JDEP Vol. 8, No. 3 (2025) 221-241

JDEP

Jurnal Dinamika Ekonomi Pembangunan

https://ejournal.undip.ac.id/index.php/dinamika_pembangunan

Determinant Analysis for Food Security Empirical Study in Central Java Province

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Received: 5th January 2026; Last Revised: 24th May 2026; Accepted: 12th June 2026; Available Online: 30th June 2026; Published Regularly: December 2025

Abstract

This study examines the determinants of food security in Central Java Province, with a particular focus on the role of regional fiscal capacity within the context of fiscal decentralization. Despite strong aggregate food production, disparities in welfare indicate unresolved structural challenges, highlighting the need to better understand macro-level drivers of food security at the regional level. This research employs panel data of 35 regencies/cities over the period 2019-2023 and applies a Fixed Effects Model (FEM) to control for unobserved heterogeneity. The analysis incorporates key variables, including agricultural productivity, per capita income, poverty rate, education level, food prices, and regional fiscal capacity. The estimation results show that fiscal capacity, per capita income, agricultural productivity, and education have a positive and significant effect on food security, while poverty and food prices exert a negative influence. Among these factors, fiscal capacity demonstrates a statistically significant contribution, confirming its role as an important enabler in strengthening regional food security. These findings imply that food security is shaped by an integrated interaction of economic, social, and fiscal factors. Strengthening regional fiscal capacity, alongside poverty reduction, human capital improvement, and food price stabilization, is essential to achieve sustainable food security. This study contributes to the limited empirical literature by providing one of the first panel-based analyses at the regency/city level in Indonesia that explicitly incorporates fiscal capacity as a determinant of food security.

Keywords: *Food Security, Fiscal Capacity, Food Price, Agricultural Productivity, and Fixed-Effect Model* (FEM)

JEL Classification: *Q11, Q13, Q18, Q19, H53, I32, O13, and O15*

https://doi.org/10.14710/jdep.8.3.221-241

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Introduction

Food security is a multidimensional and strategic development issue. It is not only concerned with the capacity to produce food but also encompasses the dimensions of access, utilization, and stability over time. Recent literature suggests that food security is shaped by a combination of economic, social, and structural factors, including prices, income, public policies, as well as climatic and institutional conditions (Abafita & Kim, 2014; Bloem & Farris, 2022; Manikas et al., 2023; Omay et al., 2025).

Most empirical studies have examined food security at the household level, focusing on micro-level socioeconomic determinants such as income, education, and food prices. However, regional-level studies have gained increasing attention and indicate that macroeconomic variables and public fiscal capacity play a significant role in ensuring the stability of food systems (Dardeer & Shaheen, 2025; Li & Chu, 2024; Mohamed et al., 2024).

Despite the importance of this perspective, studies employing an regional-level studies remain relatively limited, particularly those that link food security to local fiscal performance within the context of fiscal decentralization. Yet, at the local government level, fiscal policy plays a key role in providing food-related infrastructure, maintaining price stability, and protecting vulnerable groups through various social programs (Mohamed et al., 2024; Schmitt-Sands, 2017). Recent studies further demonstrate that fiscal capacity and the effectiveness of local government expenditure are important determinants of regional food security (International Monetary Fund, 2022; Tahawa et al., 2025).

Central Java Province occupies a strategic position within Indonesia's national food security system. On the one hand, Central Java possesses strong food production capacity and ranks second nationally in the Food Security Index (FSI). On the other hand, the province continues to face structural challenges, including a relatively high poverty rate compared to other provinces on Java Island. This situation reflects a paradox between food production strength and community welfare.

Food security can be examined at both the individual and aggregate regional levels. For example, Mohamed et al. (2024) approached food security from an aggregate perspective, whereas Geda et al. (2024) conducted their analysis at the household level. The novelty of this study lies in incorporating local fiscal capacity as a determinant of food security at the regency and municipality level using panel data analysis, which allows for controlling unobserved heterogeneity across regions. This approach is expected to provide new empirical evidence to the regional food security literature while offering policy implications that are more relevant to local governments (Li & Chu, 2024; Mohamed et al., 2024).

Several recent studies have also emphasized that food price dynamics and inflation directly affect food accessibility, particularly among vulnerable populations. Consequently, price stability has become a critical component of food security policy. In addition, socioeconomic factors such as asset ownership, education, and regional inequality have been shown to contribute significantly to food security conditions across regions (Parum & Dharmasena, 2024; Shifat et al., 2025).

This study is among the first in Indonesia to empirically examine the effect of local fiscal capacity on the Food Security Index at the regency and municipality level using panel data. Therefore, it contributes to the growing literature on regional food security from an aggregate perspective while strengthening the evidence base for the formulation of more effective local fiscal policies.

Literature Review

Empirical literature indicates that food security is influenced by a range of interrelated factors, including income, poverty, food prices, and agricultural productivity (Mohamed et al., 2024; Smith & Haddad, 2018). Recent studies have further highlighted that structural factors such as climate change, population dynamics, and economic stability exert significant effects on food security across countries (Dardeer & Shaheen, 2025; Omay et al., 2025).

