40; and high food security if the IKP score exceeds 74.40. This categorization is used to facilitate the mapping of regions based on their respective food security conditions (Azhar et al., 2023).

Table 1. Food Security Index in Indonesia 2019-2023

No	Province	2019	2020	2021	2022	2023
1	Aceh	66.22	70.92	71.63	70.16	72.96
2	North Sumatra	69.81	71.84	72.25	71.22	75.97
3	West Sumatra	75.43	78.64	79.55	79.45	83.22
4	Riau	62.37	64.12	66.84	67.59	68.68

5	Jambi	68.23	70.00	74.18	69.50	72.17
6	South Sumatra	69.30	68.67	69.55	69.64	73.82
7	Bengkulu	61.78	70.28	70.32	67.99	72.27
8	Lampung	71.36	77.43	77.96	78.61	81.56
9	Kepulauan Bangka Belitung	56.03	71.21	73.22	71.71	71.14
10	Kepulauan Riau	59.26	62.70	63.26	63.83	65.10
11	Jakarta	66.87	77.97	78.01	78.25	83.80
12	West Java	76.44	76.78	77.79	77.55	82.19
13	Central Java	78.85	82.31	82.73	82.95	84.80
14	DI Yogyakarta	83.63	80.67	81.43	80.88	83.17
15	East Java	73.71	79.90	79.70	79.85	82.46
16	Banten	74.47	73.48	74.38	73.78	78.71
17	Bali	85.15	84.54	83.82	85.19	87.65
18	West Nusa Tenggara	62.43	75.60	75.67	76.58	76.51
19	East Nusa Tenggara	50.69	66.92	67.35	68.42	71.25
20	West Kalimantan	55.17	71.13	71.32	70.81	72.20
21	Central Kalimantan	71.57	72.58	73.68	69.96	68.90
22	South Kalimantan	74.71	80.04	80.29	81.05	81.26
23	East Kalimantan	76.90	78.24	77.46	77.65	72.29
24	North Kalimantan	73.12	71.90	73.02	71.04	74.59
25	North Sulawesi	81.44	77.79	78.30	74.30	77.32
26	Central Sulawesi	68.17	75.10	75.73	75.92	75.83
27	South Sulawesi	78.69	81.81	80.82	81.38	83.36
28	Southeast Sulawesi	76.99	77.06	76.64	75.04	74.96
29	Gorontalo	69.06	80.40	80.52	80.35	81.63
30	West Sulawesi	60.37	76.36	75.49	74.04	73.03
31	Maluku	52.35	58.15	58.70	60.20	64.37
32	North Maluku	66.58	63.12	59.58	58.39	62.34
33	West Papua	30.12	49.40	46.05	45.92	47.95
34	Papua	25.13	34.79	35.48	37.80	42.27
	Indonesia	**66.84**	**72.11**	**72.43**	**71.97**	**74.11**

Source: National Food Agency 2023 (processed data)

Food Security Index Data in Indonesia from 2019 to 2023 shows fluctuations in most provinces. Several provinces demonstrated a consistent increase in the index, including West Sumatra (from 75.43 to 83.22), Lampung (from 71.36 to 81.56), and Central Java (from 78.85 to 84.80). However, some provinces experienced a decline in the index during certain years, such as Central Kalimantan, which decreased from 73.68 (2021) to 68.90 (2023), and East Kalimantan, from 78.24 (2020) to 72.29 (2023). Overall, most provinces recorded an upward trend in food security index scores, indicating improvements in food availability, accessibility, and stability. Nonetheless, the observed fluctuations in several provinces highlight the challenges in maintaining stable food security year over year.

There is a significant disparity in food security index scores among provinces. The province with the highest index score is Bali, consistently maintaining a high score from 85.15 (2019) to 87.65 (2023). In contrast, the provinces with the lowest scores are Papua and West

Papua, although both show an increasing trend. In 2019, Papua's index was only 25.13, rising to 42.27 in 2023. Meanwhile, West Papua increased from 30.12 (2019) to 47.95 (2023). This gap reflects substantial differences in food security between western and eastern regions of Indonesia, likely due to disparities in accessibility, infrastructure, and food distribution. Continuous monitoring of index improvements in certain provinces is essential to reduce the gap and promote more equitable food security across the country.

