Interdependence Of Economic, Demographic And Environmental Variables In Determining Food Security In Indonesia

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Abstract. *Food security is a strategic issue in Indonesia's development, especially with the increasing need for food along with population growth. This study aims to analyze the effect of population, gross domestic product (GDP), inflation, and forest land on food security in Indonesia using the Error Correction Model (ECM) on time series data 2000–2021. The results of the study indicate that only forest land has a significant negative effect. The model also shows a significant long-term equilibrium adjustment mechanism, with an ECT of -0.4496. This finding confirms the importance of the long-term relationship of these variables in determining food security. In addition, these results indicate that forest land management needs to be carried out carefully so as not to disrupt food availability. This study provides a basis for policy makers to formulate a more sustainable food security strategy in the future.*

Keywords: *ECM, Food Security, Good Governance*

1. INTRODUCTION

The country's extensive use of natural resources to support economic growth risks inefficient extraction and environmental degradation. This creates environmental challenges that negatively impact the country's economic performance in the long term. Inefficient and excessive use of natural resources has serious implications for food security. This not only worsens environmental conditions but also has a direct impact on agricultural productivity. As a result, food security is threatened. The situation is exacerbated by rapid population growth, which increases consumption of natural resources and weakens food security. The food crisis is getting worse, hampering sustainable development and affecting people's quality of life.

In the study (Chukwuma et al. 2024) food security according to FAO is a state in which every individual has consistent and unlimited access to a sufficient, safe, nutritious supply of food that meets their dietary needs and preferences, enabling them to maintain an active and healthy lifestyle. Achieving the ambitious Sustainable Development Goals (SDGs), namely eradicating hunger and malnutrition, requires a comprehensive approach. This involves increasing sustainable food production, improving distribution, increasing access to nutrition, and strengthening community economies. In doing so, we can achieve better community well-being and meet SDG Goal 2.

According to (BPS 2023)Statistical data shows that the population of Indonesia in June 2022 is 269.58 million. Based on three scenarios (trend, optimistic, and moderate), population growth is expected to continue to increase. In 2035, the population is predicted to reach 308-309 million, and in 2050 it will reach 329-338 million. On the other hand, the increasing number of growth is followed by increasing deforestation as

evidenced by the decreasing forest land spread across Indonesia, thus stimulating food security problems. Indonesia's rapid population growth has dual consequences, namely increasing deforestation and threatening food security. The higher the population growth, the more forest land is converted into residential areas, reducing food productivity and threatening national food security.

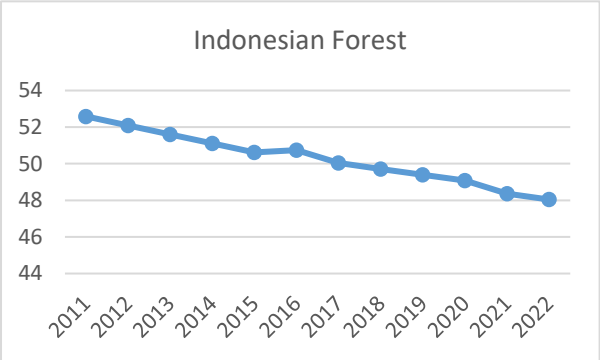

Figure 1. Indonesian forest land 2011-2022
(Source: *WorldBank 2025)*

Food security in Indonesia is faced with several challenges, such as climate change, deforestation, and limited land. In addition, factors such as population growth, changes in food consumption and dependence on food imports also affect food security. According to the GFSI (*Global Food Security Index*) based on 2012-2022, the GFSI Report shows that Indonesia's food security has not reached global standards. With a score of 62.2, Indonesia is still below the global and Asia Pacific average. However, food prices in Indonesia are relatively affordable (81.4). However, the availability of supply (50.9), nutritional quality (56.2), and sustainability (46.3) need to be improved. To overcome this, a comprehensive strategy is needed involving the government, community and private sector. The development of an efficient food logistics and distribution system and increasing access to balanced and nutritious food are also very important.