The literature on food security determinants consistently shows that income, poverty, education, and food prices affect food security conditions at both the household and aggregate regional levels. Income and market access play an important role in improving household food security status (Worku, 2023). At the aggregate level, studies have found that food prices and fiscal policies significantly influence food security indices (Mohamed et al., 2024; Widada et al., 2017). Empirical evidence also suggests that per capita income, poverty, education, and food prices are key determinants of food security in both developing countries and emerging economies (Bloem & Farris, 2022; Digdowiseiso, 2022; Kolog et al., 2023; Smith & Haddad, 2018).

Table 1. Summary of Previous Literature

Author & Year	Location	Method	Main Variable	Main Findings
Worku (2023)	Ethiopia (Gojjam Zone)	Logistic Regression	Age, household size, food prices, income	Small-scale irrigation improves household food security.
Kolog et al. (2023)	Ghana	Ordered Probit	Household hunger scale, food access	Income and market access positively affect food security.
Geda et al. (2024)	Ethiopia (Arsi Zone)	Panel Regression	Income, education, food prices	Education and income improve food security, whereas inflation has a negative effect.
Mohamed et al. (2024)	Negara Maghreb	Panel Data (Fixed Effect)	Food production, food prices, fiscal policy	Fiscal capacity and agricultural productivity positively influence the Food Security Index
Widada et al. (2017)	Indonesia	Multidimensional Analysis (FIMI)	Food prices, poverty, food access	Food prices and poverty are dominant factors contributing to food insecurity.

In more recent literature, panel data approaches have been increasingly employed to analyze the determinants of food security because they are capable of capturing temporal dynamics and regional heterogeneity. Previous studies have shown that macroeconomic variables and fiscal decentralization play significant roles in

shaping regional food security (Li & Chu, 2024; Mohamed et al., 2024). Nevertheless, empirical evidence at the subnational level, particularly at the regency and municipality level in Indonesia, remains very limited.

Furthermore, several recent studies suggest that fiscal capacity contributes to food security not only directly through public expenditure, but also indirectly through mechanisms such as infrastructure development, price stabilization, and the strengthening of food distribution systems (Chang, 2024; Tahawa et al., 2025).

Most regional-level studies continue to focus on production and price variables, while the role of local fiscal capacity as an enabler of food security policies has received relatively limited attention, particularly at the regency and municipality level in Indonesia. Local fiscal capacity influences food security through the ability of local governments to finance food-related infrastructure, maintain price stability, and implement social protection programs (Li & Chu, 2024; Schmitt-Sands, 2017). In addition, the literature points to the possibility of bidirectional relationships (endogeneity) among income, poverty, and food security, which should be taken into account when interpreting empirical findings. This review suggests that factors such as income, education, food prices, and fiscal capacity play important roles in shaping food security at both the micro and macro levels.

The Concept of Food Security

The conceptual foundation of the term food security can be traced to the 1996 World Food Summit organized by the FAO in Rome, Italy. At the summit, food security was defined as: “Food security exists when all people, at all times, have physical and economic access to sufficient, safe, and nutritious food that meets their dietary needs for an active and healthy life. Building on this conceptual foundation, the definition and interpretation of food security have evolved over time and have been adopted by various countries with adjustments reflecting their respective endowments and national characteristics (FAO, 2024).

The term food security has been used over time to refer to different meanings (Pinstrup-Andersen, 2009). A fundamental question raised in this discussion concerns what food security actually is and how it should be measured. More specifically, attention has been directed toward the notion of "sufficiency" embedded in the definition of food security. Does "sufficient" refer to meeting economic demand, and if so, at what price? Or does it refer to meeting dietary energy and nutritional requirements? Initially, the concept of food security was used to describe whether a country had adequate access to food to meet dietary energy requirements. National food security was subsequently interpreted by some scholars and policymakers as food self-sufficiency, namely the ability of a country to produce the food required by its population. As a result, food security was often understood primarily from a production perspective (the supply side), focusing on whether food needs were adequately met. In this context, Pinstrup-Andersen (2009) argues that a country could claim to have achieved self-sufficiency—often perceived as synonymous with food security—while allowing domestic markets to balance supply and demand regardless of the resulting price level.

In recent literature, food security has increasingly been understood as a multidimensional and cross-sectoral phenomenon. The classical four pillars of food

security—availability, access, utilization, and stability—are now considered insufficient to fully capture the complexity of contemporary global food systems. A growing body of research suggests the need to expand the dimensions of food security by incorporating additional aspects such as sustainability and agency, which emphasize the role of individuals, households, and institutions in determining access to and control over food systems. Furthermore, multidimensional approaches to food security analysis have advanced through the use of composite indices that integrate social, economic, and environmental indicators to capture food vulnerability more comprehensively. These developments indicate that food security is no longer viewed merely as an issue of food production or availability, but rather as a complex system shaped by the interaction of multiple structural and institutional factors (Clapp et al., 2025; Moura et al., 2025).

