

The Impact of Food Energy Consumption and Poverty Levels on the Prevalence of Food Inadequacy in Indonesia

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ABSTRACT

Food security in Indonesia continues to face serious challenges despite the declining poverty rate, indicating that income growth alone does not necessarily translate into improved nutritional outcomes. This study examines the effects of household food energy consumption and poverty levels on the prevalence of inadequate food consumption across 34 provinces in Indonesia from 2019 - 2024. The findings reveal that higher household food energy consumption significantly reduces the prevalence of inadequate food consumption, whereas poverty levels do not exhibit a significant effect. These results diverge from much of the existing literature that positions poverty as the primary determinant of food insecurity. The novelty of this study lies in demonstrating that food energy adequacy exerts a more direct and consistent influence than poverty status in explaining food insecurity at the provincial level. The policy implication is that poverty alleviation alone is insufficient to address nutritional deficiencies. Instead, interventions should focus on improving household access to energy-dense and nutritious foods through local agricultural development, food price stabilization, and targeted nutrition programs. Such strategies are considered more effective in supporting the achievement of the Zero Hunger target in Indonesia.

Keywords: food energy consumption, food inadequacy, food security, poverty

JEL: Q18, I32, I38, O15

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1. INTRODUCTION

Food security is a crucial aspect of sustainable development goals (SDGs), particularly for developing countries such as Indonesia. The Food and Agriculture Organization (FAO) emphasizes that food security encompasses availability, accessibility, affordability, utilization, and stability. One of the most widely used indicators is the Prevalence of Undernourishment (PoU), which measures the proportion of the population whose dietary energy consumption falls below the minimum requirement. A high PoU indicates limited access to nutritious food and poses a serious threat to the achievement of the second Sustainable Development Goal (SDG 2): Zero Hunger (Pérez-Escamilla, 2017)

However, progress toward the second Sustainable Development Goal (SDG 2) continues to face global challenges such as climate change, geopolitical conflicts, and economic instability, which hinder its achievement (Dangles & Struelens, 2023; Sporchia et al., 2024). The global cost of achieving Zero Hunger is even estimated at USD 39–50 billion per year, underscoring the need for strong political commitment and resource mobilization (Braun & Torero, 2021). In Indonesia, food security challenges remain significant. The Food Security Index shows regional disparities, with some



provinces experiencing higher levels of food insecurity due to limited access and low purchasing power (Kementan, 2022). Data from Statistics Indonesia (Badan Pusat Statistik Indonesia) in 2023 recorded a national poverty rate of 9.36 percent, or 25.9 million people. Although the poverty rate has declined, poor households still allocate most of their expenditure to staple foods that are high in calories but low in protein. As a result, Indonesia's PoU remains above 5 percent (Secretariat General - Ministry of Agriculture Republic of Indonesia, 2023), indicating that poverty reduction alone does not necessarily improve the quality of food consumption. variety (Mehraban & Ickowitz, 2021).

Most previous studies have focused on poverty as the primary determinant of food insecurity, whereas this study seeks to shift the attention toward dietary energy consumption, which is considered to have a more direct impact on nutritional adequacy. By positioning dietary energy consumption as the main variable of analysis, this study offers a new perspective that emphasizes the importance of improving food quality alongside poverty alleviation. In addition, the Food and Nutrition Security Theory emphasizes that food availability alone is not sufficient to achieve overall food security. Equally important are access, utilization, and the nutritional quality of food consumption, which together determine the level of nutritional well-being within a population (Simelane & Worth, 2020).

Classical economic theory, particularly consumer demand theory, posits that the consumption of goods is influenced by relative prices and income levels (Varian, 2014). In the context of food, demand follows elasticity patterns in response to changes in price and income. (Rozi et al., 2023) provides empirical evidence that income elasticity of food consumption varies across commodities, thereby reinforcing the traditional demand framework.