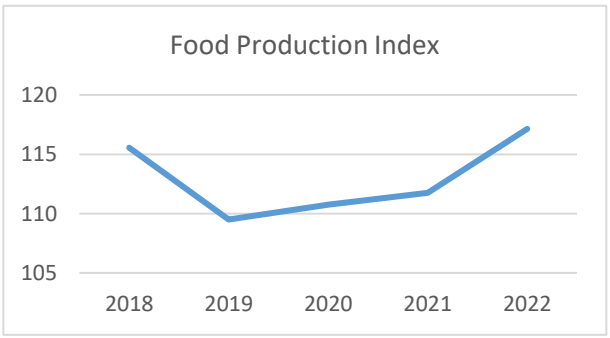

Figure 2. Food Production Index Indonesia 2018 - 2022
(Source: *WorldBank 2025)*

Although Indonesia recorded a significant increase in the Food Production Index (FPI) of 6% in the 2021-2022 period, its food security has yet to reach global standards. This increase shows progress in food production, but the Global Food Security Index (GFSI) still assesses Indonesia's food security below the global average, indicating that there are still many challenges to be overcome in achieving adequate food security. The phenomenon of suboptimal food security in Indonesia, reflected in the Food Production Index (FPI) value which is still below the Global Food Security Index (GFSI) average, is an important background for this study. This study aims to analyze the influence of

macroeconomic and demographic variables on food security in Indonesia, in order to identify factors that influence FPI performance and improve national food security.

2. LITERATURE REVIEW

Research by (Chukwuma et al. 2024) shows that globalization, inflation, and economic growth have different effects on the Food Production Index (FPI) depending on the quantity level. Globalization has a positive impact on FPI at low quantities, but becomes significantly negative at medium to high quantities, indicating a potential threat to the domestic food sector at certain levels of globalization. Inflation has a positive impact on FPI at low quantities, but turns negative at higher quantities, indicating that price pressures can hinder production. In contrast, economic growth consistently has a positive impact on FPI at all quantity levels, reflecting its role in supporting the food sector. In the short-term dynamics, the magnitude of the variable coefficient increases with the shift to higher quantities, emphasizing the importance of contextual policies to encourage food production at various scales.

In the study (Widiarsih 2012) , According to WTO supporting food security includes three main components, namely: 1). Food Availability, which is influenced by policies related to restrictions on imports of basic foodstuffs, government initiatives to increase domestic production, and management of food reserves by related agencies, 2). Food Affordability, which includes aspects of price and accessibility for the wider community, and 3). Food Quality and Nutrition, which focuses on increasing nutritional content and food safety to meet public health standards.

In the study (Partiwi and Sukamdi 2016), the population dimension indicators (population number and growth rate) with each dimension of food security showed that the population has a significant influence on the dimensions of food utilization, socio-economic-cultural access dimensions, and infrastructure access dimensions in the West Java region.

2.1 Food Security Theory.

According to (Bozsik and Stalbek 2022) Lack of access to food is often the main cause of food insecurity, which can be caused by various factors. Insufficient food due to low local production or dependence on imports can worsen the situation, especially in areas with poor infrastructure. Delayed food delivery, either due to inadequate logistics or disruptions in the supply chain, is also a significant obstacle. In addition, lack of money or low income limits the ability to buy food, while high food costs due to inflation or price policies exacerbate food affordability. The combination of these factors creates large gaps in food distribution, which ultimately increases food insecurity in various levels of society, especially in rural areas and vulnerable groups.

2.2 Population Growth

Food security is one of the important elements in the demographic dimension, which is the basis for ensuring the welfare of society. As a basic need for every individual, food must be met adequately to support a healthy and productive life. Moreover, food plays a very vital role in maintaining social, economic stability and the sustainability of a nation. (Pangan, Harga, and Strategis 2024). Good food security is the foundation for sustainable development and national independence.

