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DETERMINANTS OF FOOD SECURITY IN INDONESIA

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Abstract

Food security in Indonesia is not only part of the country's commitment to achieving the Sustainable Development Goals (SDGs), but also constitutes a national priority embedded in the Asta Cita agenda through the strengthening of the food sector. This study aims to analyze the determinants of food security in Indonesia, employing the Food Security Index as the dependent variable and gross regional domestic product per capita, total population, and government expenditure on economic functions as independent variables. The study applies the panel Autoregressive Distributed Lag (ARDL) method across 34 provinces over the period 2019 - 2024. The findings reveal that in the short run, increases in gross regional domestic product per capita, total population, and government expenditure on economic functions tend to reduce food security in Indonesia. In contrast, in the long run, all three variables contribute positively to improving food security. The implications of this study underscore the necessity of stabilizing food prices and distribution in the short run. In the long run, the government is encouraged to promote economic growth, optimize expenditure on economic functions, and expand food production capacity. This study is subject to limitations, including a relatively short observation period and a restricted set of variables, which may not fully capture all dimensions of food security.

Keywords: Food Security, Gross Regional Domestic Product (GRDP) per Capita, Total Population, Government Expenditure, Panel ARDL.

INTRODUCTION

Food security represents a critical global issue, as reflected in the second goal of the Sustainable Development Goals (SDGs), namely Zero Hunger. Nevertheless, global progress toward this target remains considerably off track, with approximately 2.33 billion people, or 28.9 percent of the world's total population, experiencing moderate to severe food insecurity (UNICEF, 2023). Indonesia faces a similar challenge, as evidenced by its Food Security Index (FSI) score of 60.2, which falls below the global average of 62.2 (Economist Impact, 2022).

In response to these challenges, the Indonesian government has established food security as a central priority within the Asta Cita 2024 - 2029 development agenda. This commitment is articulated in the second mission, which seeks to strengthen national defense and security while fostering national self-reliance through food, energy, and water self-sufficiency, alongside the development of the creative, green, and blue economies. This mission explicitly positions food self-sufficiency as a foremost national priority (Forum Asta Cita Indonesia, 2026) . The urgency of this commitment is further reinforced by Indonesia's persistent reliance on imports to meet domestic demand for strategic food commodities, particularly rice, over recent decades. The import volume

of this commodity has followed a consistently upward trend from 2022 through 2024, as illustrated in the following figure.

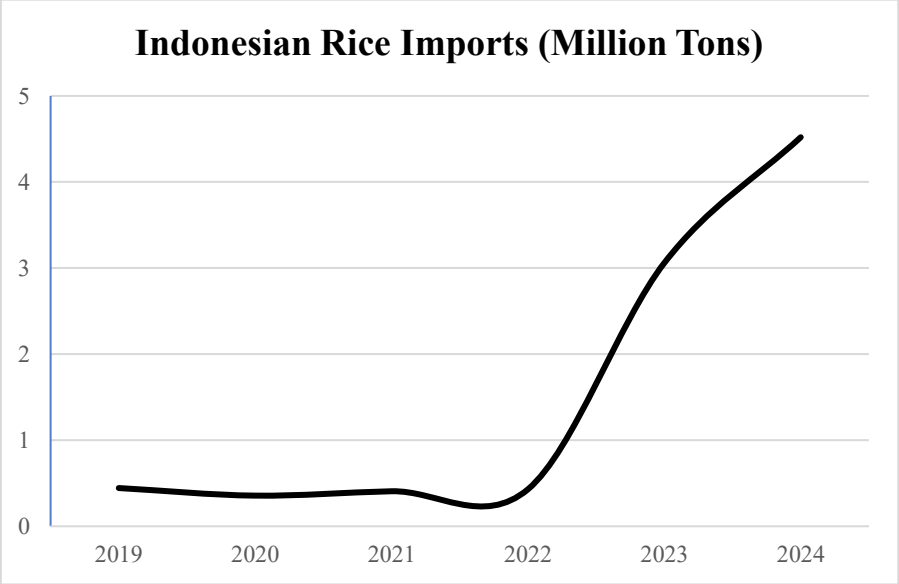


Figure 1. Indonesian Rice Imports (Million Tons), 2019–2024

Figure 1 illustrates that Indonesia's rice import volume remained relatively stable during the 2019 - 2022 period, ranging from approximately 356 thousand to 444 thousand tons per year. However, from 2023 onward, rice imports increased dramatically, reaching 3.06 million tons and rising further to 4.52 million tons in 2024. This pronounced dependence on rice imports constitutes one of the primary factors underlying the government's decision to designate food self-sufficiency as a national development objective.

The pursuit of food security in Indonesia confronts a significant challenge in the form of substantial inter-regional disparities in food security. Based on data from Badan Pangan Nasional (2024) the average Food Security Index (FSI) across regional groups exhibits considerable variation, as illustrated in the following figure.