Hamzah & Huang (2023) introduces a consumer preference dimension: shifts in the consumption of strategic food items (for instance, from staple foods to processed foods) may lead to welfare losses when consumers face fluctuations in prices or income. This finding aligns with utility theory, which states that consumers choose consumption bundles that maximize their utility given their preferences, prices, and income. Furthermore, the multi-dimensional framework proposed in Galanakis et al. (2025) highlights that economic variables are not the sole drivers of food consumption. Political, distributional, technological, and social factors also play critical roles in determining access, stability, and the quality of consumption. Hence, traditional economic theories can be extended through integrative models that incorporate non-economic determinants.

Recent empirical evidence shows that energy and protein intake are more decisive for ensuring adequate nutrition. Agustina et al. (2025) found that the majority of Indonesian adults still consume insufficient dietary energy, while Headey et al. (2024) demonstrated that social assistance programs can reduce the risk of energy deficiency even without significant improvements in poverty status. Child nutrition studies also reveal that low animal protein intake is strongly associated with stunting and anemia, even in households not classified as poor (Samosir et al., 2023).

From an economic theory perspective, this argument is consistent with the consumer demand theory, which states that households allocate their limited income to maximize utility under budget constraints. In the context of food consumption, this means that income growth can increase food expenditure, but the quality and diversity of the diet depend on consumer preferences, relative food prices, and knowledge about nutrition. Therefore, improving household welfare does not automatically ensure better dietary energy consumption or nutritional adequacy. Furthermore, rising rural incomes do not always translate into better dietary diversity, as agricultural specialization often leads to reduced food oriented towards economic indicators, but also encompasses the nutritional and food quality dimensions.

Based on the background described earlier. This study formulates two main research questions. First, how does household food energy consumption affect the prevalence of food inadequacy in Indonesia during the period 2019–2024? Second, does the poverty rate have a significant influence on the prevalence of food inadequacy in Indonesia over the same period? In line with these research questions, the objectives of this study are to identify the effect of household food energy consumption

on the prevalence of food inadequacy in Indonesia and to analyze the effect of poverty levels on food inadequacy at the provincial level. Accordingly, this research is expected to contribute to the development of food security policies that are not solely previous studies have mostly emphasized the link between poverty and food insecurity (Fatmah, 2024; Maitra & Rao, 2015). By providing a comprehensive understanding of the determinants of food security, this study offers valuable insights for the formulation of policies aimed at eradicating hunger and improving the quality of food consumption in Indonesia.

2. METHODS

This study employs a quantitative approach using panel data analysis methods to examine the effect of household food consumption and poverty levels on the prevalence of inadequate food consumption in Indonesia. The research uses panel data from 34 provinces in Indonesia, covering the observation period from 2019 to 2024. The data used are secondary data derived from publications of Statistics Indonesia related to socio-economic and poverty indicators, as well as food security data from the National Food Security Agency.

This study applies panel data regression methods with the Random Effect Generalized Least Square (GLS) approach, as this model can capture differences in characteristics across provinces and over time while minimizing potential bias in estimation. Panel regression models can be constructed using three approaches, including Pooled OLS (Common Effect Model) assumes no differences across units (provinces) or over time. The Fixed Effect Model (FEM) assumes unobserved heterogeneity across units is captured through different intercepts. Random Effect Model (REM) assumes heterogeneity across units is random and uncorrelated with the independent variables. Model selection was carried out using the Chow test (OLS vs. FEM), the Hausman test (FEM vs. REM), and the Lagrange Multiplier Breusch-Pagan test (OLS vs. REM). In this study, the Random Effect Generalized Least Square (GLS) approach was chosen because it is more efficient when heterogeneity across provinces is random in nature. Panel regression is widely applied in economic research to address heterogeneity across units and over time (Baltagi, 2021; Gujarati & Porter, 2009).