Moreover, global dynamics such as climate change, urbanization, and the transformation of agrifood systems have reinforced the understanding that food security is strongly influenced by systemic external factors. Recent empirical studies demonstrate that climate change directly affects agricultural productivity through rising temperatures, rainfall variability, and the increasing frequency of extreme weather events, which ultimately disrupt food availability and stability. At the same time, reports from the FAO and other international organizations highlight that the interaction of economic conditions, conflict, inequality, and shifts in food consumption patterns associated with urbanization further constrains people's access to nutritious food. Consequently, contemporary food security policies require an integrated approach across sectors and levels of government, taking into account the interconnections among production, distribution, and consumption systems, as well as environmental and socioeconomic factors simultaneously (FAO et al., 2023; Kumari, 2024).

Conceptual Framework

Drawing upon the multidimensional concept of food security, this study views food security as an outcome of the interaction among economic, social, production, price, and fiscal factors. Local fiscal capacity influences food security through its ability to finance agricultural development, supporting infrastructure, price stabilization measures, and social protection programs. This conceptual framework serves as the basis for selecting the study variables and specifying the empirical model.

The analysis is conducted at the regency and municipality level using the Food Insecurity Multidimensional Index (FIMI), proxied by the Food Security Index (FSI). This study examines the likelihood of a region being classified as food secure or food insecure. One of the primary objectives of this analysis is to provide input for the design of food security policies by considering relevant determinants (Figure 1). The findings of the empirical analysis are not merely a statistical exercise; they also provide a strong scientific foundation for policy formulation. Building on previous studies, this research seeks to identify and analyze the determinants of food security in Central Java Province from an aggregate macro-level perspective, using regencies and municipalities as the unit of analysis. In doing so, the study contributes to the literature on regional food security by emphasizing the role of fiscal capacity within the context

of fiscal decentralization in Indonesia (Caccavale & Giuffrida, 2020; Mohamed et al., 2024).

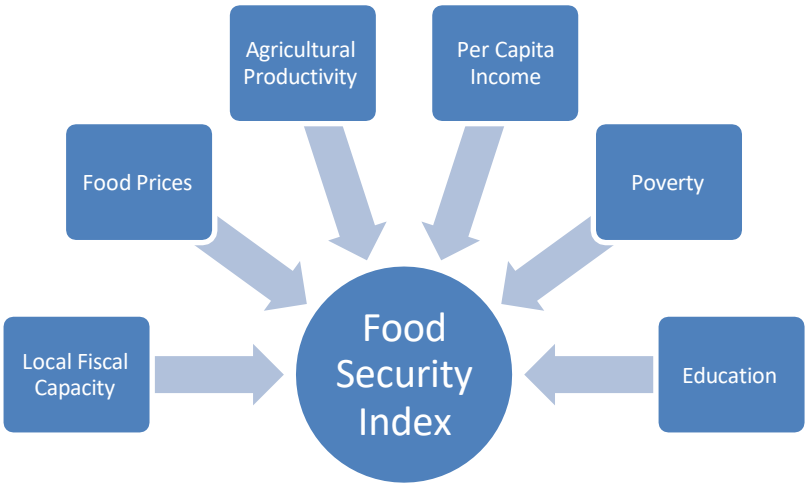


Figure 1. Conceptual Framework

Food Security in Indonesia

The concept of food security in Indonesia has been developed by adapting internationally recognized frameworks, including those proposed by the World Bank, The Economist Group, the Food and Agriculture Organization (FAO), the World Food Programme (WFP), and other international institutions. The conceptual framework and technical measurement of food security are documented in publications issued by the Ministry of Agriculture and the National Food Agency (Badan Pangan Nasional/Bapanas). The most fundamental conceptual definition is provided in Law No. 18 of 2012 on Food[1], which states that:

"Food Security is a condition in which food is fulfilled for the state down to individuals, as reflected in the availability of sufficient food in both quantity and quality, that is safe, diverse, nutritious, equitably distributed, and affordable, and that does not conflict with the religion, beliefs, and culture of the community, thereby enabling people to live healthy, active, and productive lives on a sustainable basis."

Bapanas operationalized this conceptual definition through a technical measurement framework known as the Food Security Index (FSI), which is calculated at the national, provincial, and regency/municipality levels. This index adopts elements of the Global Food Security Index (GFSI) developed by the Economist Intelligence Unit (EIU). The GFSI is measured through four dimensions: affordability, availability, quality and safety, and sustainability and adaptation. Each dimension comprises a set of more specific indicators. According to the 2022 GFSI publication, Indonesia ranked 63rd out of 113 countries, with an affordability score of 81.4 (44th rank), an availability score of 50.9 (84th rank), a quality and safety score of 56.2 (78th rank), and a sustainability and adaptation score of 46.3 (83rd rank). From a global

[1] Law No. 18 of 2012 was subsequently amended through Law No. 6 of 2023 concerning the Enactment of Government Regulation in Lieu of Law No. 2 of 2022 on Job Creation into Law.

perspective, Indonesia's position remains a matter of concern, with affordability being the only dimension showing relatively strong performance. These statistics serve as a warning that although Indonesia has achieved production surpluses for several major food commodities, other aspects of food system governance have yet to reach optimal levels compared with countries at a similar stage of development.