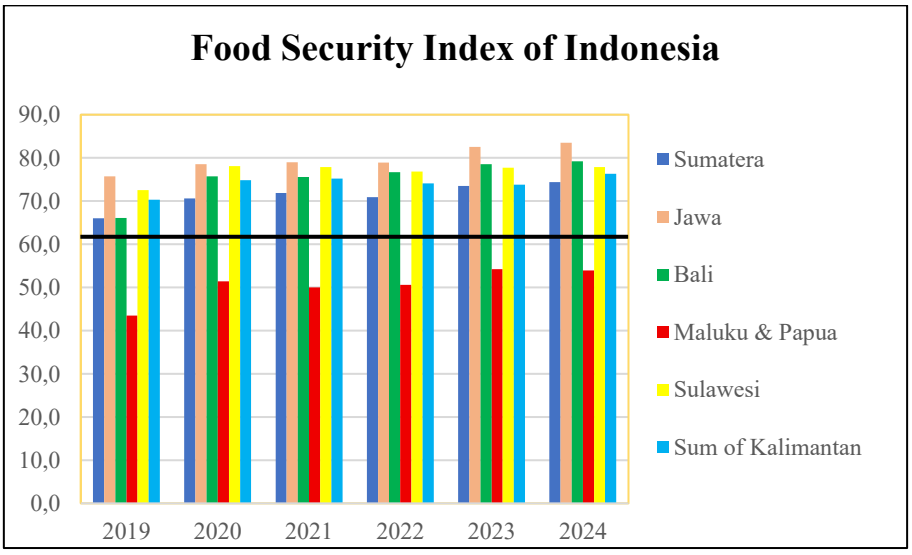


Figure 2. Average Food Security Index of Indonesia by Island Group, 2019 - 2024

Figure 2 reveals that provinces located in Java, Sulawesi, Bali, Kalimantan, and Sumatra recorded Food Security Index (FSI) values above the national average, whereas provinces in eastern

Indonesia, particularly Papua and Maluku, remain considerably below it. This inter regional disparity is closely associated with the economic access dimension of food security, consistent with the entitlement approach proposed by Amartya Sen (1981), who argued that access to food is determined primarily by the entitlements held by individuals, particularly income and purchasing power, rather than by the mere physical availability of food. This finding is further corroborated by Holleman & Conti (2020), who demonstrated that increases in gross domestic product (GDP) per capita are associated with reductions in food insecurity, although this effect may be attenuated by income inequality.

Beyond economic factors, demographic pressure constitutes another important determinant of food security. Regions with high GRDP per capita but large populations, such as Java, face considerably more complex food distribution challenges compared to regions with relatively smaller populations and high GRDP per capita, such as Kalimantan. This is consistent with the findings of Miladinov (2023), who reported that population growth, particularly in rural areas, is positively correlated with a higher prevalence of undernourishment. Furthermore, the fiscal capacity of local governments, as reflected in public expenditure allocated to economic functions, plays a crucial role in determining a region's ability to ensure food availability and accessibility. Throughout the 2019-2024 period, Java consistently received the largest share of government expenditure allocations.

The three factors outlined above namely economic capacity, demographic dynamics, and government fiscal intervention are closely interrelated in shaping inter-regional food security disparities across Indonesia. Nevertheless, studies that simultaneously analyze the influence of all three factors remain limited, particularly those employing a provincial panel data approach. Prior research has largely relied on cros-sectional data or national aggregate time-series data, which are unable to capture inter-provincial heterogeneity and temporal dynamics. This study seeks to address that gap by analyzing the effects of GRDP per capita, total population, and government expenditure on economic functions on the Food Security Index across 34 provinces in Indonesia over the period 2019 - 2024. The findings of this study are expected to provide empirical evidence in support of policy formulation aimed at achieving national food self-sufficiency.

LITERATURE REVIEW AND HYPOTHESIS FORMULATION

LITERATURE REVIEW

Development Objectives

Todaro (2000) argues that development extends beyond mere economic growth and encompasses broader objectives, including equitable income distribution, poverty alleviation, and the overall improvement of human well-being. In the context of this study, human well-being is closely associated with the fulfillment of basic needs, particularly the availability of food that is sufficient, nutritious, and affordable for all segments of society.

At the global level, the commitment to ensuring food security is explicitly reflected in the second goal of the Sustainable Development Goals (SDGs), namely Zero Hunger, which aims to end hunger, achieve food security, improve nutrition, and promote sustainable agriculture by 2030. In alignment with this objective, Indonesia, as a country committed to the SDGs agenda, has integrated the Zero Hunger target into its national development vision. Under the leadership of Prabowo Subianto, this commitment is realized through the second pillar of Asta Cita, which emphasizes the attainment of food self-sufficiency as a means of strengthening national food security.

Food Security

According to the Food Security Cluster (2026), food security refers to a condition in which every individual or group has sufficient food availability to meet their daily needs. This concept is

built upon four interrelated pillars that must be fulfilled simultaneously, namely availability, accessibility, utilization, and stability.