With regression coefficient estimation using the Random Effect Generalized Least Square (GLS) method to address the problems of autocorrelation and heteroscedasticity that often arise in panel data. The panel regression model equation in this study can be formulated as shown in equation 1.

$$FoodInsufficiency_{it} = \beta_0 + \beta_1 Poverty_{it} + \beta_2 Consumption_{it} + \varepsilon_i \quad (1)$$

In this model (equation 1), ‘*FoodInsufficiency*’ represents the level of food insufficiency in province *i* at time *t*. The variable *Poverty_{it}* denotes the poverty rate, while *Consumption_{it}* captures household food consumption. The parameter β_0 is the intercept, and β_1 and β_2 are the regression coefficients measuring the effects of poverty and food consumption on food insufficiency, respectively. The error term ε_{it} captures unobserved factors affecting food insufficiency, assumed to follow a normal distribution with zero mean and constant variance. This specification allows us to analyze how changes in poverty and food consumption contribute to variations in food insufficiency across provinces and over time. Hypothesis 1 describes a positive and significant β_1 , indicates that higher poverty levels are associated with an increase in food insufficiency. Hypothesis 2 states that a negative and significant β_2 suggests that higher household food consumption reduces food insufficiency. Accordingly, this study tests whether poverty exacerbates food insecurity while food consumption acts as a mitigating factor that strengthens household resilience against food insufficiency.

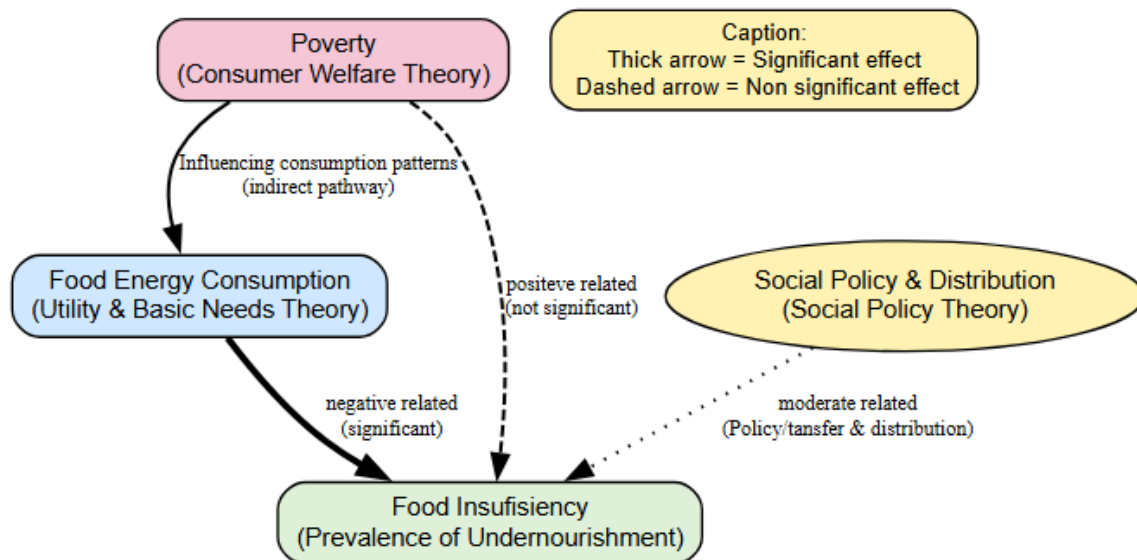
Classical assumption tests were carried out to ensure the validity of the panel data regression model. The multicollinearity test was conducted using the Variance Inflation Factor (VIF) to detect whether there is a high correlation among independent variables. The autocorrelation test was performed to

determine the presence of serial correlation in the error terms across different time periods. Meanwhile, the heteroskedasticity test was conducted to examine whether the error variance is constant (homoscedastic) or not, since ideally the error variance should remain constant, and this was tested using the Breusch–Pagan test or the Modified Wald test in panel data (Baltagi, 2021; Halunga et al., 2017).

If classical assumptions are violated (particularly heteroskedasticity and autocorrelation), robust estimation is applied so that the regression results remain consistent, although not fully efficient. The robust technique used is the Huber-White Sandwich Estimator (commonly referred to as robust standard errors or cluster-robust), because the error is corrected by clustering based on the variable prov → “Std. error adjusted for 34 clusters of provinces” (Awad, 2023). Therefore, this study applied robust estimation to address the issue of heteroskedasticity.