Malthus' theory (1998) states that food growth develops like an arithmetic progression, while population growth follows a geometric progression. This shows that in line with the increase in population, food needs also increase. (Transfer et al. 2024). Therefore, analysis of the influence of population dynamics on food conditions is important as input in efforts to achieve food security, especially in Indonesia. The population dynamics in question include changes in population growth trends, structure, and distribution, which can be concluded as changes in the number of individuals in a larger community over time.

2.3 Inflation

Indonesia is a country that still has a large dependence on the agricultural sector, especially the rice food sub-sector which is controlled by setting basic prices and maximum prices for food. The implementation of this policy is expected to help farmers to produce, sell their harvests and also to maintain the stability of agricultural product prices both during overproduction and during harvest failures so that there will be no fluctuations in agricultural product prices that can have a negative impact on the stability of prices of goods and services in general. Food price inflation can cause food prices to rise, which in turn can make it difficult for households with fixed incomes to buy enough food. According to (Bozsik and Stalbek 2022) , food inflation refers to the increase in the price of food products over time, which has an impact on consumer purchasing power. This can have varying effects on different segments of the population, with the urban poor being particularly vulnerable to price spikes due to their direct impact on food purchases.

The purpose of this study is to analyze the influence of population, gross domestic product (GDP), and the impact of inflation on food security in Indonesia. This study focuses on the analysis of population data, Gross Domestic Product (GDP), and inflation in Indonesia, and their relationship to food security. In this study, we use secondary data from official institutions, namely the relevant World Bank. This study covers a certain period of time to ensure a comprehensive and contextual analysis.

3. RESEARCH METHODS

3.1 Theoretical Framework

The basis of this research is based on the *Environmental Kuznet Curve* (EKC) theory proposed by Kuznet. This theory states that the Environmental Kuznet Curve (EKC) Theory can explain the relationship between economic growth, environmental quality, and food security as measured by the Food Production Index (FPI) (Gravina et al. 2024) . In the early stages of economic development, increasing food production is often carried out in environmentally damaging ways, such as deforestation, excessive use of chemicals, and exploitation of natural resources, which temporarily increase FPI but threaten sustainability. As economic growth and income increase, awareness of the importance of environmental conservation begins to emerge, encouraging the adoption of environmentally friendly technologies, sustainable agricultural practices, and policies that support the protection of natural resources. This can encourage improvements in environmental quality while ensuring food security as reflected in the FPI in a sustainable manner. However, to achieve this relationship, strategic environmental policies and development of innovation in the agricultural sector are needed, especially in developing countries that face major challenges to natural resources and food production. Therefore, the hypothesis in this study assumes that Forest Land can have both positive and negative impacts on food security, as measured using the Food Production Index (FPI). This is given $\left(\frac{\partial fpi}{\partial fl}\right) > 0 < \left(\frac{\partial fpi}{\partial fl}\right)$Furthermore, Gross Domestic Product (GDP) reflects the level of prosperity and economic welfare of a country as a whole. When economic activity increases, the availability of goods and services for domestic consumption and export also increases. Revenue from exports, which increases foreign exchange reserves, can be used to meet the needs of the community, including food needs. Therefore, an increase in GDP is expected to have a positive impact on a country's food security. $\left(\frac{\partial fpi}{\partial gdp}\right) > 0$. Furthermore, a phenomenon known as population pressure (POP) can have both positive and negative impacts on food security conditions. This is described as $\left(\frac{\partial fpi}{\partial pop}\right) > 0 < \left(\frac{\partial fpi}{\partial pop}\right)$. An increase in population demands an increase in adequate food supply to meet needs. However, problems arise when population growth exceeds the growth in food availability. This situation can threaten food availability and have a negative impact on food security. This view is in line with Malthus' Population Theory, which states that if the population grows

exponentially while food supply only increases linearly, it can lead to food shortages and poverty. Finally, it should be noted that inflation (INF), which indicates an increase in the price of goods and services, can have a negative impact on food security, as shown by the negative relationship between the food price index and inflation $\left(\frac{\partial fpi}{\partial infl}\right) < 0$. When the cost of goods and services increases while income remains unchanged, the purchasing power of individuals and households will be negatively affected. However, the adverse effects of INF can be mitigated through government assistance and higher incomes $\left(\frac{\partial fpi}{\partial infl}\right) > 0$.