In the context of Indonesia, food security at the regional level is measured using the Food Security Index (FSI), published by Badan Pangan Nasional. FSI scores range from 0 to 100, where lower values indicate higher levels of food insecurity, while scores approaching 100 reflect stronger food security conditions. According to Badan Pangan Nasional (2022), the FSI is calculated using a weighted approach based on nine primary indicators, as follows:

1. The normative consumption ratio relative to net production of rice, maize, sweet potato, and cassava, as well as local government rice reserves;
2. The percentage of the population living below the poverty line;
3. The percentage of households whose food expenditure exceeds 65 percent of total household expenditure;
4. The percentage of households without access to electricity;
5. The average years of schooling for women aged 15 years and above;
6. The percentage of households without access to clean water;
7. The ratio of population to healthcare workers, adjusted for population density;
8. The prevalence of stunting among children under five years of age; and
9. Life expectancy at birth.

Production Theory

Production theory can be represented through a production function, which describes the relationship between inputs (factors of production) and outputs (goods or services produced). One of the most widely applied production theories is the Cobb-Douglas production function, which posits that food production is theoretically influenced by several primary inputs, including land, labor, capital, and technology. These factors collectively determine the level of output generated, whereby improvements in both the quantity and quality of inputs are expected to enhance production capacity and productivity.

Entitlement Approach Theory (Sen, 1981)

Amartya Sen (1981) argued that famine and food insecurity are not caused solely by the physical shortage of food, but rather by the inability of individuals or groups to access food due to limitations in their entitlements, namely the rights over resources required to obtain that food. In other words, a person may experience hunger even when food is available in the market, if they lack adequate economic or social capacity to acquire it.

In the context of this study, the Entitlement Approach provides the conceptual foundation explaining the mechanism of the relationship between the three independent variables and food security. GRDP per capita reflects exchange entitlement, namely the community's economic capacity to exchange its income for adequate food, so the higher a region's GRDP per capita, the greater its community's ability to access food. Total population relates to the distribution of entitlement among members of society, so the larger the population, the more divided the available resources and food access become per individual. Meanwhile, government expenditure on economic functions reflects a form of state intervention aimed at expanding the entitlements of those unable to access food independently through market mechanisms. This is consistent with Sen's (1981) argument that institutional reform and public policy are key to addressing food insecurity.

Engel's Law (Ernst Engel, 1857)

Engel's Law states that as household income increases, the proportion of income spent on food tends to decline, even though the absolute amount of food expenditure may continue to rise. The relevance of Engel's Law to food security lies in its ability to explain consumption patterns

across different income levels. Households with low purchasing power tend to allocate a large share of their income to meeting basic food needs. Conversely, as income rises, consumption patterns shift toward more diverse and higher-quality food products.

In this study, purchasing power as conceptualized in Engel's Law is measured using Gross Regional Domestic Product (GRDP) per capita, which reflects the average level of welfare of the population in a given province. GRDP per capita is calculated by dividing the total gross value added generated within a region over one year by its total population. This study employs real GRDP per capita based on constant prices in order to eliminate the effects of inflation, so that inter-temporal comparisons reflect actual economic growth rather than mere changes in price levels.

Population Theory (Malthus, 1798)

In his seminal work entitled *An Essay on the Principle of Population*, published in 1798, Thomas Robert Malthus argued that population growth tends to outpace the growth of food production. According to Malthus, population increases geometrically, whereas food production grows only arithmetically. Rapid population growth that is not accompanied by a corresponding increase in food production capacity can exert significant pressure on food security. This theory underscores the importance of accounting for demographic dynamics in the formulation of food policy, as sustained population growth may exacerbate the challenges of ensuring adequate food availability and access for the entire population.

Government Intervention

In his influential work entitled *The General Theory of Employment, Interest, and Money*, published in 1936, John Maynard Keynes argued that the economy does not always reach equilibrium automatically through market mechanisms. Accordingly, active government intervention through fiscal policy is necessary to stabilize the economy and improve public welfare.

In the context of this study, Keynesian theory provides a robust theoretical foundation for understanding the role of government expenditure in the economic sector as a fiscal policy instrument in supporting food security. Regions that receive greater government expenditure are expected to experience improvements in agricultural infrastructure, food distribution systems, and social protection programs, which ultimately strengthen public access to food. Conversely, limited government expenditure may undermine a region's capacity to ensure adequate food availability and accessibility for its population. Government fiscal intervention therefore plays a crucial role in strengthening food security, particularly in areas where market mechanisms alone are insufficient to address food-related challenges.

HYPOTHESIS FORMULATION

The Simultaneous Effect of GRDP per Capita, Total Population, and Government Expenditure on Food Security

Food security is a complex phenomenon influenced by the dimensions of food availability, accessibility, utilization, and stability. Simultaneously, economic growth as reflected by Gross Regional Domestic Product (GRDP) per capita can enhance public purchasing power and improve food-related infrastructure. On the other hand, population growth increases demand for food and places greater pressure on food availability. In addition, government expenditure in the economic sector functions as a fiscal policy instrument that can support the development of agricultural infrastructure, strengthen food distribution systems, and expand social protection programs, thereby ultimately improving public access to food. It is therefore hypothesized that these variables jointly influence the Food Security Index (FSI) of a given region.

H1: Gross Regional Domestic Product (GRDP) per capita, total population, and government expenditure simultaneously affect food security in both the short run and the long run.