Meanwhile, Bapanas constructs the Food Security Index (FSI) based on three main dimensions: food availability, food access, and food utilization, each of which is measured using a set of specific indicators. This framework closely resembles the food security concepts adopted by the World Bank and the Global Food Security Index (GFSI) developed by the Economist Intelligence Unit (EIU). The weights assigned to the indicators used in calculating the FSI are determined based on expert judgment.

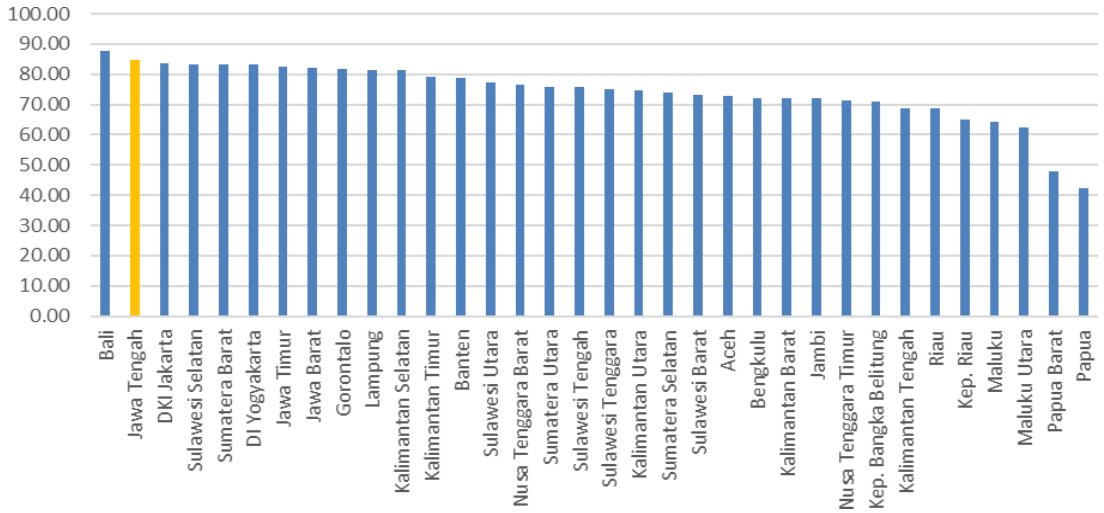


Figure 2. Food Security Index (FSI) by Province, 2023
Source: National Food Agency (Badan Pangan Nasional, 2024)

Figure 2 illustrates the provincial Food Security Index scores for 2023. The figure shows that Central Java Province occupies a highly strategic position within Indonesia's national food security landscape, ranking second nationally after Bali Province. The scores for all three dimensions exceed 80, with food availability scoring 87.69, food access 83.44, and food utilization 83.61. Among these dimensions, food availability records the highest score. This finding is consistent with food commodity production statistics published by Statistics Indonesia (BPS), which indicate that Central Java is a leading producer of numerous food commodities.

Research Method

This study used panel data from 35 regencies and municipalities in Central Java Province covering the period 2019–2023. The study period was selected based on the availability and consistency of Food Security Index (FSI) data at the regency and municipality level. The empirical model was estimated using a Fixed Effects Model (FEM) to control for unobserved region-specific heterogeneity that remained constant over time, such as geographical, cultural, and institutional characteristics (Badan Pangan Nasional, 2022, 2023, 2024; Dardeer & Shaheen, 2025; Li & Chu, 2024). The

FEM approach was considered appropriate in the context of food security analysis because structural differences among regencies and municipalities in Central Java are substantial. The Fixed Effects Model (FEM) was selected because it can control for unobserved heterogeneity across regions and is widely used in panel-data studies of food security (Li & Chu, 2024; Mohamed et al., 2024).

Agricultural productivity was proxied by agricultural land area as an indicator of production land availability. Although this proxy does not fully capture productivity in terms of output per unit of input, the lack of consistent production data across regions made this approach the most feasible alternative. Similar proxies have also been used in aggregate regional studies.

This study acknowledged potential econometric issues, including endogeneity and the limited observation period. Therefore, the estimated relationships were interpreted as empirical associations rather than strict causal effects (Mohamed et al., 2024; Schmitt-Sands, 2017). Panel data provide advantages in capturing temporal dynamics; however, they also have limitations in addressing potential endogeneity issues that are frequently encountered in food security research (Dardeer & Shaheen, 2025).