Factors affecting food security include food production, particularly rice, which is the staple food for the majority of Indonesia's population. National food availability is largely determined by harvested area and rice production volume (BPS, 2024). Research by Wehantouw et al. (2021) confirmed that rice production significantly influences the improvement of the Food Security Index (FSI), consistent with findings by Azzahra et al. (2021), who stated that rice is the primary source of carbohydrates in Indonesia.

In addition to production, purchasing power and income levels also play a crucial role. Several studies have produced varying results: Azyan et al. (2023) found that GDRP per capita has a negative effect on food security, while Fauziyyah and Duasa (2021) reported a positive and significant influence. These findings suggest contextual or regional characteristics may determine the direction of GRDP's influence. Further, research by Purwaningsih et al. (2015) confirmed that per capita food expenditure is a significant determinant of food security.

Poor households are the most vulnerable to food insecurity, as limited income restricts access to nutritious and safe food. Moreover, natural disasters such as floods may worsen these conditions by disrupting food production and distribution (Ermawati, 2011). Access to clean water is also a key determinant. Clean water is necessary not only for direct consumption but also for sanitation and food preparation. Poor water quality adversely affects nutrient absorption and may exacerbate malnutrition (Vilakazi et al., 2019; Nugroho & Mutisari, 2015). The FAO (2015) emphasizes that water crises and poor sanitation pose serious challenges to sustainable food security.

The Covid-19 pandemic, which began in March 2020, added further pressure to global and national food systems. FAO (2020) warned of a potential increase of up to 161 million people suffering from undernourishment due to disruptions in food systems, especially in developing countries. Food security is hierarchical: even if national food security is achieved, it may not be reflected at the household or individual level.

Based on the background described, this study aims to analyze the effects of five socio-economic variables on food security in Indonesia. These variables were selected based on the three key dimensions of food security—availability, accessibility, and utilization—as outlined by the National Food Agency (BAPANAS). This study uses panel data of the Food Security Index (FSI) from 34 provinces in Indonesia for the period 2019–2023. The data are analyzed using panel data regression with the Random Effect Model (REM) approach. The results of this study are expected to provide insights for formulating more targeted and sustainable regional food security policies.

2. METHOD

This research adopts a quantitative approach using an associative research design to analyze the effects of the independent variables—rice production volume, GRDP per capita, poverty rate, access to clean water, and COVID-19—on the dependent variable, namely food security in Indonesia during the 2019–2023 period. The study covers all regions in Indonesia with a total of 170 observations (34 provinces × 5 years), using secondary data obtained from the publications of Statistics Indonesia (BPS) and the Food Security Agency. Data collection was conducted through non-participant observation and document review, including journals, reports, and relevant official publications.

The variables in this study consist of independent variables (X1–X5): rice production volume (tons), GRDP per capita (IDR/capita), poverty rate (%), access to clean water (%), and COVID-19 (dummy variable), and the dependent variable (Y), food security, measured using the Food Security Index (FSI). Operational definitions were formulated for each variable to ensure consistency of meaning, encompassing aspects of food availability, access, and utilization for the food security variable. Measurement scales include nominal, ordinal, interval, and ratio, depending on the nature of each variable.

Data analysis techniques include descriptive statistics and panel data regression using EViews version 12. Descriptive statistics are used to illustrate the general characteristics of the data, such as mean, minimum, maximum, and standard deviation. Panel data regression was chosen due to its ability to combine the strengths of time series and cross-sectional data in estimating relationships between variables. This analysis aims to identify and measure the extent to which each independent variable influences food security across Indonesian provinces during the study period.

3. RESULTS AND DISCUSSION

Data Analysis Results

Descriptive Statistical Analysis

Table 2. Descriptive Statistics of Variables

	Y	X_1	X_2	X_3	X_4	X_5
Mean	71,492	1602344	73,839	10,395	86,428	0.600
Maximum	87,650	9944538	496,904	27,530	99,860	1,000
Minimum	25.130	324.0100	2,683	3,470	57,600	0.000
Std. Dev	10,811	2649781	102,703	5.334	8,822	0.491
Observation	170	170	170	170	170	170

Source: EViews output (processed data)

The Food Security Index (FSI) (Y), serving as a composite indicator of a region's capacity to fulfill its food requirements (Bapanas, 2022), recorded an average score of 71.49 during the study period. According to the classification by the National Food Agency, this figure falls within the "Very Resilient" category, indicating a generally favorable level of food security across Indonesia. However, the presence of extreme values—a minimum of 25.13 in Papua Province, categorized as "Very Vulnerable," and a maximum of 87.65 in DKI Jakarta—

along with a relatively high standard deviation of 10.81, underscores considerable disparities in food security conditions among provinces.