3.2 Data

This study uses annual data from 2000 to 2022 to analyze the determinants of food security. Table 1 presents a complete overview of the data sources and units of measurement used. The variable used to represent food security is the Food Production Index (FPI).

Table 1. Data description and sources

Variable	Symbol	Metric	Source
Food Security	FPI	FoodProdindex(2014–2016= 100)	WDI (2024)
Economic Expansion	GDP	constant %	WDI (2024)
Inflation	INFL	Consumer price index (2010=100)	WDI (2024)
Population	POP	Population Growth %	WDI (2024)
Florest Land	FL	Florest Land %	WDI (2024)

(Source: Author)

The Production Index, measured in metric tons, is the main indicator of food production. GDP per capita serves as a proxy for economic expansion. Inflation is measured through the Consumer Price Index (CPI), while population is determined by estimating the total number of people based on census data. In addition, forest land can be assessed as the percentage population (%) of the distribution of forest land. Data from the Globalization Index website (2024) was used to collect globalization data, while all other data were sourced from the World Bank Development Indicators Database.

$$FPI = f(infl + gdp + pop + fl) \quad (1)$$

Equation (1) can also be expressed as follows:

$$fpi_t = \theta_0 + \theta_1 infl_t + \theta_2 gdp_t + \theta_3 pop_t + \theta_4 fl_t \quad (2)$$

3.3 Econometric Strategy

3.3.1 Unit root test

The ADF unit root test is used to assess the stationarity of a data series. However, the reliability of traditional methods such as ADF is often compromised by structural changes. Therefore, this study uses the unit root test with structural changes introduced by Lee and Strazicich (LS) (Aktivani 2021) . The LS unit root test endogenously determines the time of structural change. This LS test allows for one structural change in each data series. The LS model is used to endogenously detect multiple structural changes in a data series (Xt).

$$\Delta X_t = \delta Z_t + \beta \Delta Z_{t-1} + et$$

Where Z t is a vector of exogenous variables, β are parameter coefficients, and et ~ IIDN (0,σ 2) is the error component. This LS test allows for one structural change in each data series. The LS model is used to endogenously detect multiple structural changes in a data series (Xt).

3.3.2 Long-term model equation

Establishing a long-term model equation is an important step to analyze the relationship between relevant variables in this study. Long-term models are designed to

identify stable and sustainable patterns of relationships between variables, regardless of possible short-term fluctuations. In this study, a long-term model will be estimated to test how certain factors, such as economic growth, inflation, population, globalization, and other variables, affect food security as measured by the *Food Production Index* (FPI). With this approach, it is expected that the study can provide an in-depth picture of the causal and structural relationships underlying the dynamics of food security during the observation period.

$$fpi_t = \theta_0 + \theta_1 infl_t + \theta_2 gdp_t + \theta_3 pop_t + \theta_4 fl_t + \varepsilon t$$

Where

Fpi $_t$: *Food Production Index to t* (tons)
Infl $_t$: Inflation to t (percent)
Gdp $_t$: *Gross Domestic Product* to t (percent)
Pop $_t$: *Population Growth* to t (percent)
Fl $_t$: *Florest Land* to t (percent)

3.3.4 Cointegration Test

Cointegration test is conducted to test the long-term relationship between variables, using the Johansen method. Furthermore, to determine whether the analysis using *the Error Correction Model* (ECM) can be carried out up to the short-term model, a stationarity test is conducted on the residuals obtained from the long-term equation using the ADF test. If the residuals are stationary at the level level, then it can be concluded that the variables in the study have been cointegrated. Thus, ECM analysis to identify short-term relationships can be carried out.