Empirical Model

Drawing on the conceptual framework and findings of previous studies, while taking into account the specific characteristics of the study area, the empirical model used to estimate the determinants of food security in Central Java was formulated as follows:

$$FSIit = \beta 0 + \beta 1\, AGRIPRODit + \beta 2\, KAPITAit + \beta 3\, POVit + \beta 4\, EDUit + \beta 5\, PBERASit + \beta 6\, PTELORit + \beta 7\, FISCALit + \alpha i + ui \quad (1)$$

The model includes seven explanatory (independent) variables: agricultural productivity (AGRIPROD), real per capita income (KAPITA), poverty rate (POV), educational attainment (EDU), medium-grade rice price (PBERAS), chicken egg price (PTELOR), and local fiscal capacity (FISCAL). The dependent variable is the Food Security Index (FSI), which is further disaggregated into three sub-indices: food availability, food access, and food utilization. The estimation was conducted using regency- and municipality-level data covering 35 administrative regions over the 2019–2023 period. The model was estimated using the within Fixed Effects Model (FEM) estimator following Wooldridge (2020). A detailed description of the variables included in the empirical model is presented in Table 2.

Description of the Food Security Index (FSI)

As discussed earlier, the Food Security Index (FSI) used in this study is based on data published by the National Food Agency (Badan Pangan Nasional/Bapanas). Table 2 presents the construction of the FSI, which comprises three sub-indices: food availability, food access, and food utilization. These sub-indices are assigned specific weights based on expert judgment.

The composition of these sub-indices is important for understanding how

individual explanatory variables may influence different dimensions of food security. A total of nine indicators are used to construct the three sub-indices. Given this structure, interpreting the effects of the independent variables in the empirical model becomes more complex, as the relationship between each explanatory variable and food security must be examined in light of the individual indicators that constitute the index.

Table 2. Description of Variables Used in the Empirical Model

Variable	Description	Measurement/Unit	Data Source
FSI	Food Security Index (FSI), consisting of: Composite Index; Food Availability; Food Access; Food Utilization The FSI is developed by Bapanas with reference to the Global Food Security Index (GFSI)	Index	National Food Agency (Bapanas)
AGRIPROD	Agricultural productivity	Agricultural land area	Statistics
KAPITA	Real per capita income	Million IDR per capita	Statistics
POV	Poverty rate (P0)	Percentage (%)	Statistics
EDU	Educational attainment	Mean Years of Schooling	Statistics Indonesia (BPS)
PBERAS	Medium-grade rice price	Rp/Kg	SiHati (Central Java Price and Production Information
PTELOR	Chicken egg price	Rp/Kg	SiHati
FISCAL	Local fiscal capacity	Ratio of GRDP to Local Own-Source Revenue (%)	Regional Office of the Directorate General

The use of composite indices such as the FSI is consistent with recent methodological developments that emphasize the importance of multidimensional indicators in capturing the complexity of food security. Recent studies suggest that reliance on a single indicator is often insufficient to fully represent food security dynamics, as the dimensions of availability, access, and utilization interact with one another in shaping the overall food security condition of a region. Therefore, the development of indices that integrate multiple indicators enables a more comprehensive assessment of food vulnerability and provides a more accurate picture of food security conditions across regions. This approach also facilitates the identification of which dimensions contribute most significantly to food security challenges, thereby providing a stronger basis for the formulation of more targeted policy interventions (FAO et al., 2023).

Furthermore, recent empirical literature suggests that the composite structure of food security indices offers advantages for policy analysis because it can capture non-linear relationships and interdependencies across dimensions. A multidimensional approach serves not only as a measurement tool but also as a diagnostic instrument for evaluating the effectiveness of policy interventions across different aspects of the food system. In addition, the use of expert judgment-based weighting, as applied in the Food

Security Index (FSI), is consistent with international practices in the construction of socioeconomic indices. Nevertheless, such an approach requires careful interpretation due to the potential subjectivity involved in determining indicator weights. Accordingly, the FSI not only reflects aggregate food security conditions but also provides a robust analytical framework for understanding the structural dynamics of food security at the regional level (Calloway et al., 2023).

Table 3. Composition of the Food Security Index (FSI) and Indicator Weights for Regencies and Provinces Based on Expert Judgment

No	Indicators	Weights
Food Availability Dimension		
1.	Ratio of normative consumption to net production of rice, maize, sweet potatoes, cassava, and sago, including	0.30
	Sub-Total	0.30
Food Access Dimension		
2.	Percentage of population living below the poverty line	0.15
3.	Percentage of households allocating more than 65% of total expenditure to food	0.075
4.	Percentage of households without access to electricity	0.075
	Sub Total	0.30
Food Utilization Dimension		
5.	Mean years of schooling among females aged over 15 years	0.05
6.	Percentage of households without access to clean water	0.15
7.	Ratio of population to health personnel adjusted for population density	0.05
8.	Percentage of stunted children under five years of age	0.05
9.	Life expectancy at birth	0.10
	SubTotal	0.40

Source: Bapanas

Results and Discussion

The estimation results indicate that per capita income, agricultural productivity, educational attainment, and local fiscal capacity are positively associated with food security, whereas poverty and food prices exhibit negative associations (Table 4). Table 4 presents the estimation results of the empirical model examining the determinants of food security in Central Java Province from an aggregate macro-level perspective. The discussion focuses on the results of Model (1), in which the dependent variable is the composite Food Security Index (FSI), representing the overall food security condition of Central Java Province.