The volume of rice production (X_1), reflecting the availability of staple food commodities (Ministry of Agriculture, 2021), shows an average provincial production of 1,602,344 tons. East Java, known as one of the country's major rice-producing regions, recorded the highest output at 9,944,538 tons, while the Riau Islands had the lowest at 324,010 tons. The large standard deviation of 2,649,781 tons highlights substantial interprovincial inequality in rice production capacity.

The Gross Regional Domestic Product per Capita (GRDP-Capita) (X_2), representing economic welfare and purchasing power for food (Todaro & Smith, 2015), averaged IDR 73.83 million annually. East Java posted the highest value at IDR 496.90 million, while the lowest, IDR 2.68 million, was observed in the Special Region of Yogyakarta. The high standard deviation of IDR 102.70 million points to sharp income disparities, which may influence the population's ability to access nutritious and sufficient food.

The poverty rate (X_3) remains a critical indicator of food insecurity vulnerability, as households in poverty often face constraints in accessing nutritious food and basic services (FAO, 2016; World Bank, 2020). On average, the provincial poverty rate stood at 10.39%, ranging from a high of 27.53% in Papua to a low of 3.47% in DKI Jakarta. The standard deviation of 5.33% further indicates stark regional poverty differences that contribute to food insecurity gaps across the country.

Access to clean water (X_4), which plays a pivotal role in food utilization and public sanitation (UNICEF, 2017), averaged 86.42% across provinces. The highest access was reported in DKI Jakarta at 99.86%, while the lowest occurred in Bengkulu at 57.60%. A standard deviation of 8.82% reveals disparities in clean water access, potentially affecting consumption efficiency and overall public health—two factors integral to food security outcomes.

Lastly, the COVID-19 dummy variable (X_5) —coded as 1 for pandemic years (2020–2022) and 0 for non-pandemic years (2019 and 2023) —was included to capture the pandemic's impact on food security. The mean value of 0.60 implies that most observations fall within the pandemic period, while the standard deviation of 0.49 suggests a relatively even distribution between pandemic and non-pandemic years. The pandemic has been widely recognized for disrupting food supply chains, logistics, and household economic resilience (OECD, 2020), which may have indirectly influenced regional food security dynamics during this period.

Panel Data Regression Analysis

Table 3. Results of the Best Model Selection

Best Model Selection		
Test	**p-value**	**Results**
Chow Test	0.000	FEM
Hausman test	0.119	REM
LM-Test	0.000	REM

Source: EViews output (processed data)

To determine the most suitable panel data estimation technique, a series of model selection tests were conducted. The Chow test, employed to compare the Common Effect

Model (CEM) with the Fixed Effect Model (FEM), yielded a probability value of 0.000, indicating statistical significance at the 5% level. This result leads to the rejection of the null hypothesis in favor of the alternative, suggesting that FEM is superior to CEM in capturing cross-sectional heterogeneity.

Subsequently, the Hausman test was applied to assess whether the Fixed Effect Model or the Random Effect Model (REM) is more appropriate. The test produced a p-value of 0.119, exceeding the 0.05 threshold, thus failing to reject the null hypothesis. This indicates that REM is preferred over FEM, as it provides consistent and efficient estimates under the assumption of no correlation between individual effects and explanatory variables.

Finally, the Lagrange Multiplier (LM) test was used to compare REM with CEM. The test produced a significant p-value of 0.000, leading to the rejection of the null hypothesis in favor of the alternative hypothesis that supports the Random Effect specification.

Taken together, the results of the Chow, Hausman, and LM tests consistently confirm that the Random Effect Model (REM) is the most appropriate specification for this panel data analysis. Consequently, all subsequent regression estimations in this study are based on the REM approach.