The Effect of Gross Regional Domestic Product per Capita on the Food Security Index

GRDP per capita reflects the level of economic prosperity of a region. Higher GRDP per capita indicates greater regional fiscal capacity as well as stronger household purchasing power to access diverse and nutritious food. Abdi et al. (2024) found that rising per capita income drives higher food demand, which ultimately contributes positively to regional food security in Sub-Saharan Africa. In line with this, Rachmaningsih & Priyarsono (2012) found that GRDP per capita is one of the key determinants of food security in Eastern Indonesia, indicating that regions with higher levels of economic prosperity tend to possess greater capacity to ensure the food security of their populations. Based on the foregoing discussion, the following alternative hypothesis is proposed:

H2: GRDP per capita has a significant effect on food security in Indonesia in both the short run and the long run.

The Effect of Total Population on the Food Security Index

Population growth generates increasing pressure on food demand, while land resources and food production capacity remain limited. This condition may threaten food security if it is not accompanied by adequate improvements in food productivity and distribution. Prabayanti (2022) found that total population has a significant effect on the rice availability ratio. In line with this, Refnaldo et al. (2019) reported that total population has a significant negative effect on the rice availability ratio, indicating that population growth that is not accompanied by increased production can undermine the food security of a given region. Based on the foregoing discussion, the following alternative hypothesis is proposed:

H3: Total population has a significant effect on food security in Indonesia in both the short run and the long run.

The Effect of Government Expenditure on the Food Security Index

Government expenditure in the economic sector constitutes one of the fiscal intervention instruments that reflects the role of local governments in supporting economic development and food security within their respective regions. Greater allocation of government expenditure in the economic sector is believed to promote improvements in agricultural infrastructure, food distribution, and social protection programs, which ultimately strengthen public access to food. Conversely, limited government expenditure in a given region may undermine local capacity to ensure adequate food availability and accessibility for its entire population. Sujai (2016) found that government fiscal instruments, including food subsidies, tax incentives, and the optimization of budget allocations, have proven effective in stabilizing food commodity prices and maintaining food supply availability in Indonesia. Based on the foregoing discussion, the following alternative hypothesis is proposed:

H4: Government expenditure has a significant effect on food security in Indonesia in both the short run and the long run.

RESEARCH METHODS

Research Design

This study employs a quantitative approach, which relies on measurable data analyzed systematically using statistical and mathematical techniques. Quantitative methods are characteristically aimed at demonstrating relationships among variables. This design was selected for its ability to produce measurable and replicable results.

Research Object and Subject

The object of this study is food security in Indonesia. The subject of this study comprises the determinants influencing food security in Indonesia, with gross regional domestic product

(GRDP) per capita, total population, and government expenditure serving as the independent variables.

Time Period and Research Location

This study covers the period from 2019 to 2024, with the research location encompassing 34 provinces across Indonesia.

Data Collection Technique

This study utilizes secondary data obtained through online searches of official institutional websites, including the Badan Pusat Statistik (BPS), Badan Pangan Nasional (BPN), Direktorat Jenderal Perimbangan Keuangan (DJPK) of the Kementerian Keuangan, ScienceDirect, Google Scholar, and other relevant sources. The following section presents an explanation of the types and sources of data employed in this study:

Table 1. Types and Sources of Data

No	Type of Data	Source of Data
1	Food Security Index (FSI)	Food Security Index (FSI) by Province, 2019–2024 (Badan Pangan Nasional)
2	Gross Regional Domestic Product (GRDP) per Capita	Gross Regional Domestic Product per Capita (Thousand Rupiah) at Constant Prices, 2019–2024 (Badan Pusat Statistik)
3	Total Population	Population by Province in Indonesia (Thousand People), 2019–2024 (Badan Pusat Statistik)
4	Government Expenditure	Realization of Regional Budget (APBD) Capital Expenditure for the Economic Function (Rupiah), 2019–2024 (Direktorat Jenderal Perimbangan Keuangan, Kementerian Keuangan)

Data Analysis Technique

This study employs a quantitative approach, which relies on measurable data analyzed systematically using statistical and mathematical techniques. To analyze the relationships among variables, this study applies the Panel Autoregressive Distributed Lag (ARDL) model. Panel data itself constitutes a combination of time series and cross-sectional data. ARDL is an econometric method that assumes a variable is influenced by its own values in preceding time periods (Ekananda, 2016). The Panel ARDL model is employed in this study because the study aims to examine the effect of the independent variables on the dependent variable in both the long run and the short run. Data processing was carried out using Stata-17 software.