3.3.5 Term correction error

The formation of short-term model equations is carried out to analyze the dynamic relationship between variables. The short-term model equations that will be estimated in this study are as follows.

$$\Delta fpi_t = \theta_0 + \theta_1 \Delta infl_t + \theta_2 \Delta gdp_t + \theta_3 \Delta pop_t + \theta_4 \Delta fl_t + Yect + \varepsilon t$$

Where

Fpi $_t$: *Food Production Index to t* (tons)
Infl $_t$: Inflation to t (percent)
Gdp $_t$: *Gross Domestic Product* to t (percent)
Pop $_t$: *Population Growth* to t (percent)
Fl $_t$: *Florest Land* to t (percent)
Δ : Change in variable value
ECT : Error Correction Term
εt : Long Term Residual Model year t

To test the significance of a model, a test will be used.

- t-Statistic Test (Hypothesis)

The t-test is a procedure in which sample results can be used to verify truth or error, where the null hypothesis (H0) is the researcher's belief that will be proven true and the alternative hypothesis (H1) is the opposite or alternative to the null hypothesis .

- f-Statistic Test (Simultaneous)

The f-test is a testing procedure to determine whether all independent variables simultaneously affect the dependent variable. If the f-statistic value is greater than the critical f value, the null hypothesis (H0) is rejected. And if the f-statistic is smaller than the critical f value, the researcher fails to reject the null hypothesis (H0) .

- Coefficient of Determination

The coefficient of determination is used to measure how much of the proportion of the variation in the independent variable explains the variation in the dependent variable. The value of the coefficient of determination is between zero and one.

3.3.6 Classical Assumption Test

- Jarque-Bera Test (Normality Test)

The Jarque-Bera test is used to test whether the residuals of a regression model are normally distributed, which is one of the basic assumptions in classical linear regression. If the residuals are not normal, the coefficient estimates can be inefficient and interfere with statistical inference. This test calculates the non-conformity of the data distribution to a normal distribution based on skewness and kurtosis. The Jarque-Bera statistical function is calculated using the formula:

$$JB = \frac{n}{6}\left(S^2 + \frac{K^2}{4}\right)$$

Where nnn is the number of observations, S is the skewness, and K is kurtosis. If the p-value of this test is less than 0.05, then it can be concluded that the residuals are not normally distributed.

- Breusch-Godfrey Test (Autocorrelation Test)

The Breusch-Godfrey test is used to test for autocorrelation in the residuals of a regression model, which indicates the dependence between the error at a certain time period and the error at the previous time period. Autocorrelation can lead to inefficient coefficient estimates. The statistical function for this test is:

$$LM = n\ x\ R^2$$

Where R2 is the coefficient of determination of the regression of the residuals on the lag variable, and n is the number of observations. If the p-value is less than 0.05, then there is an indication of autocorrelation in the residuals.

- Breusch-Pagan-Godfrey Test (Heteroscedasticity Test)

The Breusch-Pagan-Godfrey test is used to detect heteroscedasticity, a condition in which the residual variance is not constant. Heteroscedasticity can make coefficient estimation inefficient. The statistical function for the heteroscedasticity test is:

$$BP = n\ x\ R^2$$

Where R2 is the coefficient of determination of the residual regression on the independent variable. If the p-value is less than 0.05, it can be concluded that there is heteroscedasticity in the model.

- Variance Inflation Factor (VIF) (Multicollinearity Test)

Variance Inflation Factor (VIF) is used to detect multicollinearity between independent variables in a regression model. High multicollinearity can cause the regression coefficient to become unstable. The function to calculate VIF for each variable is:

$$VIF_i = \frac{n}{1 - R_{i^2}}$$

Where $R_{i^2}$is the coefficient of determination of the regression of variables XiX_i Xi against other independent variables. If the VIF value is greater than 10, then there is an indication of high multicollinearity.

By performing these classical assumption tests, we can ensure that the regression model meets the basic assumptions necessary to produce valid and reliable estimates.