The significance test in panel data regression was conducted to assess the reliability of the estimated coefficients. The partial test (t-test) was used to evaluate the statistical significance of each individual regression coefficient, indicating whether each independent variable has a significant effect on the dependent variable. Meanwhile, the simultaneous test (Wald Chi-square) was applied to examine the overall model fit, ensuring that all independent variables jointly influence the dependent variable.

Figure 1. Conceptual Diagram



Source: Processed by author (2025)

Figure 1 describe the theoretical relationship between variables can be explained Food insufficiency is primarily influenced by energy and protein consumption, which serve as direct indicators of household food security. According to the basic needs and utility theories, fulfilling energy and protein intake enhances physiological well-being and reduces the risk of food insecurity. Hile utility theory explains that food sufficiency increases satisfaction and reduces the risk of food insufficiency. Previous studies consistently demonstrate a negative relationship between adequate nutrient intake and the prevalence of food insufficiency (Varian, 2014; Todaro & Smith, 2020; Khusun et al., 2022).

Poverty plays a critical role in determining households' access to nutritious food. Based on consumer welfare theory, limited income constrains purchasing power, thereby increasing vulnerability to food insufficiency. However, empirical evidence indicates that this relationship is not always significant, largely due to food policy interventions such as price subsidies, social assistance, and rice distribution programs like Stabilization of Food Supply and Prices (Babu & Gajanan, 2021; Indraswari et al., 2024).

In addition to its direct effect, poverty also influences food insufficiency through an indirect pathway,

namely energy and protein consumption. Poor households often rely on low-cost food that is calorie-dense but protein-deficient, reducing dietary quality and exacerbating food insecurity (Puspitaningrum et al., 2023). Thus, food insufficiency emerges as the outcome of interactions between economic conditions, nutritional consumption patterns, and the effectiveness of social policy interventions.

3. RESULT AND DISCUSSION

3.1 Result

3.1.1 Model Selection Test Results

Before conducting the significance test on the model, the initial stage that must be determined and tested is the model selection test, which includes several methods such as the Chow test, the Hausman test, and the LM test.

Table 1. Model Selection Results

Test	Statistic	Prob.	Conclusion
Chow Test (F test that all $u_i=0$)	$F(33,168) = 32.17$	0.0000	Fixed Effect better than Pooled OLS
Hausman Test	$\chi^2(2) = 0.00$	1.0000	Fixed Effect preferred than Random Effect better
Breusch–Pagan LM Test	$\chi^2(1) = 259.64$	0.0000	Pooled OLS than Random Effect better (consistent & efficient)

Source: Author's data processing (2025)

The model selection tests presented in table 1 show that the Chow Test produces an F-value of 32.17 with a probability of 0.0000, indicating that the Fixed Effect Model (FEM) is preferred over the Pooled OLS model. However, the Hausman Test yields a chi-squared value of 0.00 with a probability of 1.0000, suggesting that the Random Effect Model (REM) is more appropriate compared to FEM. Furthermore, the Breusch–Pagan LM Test indicates that REM is superior to Pooled OLS, as shown by the significant probability value of 0.0000. By read the result together, it suggest that the REM is the most efficient and consistent estimation approach for this study.

3.1.2 Classical Assumption Test

In panel data regression, classical assumption tests are conducted to ensure that the estimated model produces coefficients that are consistent, unbiased, and efficient. These tests are essential because panel data often face issues such as multicollinearity among independent variables, heteroskedasticity due to differences in variance across units and time, and autocorrelation caused by error relationships across periods.