In the model of this study, the food security index is described as a function of GRDP per capita, total population, and government expenditure. Accordingly, the Panel ARDL model can be specified as follows.

$$\Delta FSIit = \alpha_i + \beta_i\left(FSI_{i,t-1} - \delta 1 GRDP_{i,t-1} - \delta 2 TP_{i,t-1} - \delta 3 GE_{i,t-1}\right) + \sum_{\iota=1}^{p-1} \lambda_i \Delta_{FSI_{i,t-1}} + \sum_{\iota=0}^{q-1} \lambda_1 \Delta_{GRDP_{i,t-1}} + \sum_{\iota=0}^{q-1} \lambda_2 \Delta_{TP_{i,t-1}} + \sum_{\iota=0}^{q-1} \lambda_3 \Delta_{GE_{i,t-1}} + \epsilon_{it} \dots\dots\dots\dots (1)$$

Description:

$\Delta FSIit$ = change in the Food Security Index in province *i* at time *t*
α_i = intercept
$\delta_1 \ldots \delta_3$ = long-run coefficients of the independent variables
$\lambda_1 \ldots \lambda_3$ = short-run coefficients of the independent variables
$p, q_1, \ldots, q_3$ = optimal lag lengths
GRDP = gross regional domestic product per capita
TP = total population
GE = government expendicture

According to Ekananda (2016), the steps that must be followed in data analysis using the Autoregressive Distributed Lag (ARDL) method are as follows:

1) Stationarity Test
   Data stationarity can be observed through the measurement of the correlogram, which can also be used to detect the presence of unit roots in the data. In the ARDL method, unit root testing is not strictly required, given that this method does not impose the same order of integration across all variables. Nevertheless, this test is still conducted in this study to ensure that no variable is integrated of order two, or I(2), meaning that no variable becomes stationary only at the second level of differencing. Unit root testing in this study is conducted using the Harris-Tzavalis Test, which is appropriate for panel data with a relatively short time dimension (T).
2) Optimal Lag Selection
   Optimal lag selection in this study is conducted by comparing three information criteria, namely the Akaike Information Criterion (AIC), the Hannan-Quinn Information Criterion (HQIC), and the Schwarz Bayesian Information Criterion (SBIC). These three criteria are used to determine the most optimal lag length in the model. The decision rule for optimal lag selection is to choose the lag length that produces the smallest (minimum) values of AIC, HQIC, and SBIC among all tested lag length alternatives.
3) Cointegration Test
   The cointegration test is employed to determine whether a long-run relationship exists among the variables in the model. Cointegration testing in this study is conducted using the Kao Test, which is based on panel regression residuals to examine the presence or absence of a long-run equilibrium relationship among the variables under investigation.
4) Short-Run Estimation
   The ARDL model is also employed to estimate short-run dynamics through the Error Correction Model (ECM) representation. This short-run estimation describes the adjustment dynamics of the dependent variable in response to changes in the independent variables over a brief period, while simultaneously indicating the speed of adjustment toward long-run equilibrium through the Error Correction Term (ECT) coefficient.
5) Long-Run Estimation
   If the results of the cointegration test indicate the existence of a long-run relationship among the variables under investigation, the analysis proceeds with estimating the long-run coefficients, which reflect the magnitude of the effect of the independent variables on the dependent variable when the model is in a state of long-run equilibrium.

RESULTS AND DISCUSSION

RESULTS

Best Model Selection

The following presents the results of the Chow Test, Lagrange Multiplier Test, and Hausman Test, which are employed to determine the most appropriate model:

Table 2. Results of the Chow, Lagrange Multiplier, and Hausman Tests

Tests	statistic	p-value	Selected Model
Chow Tests	39,33	0,0000	*Fixed Effect Model*
Lagrange Multiplier Tests	366.56	0,0000	*Random Effect Model*
Hausman Tests	12,92	0,0016	*Fixed Effect Model*

Source: Processed Data, Stata 2026

Based on the results of the Chow Test, an F-statistic value of 39.33 was obtained with a Prob > F value of 0.0000 (< 0.05), leading to the rejection of H_o and indicating that the Fixed Effect Model is appropriate for use. Subsequently, based on the results of the Breusch-Pagan Lagrange Multiplier Test, p > |t| values below 0.10 were obtained for all variables, leading to the rejection of H_o and indicating that the Random Effect Model is appropriate for use. Furthermore, based on the results of the Hausman Test, a chi2 value of 12.92 was obtained with a Prob > chi2 value of 0.0016 (< 0.05), leading to the rejection of H_o and indicating that the Fixed Effect Model is more appropriate for use. Accordingly, based on the results of all three tests, the most appropriate model for use in this study is the Fixed Effect Model.

Normality Test

Table 3. Results of the Normality Test

Variable	**Obs**	**Pr (skewness)**	**Pr (kurtosis)**	**Adj chi2(2)**	**Prob>chi2**
residu	204	0,0000	0,0000	62,54	0,0000

Source: Processed Data, Stata 2026

Based on the results of the normality test, the data in the model are found to be non-normally distributed, as indicated by a p-value of 0.0000 (< 0.05). This finding, however, does not necessarily invalidate the adequacy of the model. Given that this study employs macro panel data with a relatively large sample size (N = 204 observations), the normality assumption can be relaxed in accordance with the Central Limit Theorem, under which estimators will asymptotically converge to a normal distribution.