4. RESULTS AND DISCUSSION

Table 2. Descriptive Statistics

Variable	Obs	Mean	Std. dev.	Min	Max
fpi	17	99.99765	8.998377	85.4	115.55
infl	17	5.623529	3.13499	1.6	13.1
gdp	17	4.935294	1.935181	-2.1	6.3
glob	17	56.54588	1.881645	52.12	58.59
pop	17	1.141176	.1970369	.7	1.3

(Source: Researcher)

Table 4. Correlation Matrix

	fpi	infl	gdp	glob	pop
fpi	1.0000				
infl	-0.8064	1.0000			
gdp	-0.6150	0.5235	1.0000		
glob	0.8976	-0.7730	-0.5182	1.0000	
pop	-0.8674	0.7410	0.7314	-0.8777	1.0000

(Source: Author)

Table 1. provides an overview of the five variables analyzed, each with 17 observations. The *Food Production Index* (fpi) variable has an average value of around 100, with relatively small fluctuations, indicating stability in *the Food Production Index* , although the figures range from 85.4 to 115.55. Furthermore, the inflation variable (infl) shows an average inflation of 5.62%, but with a fairly large deviation, namely around 3.13%, reflecting the existence of quite significant inflation variations between periods, with values varying between 1.6% to 13.1%. For *the Gross Domestic Product* (gdp) variable**,** the average is 4.94%, but quite large variations are seen from negative values (-2.1%) to positive 6.3%, illustrating the economic fluctuations that occurred during the analyzed period. The globalization variable (glob) shows an average of 56.55, with a range between 52.12 and 58.59, indicating a relatively stable level of globalization, although there are slight variations . Finally, the population variable (pop) has an average of 1.14, with smaller fluctuations, being between 0.7 and 1.3, reflecting the level of population stability during the analyzed period. Overall, this table illustrates the distribution and variation of each variable, which can provide insight into the relationship between these variables in economic or financial analysis. Table 2. This correlation matrix shows that the Food Production Index (fpi) has a positive relationship with globalization but negative with inflation, Gross Domestic Product (gdp), and population, while inflation is positively related to gdp and population, but negative with globalization, while gdp is positive with population but negative with globalization.

Table 5. Root Test

Variable	Test Type	Level/Diff	Test Statistic	P-Value	Conclusion
fpi	ADF Test	1st Difference	-5.087	0	Stationary
infl	ADF Test	1st Difference	-6.748	0	Stationary
gdp	ADF Test	1st Difference	-6.291	0	Stationary
glob	ADF Test	1st Difference	-4.64	0	Stationary
pop	ADF Test	1st Difference	-3.463	0.0001	Stationary

(Source: Author)

Table 3. The results of the Augmented Dickey-Fuller (ADF) test conducted on data from 2000 to 2022 show that all tested variables, namely the Food Production Index (fpi), inflation (infl), Gross Domestic Product (gdp), globalization index (glob), and population (pop), are proven to be stationary after the first differencing. This means that each variable does not show a significant trend or time dependence after the first difference is applied, which is an indication that the fluctuations in the values of each variable do not follow a systematic pattern that develops over time. In other words, the data from the period 2000 to 2022 do not show an unstable long-term pattern, which makes the data more suitable for use in further time series analysis.

4.1 ECM Model Results

Table 6. Results of Ecm Method

D.fpi	Coefficient	Std. err.	t	P>|t|	[95% conf.	interval]
infl						
D1.	-.3561883	.2330738	-1.53	0.146	-.8502826	.1379061
gdp						
D1.	.0758804	.3420271	0.22	0.827	-.6491847	.8009455
pop						
D1.	21.21745	14.69101	1.44	0.168	-9.926108	52.36101
fl						
D1.	-8.117421	3.507417	-2.31	0.034	-15.55281	-.6820283
ect						
L1.	-.4496011	.1596092	-2.82	0.012	-.7879575	-.1112447
_cons	.5277334	1.04952	0.50	0.622	-1.697149	2.752616

(Source: Researcher)

Based on the data obtained, this study involves five main variables, namely the Forest Productivity Index (FPI) as the dependent variable, and inflation, Gross Domestic Product (GDP), population, and forest land area as independent variables. This study uses the Error Correction Model (ECM) analysis method to examine the relationship between these variables in the short and long term. The results of the analysis show that in the short term, only the forest land variable has a significant effect on FPI with a significance value of 0.034. However, its effect on FPI is negative with a coefficient value of -8.117421. This finding indicates that changes in forest land area tend to reduce forest productivity levels in the short term. This study provides important insights to understand the dynamics of the relationship between variables in the context of different time periods.