Table 4. Random Effect Model Estimation Results

Random Effect Model (REM) Estimation Results				
Variables	Coefficient	Std. Error	t-Statistics	Probability
Log (X_1)	2.105	0.461	4,564	0.000
X_2	0.001	0.009	0.115	0.908
X_3	-1.160	0.185	-6.243	0.000
X_4	0.490	0.090	5.414	0.000
X_5	1,731	0.570	3.036	0.000
C	23.581	10.137	1.263	0.208
R-Squared	0.415		F-Statistic	23.358
Adj. R-Squared	0.398		Prob (F-Statistic)	0.000
SE of Regression	3.617			

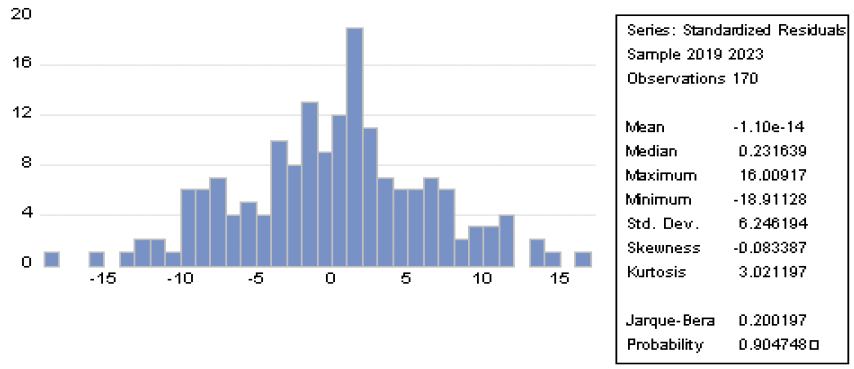
Source: EViews output (processed data)

Based on the estimation results, the regression equation for the Random Effect Model (REM) can be formulated as follows :

$$\hat{Y} = 23.581 + 2.105 \text{ Ln } (X_1) + 0.001(X_2) - 1.160(X_3) + 0.490(X_4) + 1.731(X_5)$$

Classical Assumption Test

1) Normality Test



Source: EViews output (processed data)

Figure 1. Results Normality Test

Based on Figure 1, the Jarque-Bera probability value is 0.904. Since this value is greater than 0.05 (0.904 > 0.05), it can be concluded that the residuals of the regression model are normally distributed.

2) Multicollinearity Test

Table 5. Multicollinearity Test Results

	Log(X_1)	**X_2**	**X_3**	**X_4**	**X_5**
Log(X_1)	1.000	0.171	0.086	0.036	0.003
X_2	0.171	1.000	-0.161	0.102	-0.014
X_3	0.086	-0.161	1.000	-0.273	0.018
X_4	0.036	0.102	-0.273	1.000	0.02
X_5	0.003	-0.014	0.018	0.020	1.000

Source: EViews output (processed data)

The results of the multicollinearity test show that there is no correlation coefficient value between independent variables that exceeds 0.8. Therefore, it can be concluded that the regression model does not experience symptoms of multicollinearity.

3) Heteroscedasticity Test

Table 6. Heteroscedasticity Test Results

Variable	**Coefficient**	**Std. Error**	**t-Statistics**	**Probability**
C	10.732	5.687	1.886	0.060
Log(X_1)	-0.129	0.240	-0.538	0.591
X_2	-0.004	0.004	-0.898	0.370
X_3	0.131	0.097	1.348	0.179
X_4	-0.05	0.053	-1.065	0.288
X_5	-0.525	0.458	-1.146	0.253

Source: EViews output (processed data)

The heteroscedasticity test aims to identify whether or not there is inequality in residual variance in each observation. The ideal regression model should be homoscedastic (constant residual variance). This test is carried out using the Glejser method, by regressing the absolute value of the residual against the independent variable. The test criteria are if the probability value of the independent variable is more than 0.05, then the model is declared free from heteroscedasticity. All independent variables have probability values more than 0.05. Thus, it can be concluded that the regression model does not experience heteroscedasticity problems.

Hypothesis Testing Results

1) Results of the Test of the Effect of Rice Production, GRDP, Poverty, Access to Clean Water, and COVID-19 Simultaneously on Food Security

Table 7. Simultaneous Regression Coefficient Test (F Test)

R-squared	0.415	F-statistic	23.358
Adjusted R-squared	0.398	Prob(F-statistic)	0.000
SE of regression	3.617		

Source: EViews output (processed data)

With real level α =0.05 and degrees of freedom df_1= (k–1) = (6–1) = 5 and df_2= (n–k) = (170–6) = 164, the F-table value obtained is 2.77. Based on Table 5, the F-statistic is 23.358. Because the F-statistic (23.358) > F-table (2.27) and the p-value (0.000) < α (0.05), then H_0 rejected, which means that simultaneously the variables of rice production (X_1), GRDP (X_2), poverty (X_3), access to clean water (X_4), and COVID-19 (X_5) have a significant effect on food security in Indonesia during the 2019–2023 period.