Before discussing the estimation results in detail, it is important to emphasize that the empirical model employed in this study was designed to capture the simultaneous relationships among economic, social, production, price, and fiscal factors in shaping regional food security. By employing a fixed effects model, the analysis not only identifies the direction and statistical significance of each explanatory variable but also controls for unobserved region-specific characteristics, thereby providing estimates with greater internal robustness. Accordingly, the results reported in Table 4 should be interpreted as aggregate empirical relationships among the variables that reflect food security dynamics at the regency and municipality level in Central Java Province. They also provide a basis for assessing the extent to which these

structural factors contribute to shaping food security conditions in a comprehensive manner.

Table 4. Results of the Empirical Model Estimation

Independent Variables	Food Security	Food Availability	Food Access	Food Utilization
	(1)	(2)	(3)	(4)
Agricultural Productivity (AGRIPROD)	0.0639*	0.0530	0.1341**	-0.0136
	(0.091)	(0.118)	(0.026)	(0.607)
Real Per Capita Income (KAPITA)	0.2355**	-0.1644*	0.3259**	0.3126**
	(0.046)	(0.100)	(0.026)	(0.038)
Poverty Rate (POV)	-0.0175**	-0.0026	-0.0188	-0.0227***
	(0.021)	(0.813)	(0.134)	(0.004)
Educational (EDU)	0.0653***	0.0410*	0.0187	0.1022***
	(0.00%)	(0.068)	(0.367)	(0.001)
Rice Price (PBERAS)	-0.0617	-0.0790	-0.0804	-0.0082
	(0.354)	(0.334)	(0.322)	
Chicken Egg Price (PTELOR)	-0.3630*	-0.1266	-0.3952	-0.2195
	(0.063)	(0.572)	(0.111)	
Fiscal Capacity (FISCAL)	0.0002***	-0.0001	0.0001	0.0003**
	(0.009)	(0.808)	(0.247)	
Sample	35	35	35	35
Years	5	5	5	5
Observation	175	175	175	175
F-Stat	13.03	2.79	6.79	11.09
Prob>(F)	(0.000)	(0.000)	(0.000)	(0.000)

Note: Values in parentheses are p-values; *** $p < 0.01$, ** $p < 0.05$, * $p < 0.10$; The estimation period covers 2019–2023, with a sample of 35 regencies and municipalities, yielding a total of 175 observations; The models were estimated using robust standard errors; All variables were transformed into natural logarithms (ln), except for the poverty rate and fiscal capacity variables, which are expressed as percentages.

Table 4 also reports estimation results using each food security sub-index as the dependent variable. Overall, the estimation results are broadly consistent with theoretical expectations and the existing food security literature. However, caution is required when interpreting the estimation results for models that use the food security sub-indices as dependent variables. The interpretation of these results should take into account the specific composition of each sub-index. A detailed discussion of the estimation results is presented below.

Agricultural Productivity

Agricultural productivity is a fundamental variable in the food security framework. This variable is included on the premise that agricultural productivity represents overall food availability. Food availability is a key component of food security, because without availability, it is not possible for people to have access to food. The estimation results indicate that agricultural productivity has a positive effect on food security. Higher agricultural productivity contributes to stronger food security. The results demonstrate the important contribution of agricultural productivity to regional food security. These findings also confirm that improving supply-side (on-farm) performance through enhanced land productivity can significantly support regions in

achieving food security. The aspect of food security most directly associated with agricultural productivity is food availability. Technically, productivity can be improved through both intensification and extensification approaches, as well as through the adoption of agricultural technologies. These findings are consistent with global evidence showing that improvements in agricultural productivity are a major factor in enhancing food availability and regional food security (USDA, 2015).

Furthermore, from a global empirical perspective, agricultural productivity not only increases food availability in absolute terms but also plays an important role in maintaining supply stability and reducing food price volatility. Recent studies indicate that productivity gains achieved through the adoption of modern agricultural technologies, such as improved seed varieties, mechanization, and irrigation innovations, can increase production efficiency while strengthening the resilience of food systems against various external shocks. Accordingly, agricultural productivity functions not only as a direct determinant of food availability but also as a strategic instrument for maintaining the sustainability of food systems amid environmental, market, and demographic pressures. This further underscores that investment in the agricultural sector has broad multiplier effects on food security, particularly in regions that remain dependent on the primary sector (Toromade et al., 2024; Clark, 2024).