Classical Assumption Tests

a) Multicollinearity Test

Table 4. Results of the Multicollinearity Test

Independent Variable	VIF Value	Tolerance Value (1/vif)	Description
lngrdp	1,28	0,778336	No multicollinearity detected
tp	1,26	0,794859	
ge	1,04	0,964950	

Source: Processed Data, Stata 2026

Based on the results of the multicollinearity test presented in Table 4, all variables pass the multicollinearity test, as the VIF values are all below 10. This indicates that there is no evidence of strong correlation among the variables employed in the model of this study.

b) Heteroskedasticity Test

Table 5. Results of the Heteroskedasticity Test

Chi-Square Value	*p-value* (Prob > chi2)	Description
7645,25	0,0000	Heteroscedasticity detected

Source: Processed Data, Stata 2026

The results of the heteroscedasticity test indicate a probability value of 0.0000, which is less than 0.05. This indicates that the model suffers from heteroscedasticity.

c) Autocorrelation Test

Table 6. Results of the Autocorrelation Test

F-Statistic Value	p-value (Prob > F)	Description
232,236	0,0000	Autocorrelation detected

Source: Processed Data, Stata 2026

The results of the autocorrelation test indicate an F-statistic value of 232.236 with a p-value of 0.0000 (p-value < 0.05), indicating that the model suffers from autocorrelation. The presence of autocorrelation across all four analytical groups does not diminish the validity of the estimation results in this study. Pesaran, Shin, and Smith (1999) explain that the Panel ARDL model is constructed by incorporating lags of both the dependent and independent variables as part of its model specification, so that inter-temporal dynamics in the data are directly accommodated within the model structure. Consequently, the problem of autocorrelation that is commonly found in conventional static regression models does not pose an obstacle in estimation using the Panel ARDL approach, and the estimation results for all four analytical groups remain valid for further interpretation.

Panel Autoregressive Distributed Lag (ARDL)

a) Stationarity Test

Table 7. Results of the Stationarity Test

Variable	Level I(0)	1st-Dif I(1)	2nd-Dif I(2)	Stasionarity
fsi	0,0000	-	-	Level
lngrdp	1,0000	0,0064	-	1-st Dif
tp	0,0073	-	-	Level
ge	0,0192	-	-	Level

Source: Processed Data, Stata 2026

The results of the stationarity test using the Harris-Tzavalis (HT) Test indicate that all variables, namely FSI, TP, and GE, are stationary at the level, as evidenced by probability values below 0.05. This differs from the GRDPPC variable, which requires first differencing to achieve stationarity. This condition satisfies the requirements for applying the ARDL method, as this model can be applied to variables integrated at level I(0), first difference I(1), or a combination of both, provided that no variable is integrated at the second difference I(2) (Ekananda, 2016).

b) Optimal Lag Selection

Table 8. Results of the Optimal Lag Length Selection

Information Criteria	Lag 0	Lag 1	Lag 2	Selected (Optimal) Lag
AIC	67,4105	-102,794	-118,005	Lag 2
HQIC	66,4005	-106,835	-122,046	
SBIC	66,9502	-104,635	-119,847	

Source: Processed Data, Stata 2026

All three information criteria consistently indicate the lowest values at lag 2, with AIC of -118,005, HQIC of -122,046, and SBIC of -119,847. Accordingly, the optimal lag selected for the national-scale analysis is lag 2.

c) Cointegration Test

Table 9. Results of the Cointegration Test

Statistical Indicator	Statistical Value	p-value	Description
Modified Dickey-Fuller t	-0,1707	0,4322	Cointegration exists
Dickey-Fuller t	-2,2691	0,0116	

Source: Processed Data, Stata 2026

The Dickey-Fuller t-statistic value of -2.2691 with a p-value of 0.0116 leads to the rejection of H_0, confirming that a long-run relationship exists among the variables at the national scale.

d) Short-Run Estimation

Table 10. Results of the Short-Run Estimation

Variable	**Coefficient**	**Std. Error**	**z**	**P>|z|**
ECT	-0,8788669	0,0388694	-22,61	0,000
lngrdp	-12,36175	3,606106	-3,43	0,001
D1. tp	-0,001001	0,0005766	-1,74	0,083
D1. ge	-1,24e-12	3,27e-13	-3,78	0,000
D1. _cons	-56,58297	22,24122	-2,54	0,011

Source: Processed Data, Stata 2026

By substituting the parameters into the short-run equation, the following short-run econometric model is obtained:

$$\Delta FSI_{it} = -56{,}58297 - 0{,}8788669 ECT_{it} - 12{,}36175 \Delta lnGRDP_{it} - 0{,}001001 \Delta TP_{it} - 1{,}24 \times 10^{-12} \Delta GE_{it} \quad \text{.....(2)}$$

The results of the short-run relationship estimation at the national level using a significance level of 10% are as follows:

1) The GRDP per capita variable in natural logarithm form (lngrdp) has a negative and significant effect, as evidenced by a coefficient value of -12.36175 with a p-value of 0.001. This implies that in the short run, a 1 percent increase in GRDP per capita will cause the FSI to decrease by 12.36175 points.
2) The total population variable (tp) has a negative and significant effect, as indicated by a coefficient value of -0.001001 with a p-value of 0.083. This indicates that an increase in total population of 1,000 persons will result in a decrease in the FSI of 0.001001 points in the short run.
3) The government expenditure variable (ge) has a negative and significant effect, as evidenced by a coefficient value of -1.24e-12 with a p-value of 0.000. This implies that an

increase in government expenditure of one rupiah will decrease the FSI by -1.24e-12 points in the short run.