Based on Table 5, the R-squared result of 0.415 means that 41.5 percent of the variation in food security in Indonesia in 2019-2023 is influenced by variations in the amount of rice production, GRDP, poverty, access to clean water, and Covid-19, while the remaining 58.5 percent is influenced by other variables outside the model.

2) **Test Results of the Influence of Rice Production, GRDP, Poverty, Access to Clean Water, and COVID-19 Partially on Food Security**

Table 8. Partial Test Results (t-Test)

	Partial Test Results (t-Test)				
Variables	Coefficient	Std. Error	t-Statistics	t-Table	Probability
Log (X_1)	2.105	0.461	4.564	1.654	0.000
X_2	0.001	0.009	0.115	1.654	0.908
X_3	-1.160	0.185	-6.243	1.654	0.000
X_4	0.490	0.090	5.414	1.654	0.000
X_5	1.731	0.570	3.036	1.654	0.000
C	23.581	10.137	1.263	1.654	0.208
R-Squared	0.415		F-Statistic	23,358	
Adj. R-Squared	0.398		Prob (F-Statistic)	0.000	
SE of Regression	3.617				

Source: EViews output (processed data)

Partial Test (t-test) is used to determine the effect of each independent variable on the dependent variable. The regression results were tested using the t-test at a significance level of α = 0.05. With degrees of freedom (df) = (n - k) = (170 - 6) = 164, the corresponding t-table value is 1.654. To examine the partial effect of each variable, the t-test is applied to the estimates derived from the previously selected model.

1) The Influence of Rice Production Amount on Food Security

Based on the partial test results in Table 8, the coefficient value of the rice production variable (Log X_1) is 2.105, with a t-statistic of 4.564 and a p-value of 0.000. Since the t-statistic = 4.564 > t-table = 1.654, and p = 0.000 < α = 0.05, the testing decision is to reject H_0. This

means that rice production has a positive and significant partial effect on food security in Indonesia.

Quantitatively, the coefficient value of 2.105 indicates that a 1 percent increase in rice production is estimated to increase food security by 0.021 points, assuming other variables remain constant (ceteris paribus).

This result is in line with the concept of food security adopted by FAO, which states that availability is one of the four main pillars of food security, in addition to access, utilization, and stability. Domestic production of staple foods such as rice plays an important role in ensuring sustainable food availability for the wider community.

Karya's study (2012) supports this finding through his study in Central Java which shows that optimizing rice production directly strengthens the food security of farmer households. The use of production inputs such as efficient irrigation, pesticides, and certified superior seeds has been shown to increase crop yields and reduce food vulnerability at the local level.

Mardina (2021) also conducted national food security modeling and identified that rice production has a positive relationship with food security, although it is not statistically significant at the national level. This indicates that the production variable still has a fundamental role, but it needs to be combined with other factors such as population and food prices to provide a more real impact.

A study by Erlangga and Muhammad (2022) adds another dimension by proposing food diversification as an alternative strategy for food security. Over-reliance on rice can be a structural threat if there is a disruption in rice production. Diversifying consumption with local food commodities such as tubers and sorghum can reduce vulnerability and increase long-term food security.

Zaeroni and Rustariyuni (2016) in their research found that the area of rice fields has a significant influence on food production and consumption. This means that not only the technical aspects of production are important, but also the sustainability of agricultural land as the basis for rice production in Indonesia. The shrinking area of agricultural land due to land use conversion can threaten the stability of production and food security.

Alfianti and Maulidyah's (2022) research also confirmed that variables such as harvest area, consumption level, community income, and rice price are interrelated and simultaneously affect rice production and food security at the provincial level, especially in Central Java. This complexity indicates that food security is a multidimensional issue that requires a cross-sectoral approach.

However, Amartya Sen's food security theory emphasizes that food availability alone does not guarantee the achievement of food security. In his entitlement theory, Sen emphasizes that hunger and food insecurity often occur not because of a lack of production, but because of the inability of individuals or groups to access food due to economic inequality, distribution, and market policies. Therefore, although the regression results show a positive effect of the amount of rice production on food security, policy interventions that prioritize accessibility and people's purchasing power remain crucial components.