Table 2. Results of the Classical Assumption Test on Panel Data

Test	Statistic	Prob.	Conclusion
Multicollinearity (VIF)	Mean VIF = 1.53	-	No multicollinearity detected
Heteroskedasticity (BP test)	$\chi^2(1) = 13.66$	0.0002	Heteroskedasticity present
Wooldridge Test (Autocorrelation)	$F(1,33) = 51.65$	0.0000	Autocorrelation present

Source: Author's data processing (2025)

The results of the classical assumption tests presented in Table 2 indicate that the model does not suffer from multicollinearity problems, as shown by the average Variance Inflation Factor (VIF) value of 1.53, which is below the tolerance threshold of 10. This implies that the independent variables are not highly correlated and the coefficient estimates are reliable.

On the other hand, the Breusch–Pagan heteroskedasticity test produces a chi-square value of 13.66

with a probability of 0.0002 (<0.05), confirming the presence of heteroskedasticity in the model. Similarly, the Wooldridge test for autocorrelation yields an F-statistic of 51.65 with a probability of 0.0000 (<0.05), indicating the existence of autocorrelation in the data.

These findings suggest that although the regression model does not face multicollinearity issues, it does exhibit heteroskedasticity and autocorrelation. To address these problems, the estimation was conducted using heteroskedasticity-robust standard errors to ensure consistent and unbiased results, even when classical assumptions are violated. (Gujarati & Porter, 2009) state that the use of heteroskedasticity-robust standard errors or cluster-robust standard errors can preserve the validity of statistical inferences in regression models when classical assumptions are not fully satisfied.

3.1.3 Model Coefficients and Significance

The results of the coefficient and significance tests of the model using panel data regression with the Random Effect Model (REM) approach are presented in the following table:

Table 3. Hasil Uji Random Effect GLS Regression dengan Robust Standard Errors

Variable	Coefficient	Robust Std. Error	Z	P> z	95% Conf. Interval
PKPX1 (Food Energy Consumption)	-0.0270051	0.0035707	-7.56	0.000	-0.0340035 to -0.0200067
PPMX2 (Poverty Level)	0.0007145	0.0010642	0.67	0.502	-0.0013714 to 0.0028003
Constant	66.63789	7.902444	8.43	0.000	51.14938 to 82.12639

Source: Author's data processing (2025)

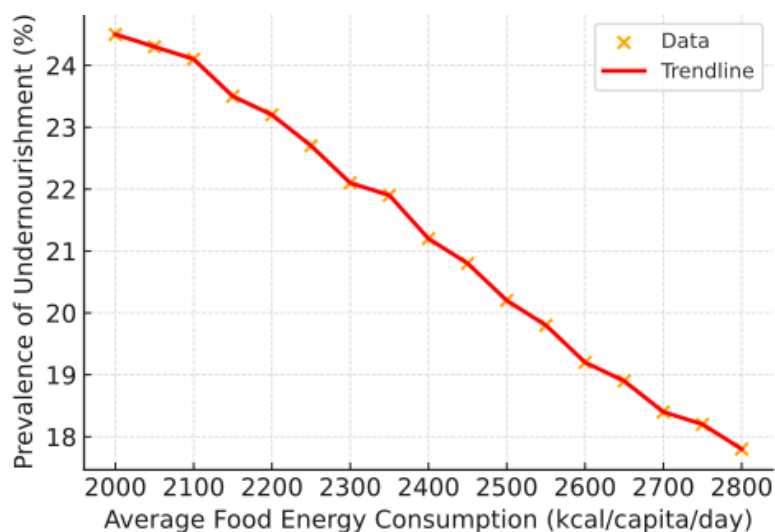
The regression results presented in Table 3 show that the variable PKPX1 (food energy consumption) has a coefficient of -0.0270051 with a p-value of 0.000 (<0.05), indicating a negative and statistically significant effect on the prevalence of undernourishment. This implies that an increase in household food energy consumption contributes to a reduction in undernourishment levels.

Meanwhile, the variable PPMX2 (poverty level) has a coefficient of 0.0007145 with a p-value of 0.502 (>0.05), suggesting that poverty does not have a statistically significant effect on the prevalence of undernourishment in this model. Although poverty reduction is important, the result indicates that its direct impact on undernourishment is not significant when food energy consumption is taken into account.