4) The ECT coefficient of -0.8788669 indicates that approximately 87.9% of the error or disequilibrium from the previous period is corrected in the current period.

e) Long-Run Estimation

Table 10. Results of the Long-Run Estimation

Variabel	Coefficient	Std. Error	z	P>|z|
lngrdp	11,43584	2,376865	4,81	0,000
tp	0,0021186	0.0006932	3,06	0,002
ge	8,37e-13	4.13e-13	2,03	0,043

Source: Processed Data, Stata 2026

By substituting the parameters into the long-run equation, the following long-run econometric model is obtained:

$$FSI_{it} = \beta_0 + 11{,}43584 lnGRDP_{it} + 0{,}0021186 TP_{it} + 8{,}37 \times 10^{-13} GE_{it} \quad \text{.....(3)}$$

The interpretation of the long-run results is as follows:

1) The GRDP per capita variable in natural logarithm form (lngrdp) has a positive and significant effect, as evidenced by a coefficient value of 11.43584 with a p-value of 0.000. This implies that in the long run, a 1 percent increase in GRDP per capita will cause the FSI to increase by 11.43584 points.
2) The total population variable (tp) has a positive and significant effect, as indicated by a coefficient value of 0.0021186 with a p-value of 0.002. This indicates that an increase in total population of 1,000 persons will result in an increase in the FSI of 0.0021186 points in the long run.
3) The government expenditure variable (ge) has a positive and significant effect, as evidenced by a coefficient value of 8.37e-13 with a p-value of 0.043. This implies that an increase in government expenditure of one rupiah will increase the FSI by 8.37e-13 points in the long run.

Coefficient of Determination

Table 11. Results of the Coefficient of Determination

Analysis Group	Rho
National	0,97949101

Source: Processed Data, Stata 2026

A rho value of 0.97949101 indicates that GRDP per capita, total population, and government expenditure on economic functions are able to explain 97.95 percent of the variation in the Food Security Index, while the remaining 2.05 percent is explained by other factors outside the model.

F-Statistic Test

Table 12. Results of the F-Statistic Test

F-statistic Value	p-value	Description
9,75	0,0000	Signifikan

Source: Processed Data, Stata 2026

An F-statistic value of 9.75 with a p-value of 0.0000 (p-value < 0.10) leads to the rejection of H_o, confirming that GRDP per capita, total population, and government expenditure on economic functions jointly have a significant effect on the Food Security Index at the national scale.

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DISCUSSION

1. Gross Regional Domestic Product per Capita

a) Short Run

At the national level, GRDP per capita has a significant negative effect on the Food Security Index in the short run. At the national scale, Indonesia is undergoing a process of structural transformation characterized by the increasing contribution of the manufacturing and services sectors to GDP, while the contribution of the agricultural sector continues to decline. The contribution of the agricultural sector to national GDP over recent decades has exhibited a downward trend, consistent with the structural transformation of the economy from an agrarian base toward industry and services. As a country advances in its development, a labor shift from the agricultural sector to the industrial and services sectors generally occurs, marked by an increasing number of employed persons with employee or worker status and a declining number of family workers who previously contributed to the agricultural sector (Badan Pusat Statistik, 2024). This condition weakens the domestic food production base in the short run, as reflected in the decline of the Food Security Index despite an increase in GRDP per capita.

This finding is consistent with Prasada et al. (2020), who demonstrated that real per capita income is one of the key factors influencing food security among the population, both in the short run and the long run. This transmission mechanism, however, requires a one-year time lag before it is reflected in the household's share of food expenditure, indicating that the benefits of income growth do not immediately affect the food security of the population within the same period.

b) Long Run

At the national level, the reversal in direction from negative in the short run to positive in the long run serves as evidence that, over the long run, agricultural sector capital has been adequately adjusted. At the national scale, this adjustment is facilitated by the government's long-term agricultural investment policies, including irrigation network expansion programs, agricultural machinery subsidies, and the development of national food reserves through the National Food Agency (Badan Pangan Nasional). With capital now being variable, long-run economic growth can be converted into productive investment in the food sector, so that increases in GRDP per capita exert a positive effect on the Food Security Index at the national level.

This condition is supported by the findings of Azzurri (2024), who demonstrated that agricultural sector productivity is a primary determinant of a country's food security, and that long-term government intervention through policies such as agrarian reform, strengthening of food institutions, and integration of the national food production chain plays an important role in converting economic growth into increased domestic food production capacity, thereby reducing dependence on imports.

2. Total Population

a) Short Run

At the national level, the total population variable has a significant negative effect in the short run. At the national scale, Indonesia's still-positive population growth rate continues to expand the labor supply available in the economy. However, in the short run, capital in the food sector is fixed, agricultural land, irrigation infrastructure, and distribution facilities cannot be expanded instantaneously. As a result, population growth increases pressure on the food demand side without a proportional increase in production capacity, leading to diminishing marginal returns in the food sector and ultimately resulting in a decline in the Food Security Index. This condition is consistent with the Malthusian

argument that in the short run, population growth tends to outpace the limited capacity of food production (Todaro and Smith, 2015).