In the long-term model study, a significant balance adjustment mechanism was found, indicated by the Error Correction Term (ECT) value of -0.4496011. The negative and significant value of ECT indicates that any short-term imbalance in the model will be adjusted towards long-term equilibrium at an adjustment rate of 44.96% per period. This indicates that the independent variables in this model, such as inflation, GDP, population, and forest land area, have important long-term relationships and contribute significantly to determining the dynamics of the Forest Productivity Index (FPI). In other words, changes that occur in these variables in the long term will have a consistent impact on the FPI, underlining the relevance of the structural relationship between variables in a more stable and sustainable context.

In addition, the R-squared value of 41.67% indicates that this model is able to explain around 41.67% of the variation that occurs in FPI, while the remaining 58.33% is influenced by other factors that are outside the scope of the model. This finding highlights the importance of the variables analyzed in explaining the dynamics of FPI,

while also indicating that there is room to consider additional variables or other external factors that may affect forest productivity in the long term.

4.2 Classical Assumption Test

1. Heteroscedasticity test

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Breusch-Pagan/Cook-Weisberg test for heteroskedasticity
Assumption: Normal error terms
Variable: Fitted values of D.fpi

H0: Constant variance

    chi2(1) =   0.01
Prob > chi2 = 0.9233
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Figure 3. Heteroscedasticity test
(Source: Researcher)

The results of the analysis show that the model passes the heteroscedasticity test, marked by a probability value of 0.9233, which is greater than the significance level of 0.05. This value indicates that there is no heteroscedasticity problem in the model, so that the residual variance can be considered constant at each level of the independent variable. Thus, the model used meets the basic assumptions of classical linear regression, so that the resulting parameter estimates can be said to be efficient. This ensures that the results of statistical analysis, such as significance tests and predictions, are reliable and provide accurate interpretations.

2. Normality test

Shapiro-Wilk W test for normal data

Variable	Obs	W	V	z	Prob>z
ect	23	0.97521	0.648	-0.881	0.81088

Figure 4. Normality test
(Source: Researcher)

The results of the analysis show that the data is normally distributed, as evidenced by the probability value of 0.81088, greater than the significance level of 0.05. Thus, this model is declared to have passed the normality test, which means that the residual distribution meets the basic assumptions of classical linear regression. This condition ensures that the results of statistical tests, such as the *t* and *F tests* , are valid and can be interpreted accurately, so that the model used has good reliability in describing the relationship between variables.

3. Multicollinearity Test

Variable	VIF	1/VIF
fl		
D1.	1.44	0.694230
pop		
D1.	1.41	0.708454
ect		
L1.	1.31	0.761650
infl		
D1.	1.28	0.779650
gdp		
D1.	1.15	0.869565
Mean VIF	1.32	

Figure 5. Multicollinearity test
(Source: Researcher)

The results of the analysis show that the regression model does not experience multicollinearity problems, as evidenced by the average value of the Variance Inflation Factor (VIF) of 1.32, which is smaller than the commonly used tolerance limit of 5. This value indicates that the relationship between independent variables in the model is not too high, so there is no indication of redundancy or significant linear dependence between these variables. Thus, this model can be considered valid for use in the analysis, because the estimation of the regression parameters is not distorted by multicollinearity.