The constant value of 66.63789 with a p-value of 0.000 confirms that, on average, the baseline prevalence of undernourishment remains high when explanatory variables are held constant. Furthermore, the Wald Chi-square test yields a value of 58.42 with a probability of 0.0000 (<0.05). This indicates that, jointly, the independent variables (food energy consumption and poverty) significantly influence the prevalence of undernourishment.

Figure 2 illustrates the negative relationship between household food energy consumption and the prevalence of undernourishment at the provincial level in Indonesia. Provinces with higher levels of food energy consumption tend to experience lower prevalence rates of food inadequacy, which supports the regression results showing that energy adequacy has a significant effect on reducing food insecurity. This finding confirms that improving the quality and adequacy of food consumption plays a more direct role in addressing nutritional challenges compared to income-related indicators alone.

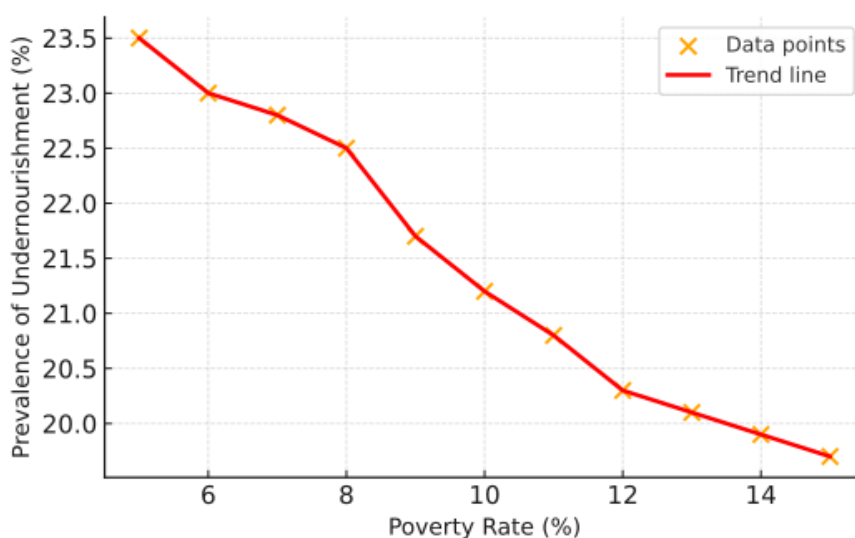
Figure 2. Scatter Plot Food Energy vs Prevalance of Undermourishment



Source: Author's data processing (2025)

In contrast, Figure 3 shows the relationship between the poverty rate and the prevalence of undernourishment. The distribution of data points appears scattered without a clear pattern, indicating that poverty does not have a statistically significant effect on food inadequacy at the provincial level. This result is consistent with the regression analysis, suggesting that the influence of poverty on food insecurity is often mediated by other factors such as food access, distribution systems, and government social protection programs.

Figure 3. Scatter Plot Poverty Rate vs Prevalance of Undermourishment



Source: Author's data processing (2025)

Together, these figures strengthen the conclusion that increasing food energy consumption provides a more immediate and measurable impact on reducing food inadequacy, while the role of poverty is less direct and highly dependent on supporting policies and structural conditions.

3.2 Discussions

3.2.1 Relationship between the Prevalence of Undernourishment (PoU) and Average Food Energy Consumption

The panel regression results indicate that the coefficient of food energy consumption (PKPX1) is negative and statistically significant with respect to the prevalence of undernourishment. This finding is consistent with utility theory, which suggests that higher energy and protein consumption enhances consumer satisfaction and, in turn, reduces the likelihood of food inadequacy. Accordingly, improving access to food, particularly energy-rich food sources, directly increases consumer utility (welfare) and lowers the probability of food insecurity. Garbero et al. (2021) emphasize that agricultural programs which expand the availability of and access to nutritious food, especially sources of animal- and plant-based protein, directly improve household nutritional intake and reduce the prevalence of food insecurity. Increased food energy and protein consumption, therefore, not only strengthens nutritional status but also serves as a concrete indicator of both household and national food security. Rosegrant et al. (2024) further highlight that access to and adequacy of food energy consumption are key components of food security. Insufficient food energy intake increases vulnerability to hunger and malnutrition, while improving food adequacy requires optimizing dietary diversity and consumption patterns. Machfud et al. (2023) demonstrate that aligning the prevalence of undernourishment with average food energy intake shows that a well-balanced food composition can meet 90–110% of daily energy requirements at relatively low cost.