On the other hand, recent literature also emphasizes that improvements in agricultural productivity should be viewed within a broader context, particularly in relation to environmental sustainability and resource-use efficiency. Unsustainable intensification practices may lead to land degradation, declining water quality, and increased dependence on external inputs, which in the long run may weaken food security. Therefore, the concept of sustainable agricultural productivity has become increasingly relevant, whereby increases in output should be accompanied by environmentally sound and climate-adaptive agricultural practices. In this regard, agricultural productivity is measured not only by increases in output but also by its capacity to support the long-term sustainability of food systems and community welfare (Rahman, 2023; Kumari, 2024; Rehman et al., 2022).

Per Capita Income

Per capita income reflects the level of welfare and purchasing power of the population, as well as the economic capacity of a region. The estimation results indicate that higher per capita income in a region contributes to improved food security. These findings confirm the theoretical expectation and suggest several important implications. One of these is the importance of sustained regional development in promoting stronger economic growth. Economic growth supports improvements in per capita income and can generate even greater benefits when accompanied by higher levels of inclusiveness. From a technical perspective, improvements in per capita income support food security through the food access dimension (Smith & Haddad, 2018). Greater purchasing power enhances households' ability to meet their food needs in accordance with acceptable standards. The results also highlight the importance of macroeconomic conditions for sustaining food security. Policy innovations and regional development programs that support economic growth, whether from the

demand side or the supply side, can contribute significantly to the achievement of regional food security.

These findings are consistent with the empirical literature showing that per capita income has a positive effect on food security through improvements in purchasing power and access to food (Bloem & Farris, 2022; Smith & Haddad, 2018).

Furthermore, from a macro-level empirical perspective, numerous studies indicate that growth in per capita income plays a dominant role in shaping food security dynamics, particularly through its effect on improving economic access to food. Higher incomes enable households to allocate greater and higher-quality expenditures toward food consumption, including nutritious and diverse food products. Cross-country studies have shown that income growth is a primary determinant of reductions in food insecurity compared with other factors, such as fluctuations in food prices. In addition, empirical evidence suggests that increases in national income contribute positively to improvements in food access indicators and reductions in the prevalence of undernutrition, particularly in developing countries. These findings underscore that the economic dimension, particularly income growth, constitutes an important foundation for strengthening food security in a sustainable manner (Bogmans et al., 2024; Miladinov, 2023).

From a macroeconomic and distributional perspective, recent literature also emphasizes that the relationship between income and food security is strongly influenced by inequality and income distribution. Although increases in aggregate income may improve food security in general, the benefits are not necessarily distributed evenly across different segments of society. Recent studies indicate that income inequality and limitations in social protection systems can constrain improvements in food access among vulnerable groups, even in the presence of overall economic growth. In addition, recent empirical evidence suggests that increases in global per capita income are associated with reductions in the number of people experiencing food insecurity, particularly when accompanied by food price stability and policies that support household purchasing power. Accordingly, increases in per capita income need to be accompanied by inclusive policies to ensure that the benefits of economic growth are shared across all segments of society in strengthening food security (Cardell & Zereyesus, 2024; Qazi, 2025).

Poverty Rate

Similar to per capita income, the poverty rate reflects societal welfare from the opposite perspective. The estimation results indicate that an increase in the poverty rate reduces food security (Smith & Haddad, 2018). This finding reinforces the importance of improving overall societal welfare. Poverty is not only related to purchasing power but also to the quality of human resources or human capital. Poor populations are unable to meet the minimum standards required by food security indicators. The dimension of food security most directly associated with poverty is food access. Poverty reduction is one of the key prerequisites for achieving food security in a comprehensive manner. The challenges and constraints of poverty alleviation, which have long been persistent issues, need to be addressed. One of the

most fundamental concerns is the targeting accuracy of social protection and social assistance programs. Another concern relates to the governance of poverty data, which continues to face institutional constraints. Addressing these issues would accelerate progress in poverty reduction while also improving the efficiency of budget allocation. The negative effect of poverty on food security is supported by a range of cross-country empirical studies demonstrating that poverty is a major structural driver of food insecurity (Omay et al., 2025).

Poverty is also closely associated with limited access to basic services that support food utilization, such as education, healthcare, sanitation, and infrastructure. Recent empirical studies indicate that poor households face not only constraints in economic access to food but also barriers to the effective utilization of food due to inadequate nutritional quality, limited knowledge, and poor health conditions. In addition, cross-country research has shown that chronic poverty increases vulnerability to external shocks, such as rising food prices and climate change, which ultimately worsen food security conditions. Accordingly, poverty can be understood as a structural factor affecting all dimensions of food security. Therefore, poverty alleviation efforts need to be designed in a comprehensive and sustainable manner to strengthen long-term food security (FAO et al., 2023).

Educational Attainment

Educational attainment reflects the quality of human resources or human capital within a region. Education is generally positively associated with higher productivity and also reflects more rational and higher-quality consumption behavior. The estimation results indicate that higher levels of educational attainment are associated with stronger food security, thereby confirming the existing theoretical framework. This finding underscores that improving access to education is a critical factor in supporting the strengthening of food security as a whole.