This finding is consistent with Prayitno (2020), who demonstrated that continuously increasing population growth without a corresponding improvement in food crop productivity can exert pressure on food availability and heighten the risk of food insecurity in the West Java region.

b) Long Run

At the national level, the total population variable has a significant positive effect in the long run. This reversal in direction from negative in the short run to positive in the long run is consistent with the production theory framework, in which capital becomes variable in the long run, allowing additional labor to be matched by proportional capital accumulation. Under these conditions, population growth no longer merely adds to demand-side pressure, but also expands the productive labor force that can be absorbed by the food sector as capital has accumulated, thereby generating a positive effect on the Food Security Index.

This finding is consistent with Risnanda et al. (2025), who found that total population has a significant effect on the Food Security Index in Indonesia. These results indicate that in the long run, population growth not only increases food demand but also expands the labor base and economic activity that can support improvements in food production capacity. With capital accumulation, investment, and the development of agricultural technology, population growth can serve as a productive resource that contributes to improvements in national food security.

3. Government Expenditure

a) Short Run

At the national level, the government expenditure variable has a significant negative effect in the short run. This negative effect can be explained through a short-run crowding out mechanism, whereby large government budget allocations for economic functions in the short run have yet to generate additional productive capital in the food sector, but may instead draw resources, including skilled labor and materials, away from ongoing food production activities toward infrastructure projects that are still under construction. As a result, the already fixed food production capacity is disrupted in the short run by this resource reallocation, causing a temporary decline in the Food Security Index.

This finding is further supported by Mahbubi (2013), who developed a dynamic system model of the rice supply chain and projected that national rice self-sufficiency would continue through 2042. However, the study also found that in the long run, national rice food security would be disrupted if the government does not halt the conversion of agricultural land, particularly paddy fields, for infrastructure development.

b) Long Run

At the national level, the government expenditure variable has a significant positive effect on food security in the long run. This reversal in direction from negative in the short run to positive in the long run is consistent with the production theory framework. In the long run, capital that was originally fixed has expanded through the accumulation of investment in agricultural infrastructure, irrigation networks, and food distribution facilities financed sustainably by the government. At the national scale, the consistency of government expenditure on economic functions throughout the study period has produced a sufficient addition to the productive capital stock in the food sector to drive improvements in the Food Security Index over the long run. Strategic programs such as

national irrigation network rehabilitation, food barn development, and agricultural input subsidies financed through the state budget have cumulatively proven capable of strengthening national food production and distribution capacity.

This is consistent with Mustikaningsih (2017), who found that agricultural sector budget allocation, particularly in the form of seed and fertilizer subsidies, has a significant effect on increasing food crop production, as both constitute direct inputs in agricultural cultivation activities.

CONCLUSION

1. In the long run, changes in GRDP per capita have a positive and significant effect on changes in the Food Security Index. However, in the short run, the opposite result is obtained, whereby GRDP per capita exhibits a negative and significant effect on the Food Security Index.
2. In the long run, changes in total population have a positive and significant effect on changes in the Food Security Index. However, in the short run, the opposite result is obtained, whereby total population exhibits a negative and significant effect on the Food Security Index.
3. In the long run, changes in government expenditure have a positive and significant effect on changes in the Food Security Index. However, in the short run, the opposite result is obtained, whereby government expenditure exhibits a negative and significant effect on the Food Security Index.

The findings of this study carry several practical implications for national-level policy. First, in order to mitigate the short-run negative effect of economic growth on food security, the government should introduce incentives to retain labor in the agricultural sector, including guaranteed paddy prices, agricultural insurance schemes, and subsidies for agricultural production inputs. Second, to address the pressure exerted by population growth on food demand, the acceleration of food production infrastructure development, such as irrigation networks, storage facilities, and agricultural road access, should be proportional to the rate of population growth, with particular attention to regions with high population density. Third, to shorten the time lag between government expenditure realization and improvements in food production capacity, reforms to budget cycle governance are necessary, including the acceleration of procurement processes and the disbursement of agricultural infrastructure spending.

This study is subject to several limitations. First, the relatively short observation period (2019–2024) restricts the scope for deeper exploration of aspects related to the research topic. Second, the government expenditure data employed in this study represents capital expenditure on economic functions drawn from regional government budgets (APBD), which does not directly refer to expenditure specifically allocated to the agricultural sector. Consequently, capital expenditure on economic functions is assumed as a proxy representing the magnitude of local government fiscal intervention in supporting economic activities, including the agricultural sector. Third, this study does not incorporate all factors that theoretically influence food security, such as infrastructure, climate change, and food prices.

In light of these limitations, several directions for future research are proposed. Future studies are encouraged to extend the observation period in order to capture longer-term dynamics and produce more robust estimations. Additionally, future research may consider employing more specific expenditure variables that directly reflect government intervention in the agricultural sector, such as agricultural spending disaggregated at the provincial level. Furthermore, the incorporation of additional variables such as infrastructure indices, climate indicators, and food price volatility into the model would contribute to a more comprehensive understanding of the determinants of food security in Indonesia.

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