Additional evidence underscores the role of poverty as a structural determinant of food inadequacy. In the case of East Java, Alfin (2025) finds that poverty is significantly influenced by education, unemployment, and wage levels, which directly shape household capacity to secure sufficient food. This finding reinforces the notion that inadequate food energy consumption is not solely a nutritional issue but is also rooted in socioeconomic constraints. From the supply-side perspective, Rizki et al. (2023) observe that the expansion of food and beverage MSMEs contributes to local food availability, thereby supporting greater household access to energy-rich foods. Likewise, Rafli et al. (2025) stress that sustainable supply chain management and process innovation in the food and beverage industry are crucial for ensuring food stability and consistency in food energy consumption. Taken together, these findings affirm that increasing average food energy consumption is a critical pathway to reducing the prevalence of undernourishment. However, this relationship is mediated by broader socioeconomic conditions and supply-side dynamics, underscoring the need for integrated and holistic food security policies.

3.2.2 Relationship between the Prevalence of Undernourishment (PoU) and the Number of Poor People

According to consumer welfare theory, household income determines the budget constraint (Pindyck, 2018). Poverty can limit consumers' ability to allocate income toward nutritious food. Thus, in the standard theory, higher poverty rates should increase the prevalence of undernourishment. However, the regression results show that the number of poor people (PPMX2) does not significantly affect PoU. This finding suggests that although poverty reduces purchasing power, it does not always directly correlate with undernourishment at the provincial level. This can be explained through the concepts of substitution and inter-household transfers, as well as government interventions such as food assistance, subsidies, and social protection programs, which reduce the direct relationship between poverty and undernourishment. Hangoma et al. (2024) argue that poverty can increase the risk of food insecurity, but its impact heavily depends on policy interventions and social safety nets. Similarly, Botreau (2020) finds that poverty does not always directly trigger food insecurity, as other factors such as food access, distribution, and gender inequality play a reinforcing role. Thus, while poverty does have a role, its mechanism of influence on food insecurity is more strongly shaped by access, food distribution, and the effectiveness of

public policies.

4. CONCLUSION

This study concludes that the prevalence of malnutrition in Indonesia is determined more by household food energy consumption than by poverty levels. This finding highlights a novelty compared to previous studies that emphasize income and poverty as the primary drivers of food insecurity. It suggests that while poverty alleviation remains important, it is insufficient to reduce food insecurity unless accompanied by interventions that directly improve food energy sufficiency.

From a policy perspective, the study's findings highlight the need to strengthen local agricultural programs to ensure the availability of energy-dense and nutritious foods, stabilize food prices to maintain affordability, expand targeted nutrition programs such as school feeding and food assistance, and develop monitoring systems that integrate economic and nutritional indicators. By shifting the focus from income-based measures to nutritional adequacy, this study contributes to the food security literature and provides a more effective policy framework to accelerate progress towards the Zero Hunger goal in Indonesia. Unlike most previous studies that emphasize poverty and income as the primary determinants of food insecurity, this study demonstrates that household food energy consumption is a more significant factor in explaining malnutrition at the provincial level.

A limitation of this study lies in the use of six-year provincial-level panel data, which yields only 204 observations and may constrain the robustness of the panel estimates. Moreover, the analysis does not account for household-level variations, which could provide a more comprehensive understanding of food adequacy. To address these limitations, future research should complement panel data with cross-sectional surveys at the district or village level. Such an approach would enrich the analysis by capturing household-level heterogeneity and provide more robust empirical evidence to inform policy formulation.

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