2) Results of Testing the Influence of PDRB on Food Security

Based on the partial test results in Table 8, the coefficient value of the GRDP variable (X_2) is 0.001, with a t-statistic of 0.115 and a p-value of 0.908. The probability value shown in

EViews is the result of a two-tailed test; therefore, for a one-tailed test, the p-value is adjusted to 0.454 (divided by two). Since the t-statistic = 0.115 < t-table = 1.654, and p = 0.454 > α = 0.05, the testing decision is to fail to reject H_0. This means that, partially, GRDP does not have a significant effect on food security in Indonesia during the 2019–2023 period.

In economic theory, GRDP per capita is often used as an indicator of food access, as stated by Amartya Sen (1981) in the entitlement approach. However, the statistical results of this test show different results. Biantoro's study, July (2017) entitled the causal relationship between food security and GRDP of Regency/City in Central Java in 2014 found that food security and GRDP of Regency/City in Central Java Province in 2014 influenced each other.

Susilastuti's study (2017) entitled Food Security against rice prices, CPI, government spending, GRDP per capita, per capita spending, calorie consumption, protein consumption, under-5 mortality rate found that GRDP per capita has a significant effect on food security.

This finding shows that high GRDP per capita of a region does not necessarily reflect high food security, especially if the income is uneven or not followed by increased access to adequate food. This indicates that food security is not only determined by average income, but also by structural factors such as income distribution, availability of food infrastructure, food price stability, and community accessibility to food sources, as explained by FAO.

This result is supported by the findings in the study by Mardina and Syamsir (2021) which stated that although GRDP per capita shows an increasing trend, it does not necessarily correlate significantly with the food security index. Income inequality and differences in economic distribution between regions are the main factors why increasing macro income is not always directly proportional to increasing people's ability to access sufficient and nutritious food.

In line with that, Research by Heru and Lestari (2020) in the context of the Sulawesi region revealed that areas with high GRDP per capita do not always have a low prevalence of food insecurity. Conversely, areas with lower per capita income but high local food availability and good distribution access actually show more stable food security. A study by Nisa, NA (2024) entitled Determinants of Food Security in Indonesia 2019-2021 found that GRDP per capita had no significance on the food security index in Indonesia.

From a policy perspective, these results emphasize the importance of not only focusing on economic growth alone as an indicator of the success of food security, but also paying attention to income equality policies, food subsidies, strengthening distribution institutions, and empowering local farmers as inseparable elements of a sustainable food security system.

3) Results of Testing the Effect of Poverty on Food Security

Based on the partial test results in Table 8, the coefficient value of the poverty variable (X3) is -1.160, with a t-statistic of -6.243 and a p-value of 0.000. Since the t-statistic = -6.243 < -t-table = -1.654, and p = 0.000 < α = 0.05, the testing decision is to reject H_0. This means that, partially, poverty has a significantly negative effect on food security in Indonesia during the 2019–2023 period.

Quantitatively, the coefficient value of -1.160 indicates that a 1 percent decrease in the poverty rate is estimated to increase the food security index by 1.160 points, assuming other variables remain constant (ceteris paribus).

The results of this study are in accordance with the formulated hypothesis, namely that poverty has a negative effect on food security.This finding is consistent with Sen's Entitlement

Theory, which emphasizes that hunger and food insecurity are not simply the result of a lack of aggregate food availability, but rather the failure of communities to gain access to food through property rights, labor, and social distribution mechanisms. In other words, the existence of food nationally does not guarantee the achievement of food security if communities are in poverty that limits their ability to access food.

Empirically, the results of this study are supported by various previous studies. Hannida (2024) in her study entitled Analysis of the Influence of Rice Production, Poverty, and Prevalence of Undernourishment (PoU) on Food Security in Indonesia found that poverty has a negative and significant influence on national food security, using the panel data analysis method. Reducing poverty levels has been shown to improve food security indicators, especially in terms of accessibility.

Similar results were also found in a study by Rizqia and Asmara (2024) who used the Fixed Effect Model (FEM) approach in their research entitled The Impact of Poverty and Other Determinants on Food Security in Indonesia for the 2019–2023 Period, which showed that poverty contributed significantly negatively to food security between provinces.

Consistent findings were also revealed by a study from IPB University entitled The Effect of Rural Transformation and Climate Change on Food Security in Eastern Indonesia, where poverty was shown to worsen food security in the region. The study stated that people in poor conditions tend to be more vulnerable to fluctuations in food prices and access to food infrastructure.