4. Linearity Test

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Ramsey RESET test for omitted variables
Omitted: Powers of fitted values of fpi

H0: Model has no omitted variables

F(3, 15) =   6.79
Prob > F = 0.0041
```

Figure 6. Multicollinearity test
(Source: Researcher)

The results of the analysis show that the model meets the linearity assumption, as indicated by a probability value of 0.0041, which is smaller than the significance level of 0.05. This value indicates that there is a significant linear relationship between the independent variables and the dependent variables in the model. Thus, this model can be declared valid for use in regression analysis, because the relationship between variables is in accordance with the basic assumptions of classical linear regression, which is important for producing accurate parameter estimates and reliable interpretations.

CONCLUSION

The results of the analysis using the Error Correction Model (ECM) model show that in the long term, the sustainability and improvement of the Forest Productivity Index (FPI) are highly dependent on key variables, namely inflation, Gross Domestic Product (GDP), population, and forest land area. These variables have a significant role in shaping the dynamics of the FPI in the long term, by making crucial contributions to the growth and sustainability of the agricultural sector and natural resources as a whole.

However, the analysis also shows that in the short term, only the forest land area variable has a significant impact on FPI. This means that changes in forest land area can directly affect the level of forest productivity in the short term, although its effect on FPI is negative. A decrease in forest land area can reduce the productivity and sustainability of the forest sector, which in turn has an impact on food security and the ecosystem as a whole. Therefore, to ensure sustainable FPI growth, more attention is needed to these variables in economic and environmental policy planning, both in the long and short term. Better management of natural resources, improvement of economic infrastructure, and policies that support forest land conservation are key to strengthening the resilience of the agricultural and environmental sectors.

REFERENCES

Aktivani, Sherly. 2021. “UJI STASIONERITAS DATA INFLASI KOTA PADANG PERIODE 2014-2019.” *Jurnal Statistika Industri dan Komputasi* 6(1): 26–33.

Bozsik, Norbert, and Bopushev Stalbek. 2022. “Food Security Management in Developing Countries : Influence of Economic Factors on Their Food Availability and Access.” *PLOS One*: 1–24.

BPS. 2023. *Proyeksi Penduduk Indonesia 2020 – 2050 Hasil Sensus Penduduk 2020*.

Chukwuma, Joshua, Makuachukwu G Ojide, Mohammad Subhan, and David Forgenie. 2024.

"Food Security in Nigeria amidst Globalization , Economic Expansion , and Population Growth : A Wavelet Coherence and QARDL Analysis." *Journal of Agriculture and Food Research* 18(August): 101413. https://doi.org/10.1016/j.jafr.2024.101413.

Gravina, Antonio Francesco, Matteo Lanzafame, Antonio Francesco Gravina, and Matteo Lanzafame. 2024. *" WHAT ' S YOUR SHAPE ?" ADB ECONOMICS the Environmental Kuznets Curve*.

Pangan, Konsumsi, D A N Harga, and Pangan Strategis. 2024. "ANALISIS PENGARUH JUMLAH PENDUDUK, KETERSEDIAAN PANGAN, KONSUMSI PANGAN, DAN HARGA PANGAN STRATEGIS TERHADAP INDEKS KETAHANAN PANGAN ANALYSIS." *Jurnal Pertahanan dan Bela Negara* 14(2022): 82–102.

Partiwi, Ajrul Arin, and Sukamdi. 2016. "PENGARUH DINAMIKA PENDUDUK TERHADAP KETAHANAN PANGAN DI PROVINSI JAWA BARAT DAN JAWA TIMUR." *Jurnal Bumi Indonesia*.

Transfer, Pengaruh et al. 2024. "Pengaruh Transfer Ke Daerah, Kelahiran, Dan Pengangguran Terhadap Jumlah Penduduk Miskin Di Indonesia." *Journal of Law, Administration, and Social Science* 4(3): 328–39.

Widiarsih, Dwi. 2012. "PENGARUH SEKTOR KOMODITI BERAS TERHADAP INFLASI BAHAM MAKANAN." *Jurnal Sosial Ekonomi Pembangunan* (6): 244–56.