Furthermore, research conducted by Rachmaningsih and Priyarsono (2013) entitled Food Security in Eastern Indonesia using the Tobit Model approach with panel data of 190 districts/cities during the period 2008–2010 also showed that the percentage of poor people has a significant negative effect on food security. The study explained that poor households are structurally more vulnerable to food insecurity due to limited resources and access to nutritious food. Supporting results were also found in Wulandari's (2018) research in her thesis entitled Analysis of Poverty and Food Security from the Availability Side in West Kalimantan Province, which used the Structural Equation Modeling (SEM) approach with panel data of 14 districts/cities during the period 2003–2015. This study states that poverty significantly affects food security in terms of availability, where areas with high poverty rates generally have more limited and less stable food availability.

However, it should be noted that not all studies show a significant relationship between poverty and food security. The study conducted by Wehantouwet al. (2021) entitled Analysis of Factors Affecting the Level of Food Security in North Sulawesi Province found that the poverty variable has a negative effect on food security but is not statistically significant. In the study, the variables that have a significant effect on food security are rice production and consumption. This shows that in the context of a particular region, the effect of poverty on food security can vary, depending on the economic structure of the region, community consumption patterns, and the effectiveness of the food intervention program implemented.

4) Test Results of the Effect of Clean Water Access on Food Security

Based on the partial test results in Table 8, the coefficient value of the clean water access variable (X_4) is 0.490, with a t-statistic of 5.414 and a p-value of 0.000. Since the t-statistic = 5.414 > t-table = 1.654, and $p = 0.000 < \alpha = 0.05$, the testing decision is to reject H_0. This

means that, partially, access to clean water has a significantly positive effect on food security in Indonesia during the 2019–2023 period.

Quantitatively, the coefficient value of 0.490 indicates that a 1 percent increase in access to clean water is estimated to raise the food security index by 0.490 points, assuming other variables remain constant (ceteris paribus).

This result is in accordance with the proposed Hypothesis and Entitlement Theory developed by Amartya Sen. In his theory, Sen states that food security does not solely depend on food availability but is also greatly determined by people's access to various resources and services, including clean water, which allows them to obtain, process, and utilize food optimally. In this context, access to clean water becomes an important form of entitlement (property rights or access) so that people can survive healthily and productively.

Furthermore, clean water is also a formally recognized component in measuring food security in Indonesia. This is reflected in the calculation of the Food Security Index developed by the National Food Agency (Bapanas). One aspect of the index is "utilization", which measures the ability of the community to consume food safely and nutritiously. In this aspect, the availability of clean water is an important indicator because it plays a direct role in sanitation, health, and food processing and consumption.

This finding is in line with research by Vilakazi et al. (2019) which shows that clean water plays an important role in food processing. Poor water quality can cause foodborne diseases such as diarrhea, which ultimately have a negative impact on the nutritional status of the community and worsen food security. Therefore, access to clean water is an important component in ensuring household and community food security at large.

Cai et al. (2020) also found that food security is highly dependent on the availability of clean water because water is used in all metabolic processes in the body, from food preparation to final consumption. In a global context, clean drinking water is an integral part of the nutritional foundation that is at the heart of food security.

Research conducted by Fathnoy (2022) in Indonesia shows that increasing access to clean water and household sanitation is significantly correlated with a decrease in the prevalence of stunting in children. Given that stunting is an indicator of poor food absorption, this finding strengthens the argument that access to clean water indirectly helps improve the food security dimension in terms of utilization.

Lestari and Astuti (2021), in their journal discussing priority villages for extreme poverty in Central Java Province, stated that the availability of drinking water providescontribution of 4.9% to the Social Resilience Index (IKS), which includes the aspect of food security. This finding indicates that interventions on clean water can strengthen food security, especially in vulnerable areas.

Next, Temesgenet al. (2016) emphasized the importance of sanitation and clean water in households because they affect food absorption. Good sanitation minimizes food contamination and increases the efficiency of nutrient absorption, thus supporting overall food security.

In line with that, Tuckeret al. (2013) stated that water security is the foundation of food security. Access to clean water not only ensures a healthy and productive life but also prevents water-based diseases that can disrupt the balance of human nutrition and productivity, which ultimately affects aggregate food security.

However, different results were found by Santoso (2019) in his study on the influence of infrastructure on food security in Indonesia using panel data from 33 provinces during 2012–2016. In the study, clean water infrastructure did not show a significant influence on food security. This is likely due to the still low coverage of PDAM services in Indonesia, especially in remote areas. In contrast, road, irrigation, and electricity infrastructure were found to have a greater influence on national food security.

5) Results of Testing the Impact of the COVID-19 Pandemic on Food Security

Based on the partial test results in Table 8, the coefficient value of the COVID-19 variable (X_5) is 1.731, with a t-statistic of 3.036 and a p-value of 0.002. The probability value displayed in EViews is the result of a two-tailed test; therefore, for a one-tailed test, the p-value is adjusted to 0.001 (divided by two). Although the t-statistic = 3.036 > t-table = 1.654 and $p = 0.001 < \alpha = 0.05$, H_0 is rejected. This indicates that there is a statistically significant difference in food security between the pandemic period and the non-pandemic period. However, the positive coefficient (1.731) suggests that the food security index during the pandemic period was higher than in the non-pandemic period. This result contradicts the initial hypothesis, which predicted a decline in food security during the pandemic.

Quantitatively, the coefficient of 1.731 indicates that the average food security index during the COVID-19 pandemic was 1.731 points higher compared to the non-pandemic period, assuming other variables remain constant (ceteris paribus). This finding contradicts the initial hypothesis, which expected a decline in food security due to the widespread economic and logistical disruptions caused by COVID-19.

This anomaly may be explained by targeted government interventions. Fauzi and Siregar (2021), using a Difference-in-Differences (DiD) approach, found that food social assistance (BSP), basic food subsidies, and local food resilience programs significantly improved household access to food. Beneficiary households experienced an increase of 8.4 points in their food security index, highlighting the effectiveness of the government's emergency response in cushioning the economic shocks of the pandemic.

Furthermore, Wicaksono et al. (2022) found that the pandemic spurred a shift toward subsistence farming and home-based food systems in several rural areas of Indonesia. Utilizing panel data and logistic regression, their study revealed that villages engaged in active local food production recorded an 11.3% improvement in food security during the pandemic. This underscores the adaptive capacity of communities and the role of local food independence in bolstering resilience.

On the other hand, the global literature offers a contrasting view. A study titled "Deciphering the Impact of COVID-19 Pandemic on Food Security, Agriculture, and Livelihoods" reports that in many developing countries, COVID-19 had a negative impact on food security due to severe disruptions in agricultural production and distribution. Restrictions on mobility hampered farmers' access to critical inputs such as fertilizers and seeds, as well as the ability to bring products to market. Fisheries and livestock sectors were similarly affected, leading to income losses and rising food insecurity, particularly among vulnerable populations.

This study emphasizes the importance of policy interventions that support smallholder farmers, safeguard food distribution networks, and maintain access to agricultural inputs as key strategies to mitigate the adverse impacts of such global crises.

In conclusion, the findings of this study, supported by national and international literature, suggest that the impact of the COVID-19 pandemic on food security is complex and context-dependent. While the overall effect in Indonesia appears statistically positive, this may reflect the effectiveness of government programs and local adaptations rather than the absence of risk. Future policy must therefore be responsive, inclusive, and tailored to regional dynamics in order to strengthen food system resilience under similar shocks.

4. CONCLUSION

This study finds that rice production, GRDP per capita, poverty, access to clean water, and the COVID-19 pandemic collectively have a significant impact on food security in Indonesia during the 2019–2023 period. Partially, rice production and access to clean water have a positive and significant influence, while poverty has a significant negative effect. GRDP per capita does not show a statistically significant relationship with food security. Interestingly, the COVID-19 pandemic appears to have had a positive effect, likely due to effective government food assistance programs during the crisis.

These results suggest that food security policies must go beyond increasing food supply. Efforts should also focus on reducing poverty, improving infrastructure for clean water, and ensuring inclusive access to food resources. A multidimensional and region-specific approach is crucial for achieving long-term food resilience.

5. LIMITATION AND FUTURE RESEARCH

While this study offers important insights, it is limited by the use of aggregate provincial-level data, which may not fully capture variations at the household level. Moreover, the COVID-19 dummy variable does not differentiate between regions based on pandemic severity or government response effectiveness. Future research could explore micro-level household surveys, incorporate environmental factors such as climate variability, and examine the role of food price inflation and land use change in shaping food security outcomes. Mixed-methods approaches may also provide richer perspectives on the interplay between socioeconomic and institutional factors.

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