In the contemporary empirical literature, education has been shown to play a strategic role in strengthening food security through improvements in the quality of household decision-making, particularly in relation to food selection, preparation, and consumption. Individuals with higher levels of education tend to possess greater nutritional literacy, a better understanding of the importance of food diversification, and a stronger ability to access information related to health and nutrition. Recent studies indicate that improvements in educational attainment are significantly correlated with better dietary quality and nutritional status, which in turn strengthen the utilization dimension of food security. In addition, education contributes to higher labor productivity and improved employment opportunities, which indirectly increase income and access to food (FAO et al., 2023; Guiné et al., 2021).

On the other hand, education also plays an important role in enhancing people's capacity to adapt to various risks affecting food security, such as price fluctuations, economic crises, and the impacts of climate change. Households with higher levels of education tend to be better able to manage resources efficiently, adopt technological innovations, and implement coping strategies when confronted with economic or food-

related shocks. Cross-country studies have shown that education is an important factor in strengthening household resilience to food insecurity, particularly among vulnerable populations. Accordingly, investment in the education sector not only improves the quality of human resources but also serves as an important instrument for strengthening food security in a sustainable and inclusive manner (FAO et al., 2023).

Inflation Rate

In this estimation, two food commodity prices were included to represent inflation, particularly food inflation: the price of medium-grade rice and the price of chicken eggs. The results clearly indicate that increases in food prices reduce food security. Rising food prices affect the affordability of food for consumers. Food inflation needs to be maintained at a level that is acceptable to society. In other words, price increases should remain reasonable so that they can still provide incentives for the production sector. The agricultural structure of Central Java has its own characteristics. Prices remain an important factor for welfare, yet at the same time rising prices reduce purchasing power. Smallholder farmers are net consumers, meaning that the output from their production is insufficient to meet their living needs from one harvest period to the next. The insignificance of rice prices in several models may reflect the effectiveness of government price stabilization policies and market intervention measures (Dardeer & Shaheen, 2025).

Rising food prices have been empirically shown to reduce food access and worsen food security, particularly in developing countries (Dardeer & Shaheen, 2025; International Monetary Fund, 2022). Other empirical studies also show that food price spikes are significantly associated with increased food insecurity, especially in developing countries whose economic structures are vulnerable to price shocks. In addition, food inflationary pressures may reduce the effectiveness of social protection programs when they are not accompanied by policy adjustments that respond adaptively to changing prices (Guiné et al., 2021).

Food price dynamics also reflect the trade-off between the interests of producers and consumers within the food system. For producers, particularly farmers, higher food prices may provide incentives to increase production. However, in the case of smallholder farmers who function as net consumers, rising prices may worsen welfare because income generated from production is insufficient to cover consumption needs until the next production cycle. Recent literature emphasizes that food price volatility is one of the key factors affecting food security through uncertainty in access and supply stability. Therefore, price stabilization policies and market interventions are essential for maintaining a balance between the interests of producers and consumers, while ensuring that the food system continues to provide affordable and sustainable access to food for all segments of society.

Local Fiscal Capacity

Local fiscal capacity reflects the direct capacity of a region to support food security through budgetary resources. The role of local governments, through their fiscal capacity, is substantial in supporting food security. The estimation results indicate that stronger local fiscal capacity is associated with stronger food security. Although the coefficient is relatively small, the finding provides a strong indication that food security must be supported by the internal strength of each region through sound budget governance (Mohamed et al., 2024; Schmitt-Sands, 2017). This finding reinforces the literature emphasizing that local fiscal capacity is an important factor in supporting food security through the financing of infrastructure, subsidies, and social programs (FAO, 2024; Li & Chu, 2024; Tahawa et al., 2025).

More broadly, the results of this study are consistent with the global literature indicating that food security is an outcome of the complex interaction among economic, social, and fiscal factors, which reinforce one another within an integrated food system (Laborde et al., 2024; Manikas et al., 2023). Local fiscal capacity reflects the ability of local governments to implement strategic and sustainable policy interventions within the food system. Regions with strong fiscal capacity have greater scope to finance agricultural infrastructure development (including irrigation, distribution roads, and logistics), strengthen food reserves, and provide social protection programs for vulnerable groups. Recent literature indicates that public expenditure on agriculture and social protection has a significant impact on food security through improvements in food access, stability, and distribution. In addition, adequate fiscal capacity enables local governments to respond more rapidly to external shocks, such as price crises or supply disruptions, thereby helping to maintain the stability of the food system as a whole (Herdiansyah et al., 2024).

The effectiveness of fiscal capacity is determined not only by the size of the budget but also by the quality of governance and expenditure allocation priorities. Recent empirical studies show that public spending efficiency and institutional quality play important roles in determining the contribution of fiscal capacity to food security. Targeted, transparent, and accountable budget allocation will enhance the impact of fiscal resources on improving public welfare and strengthening the food system. Conversely, substantial fiscal capacity that is not managed optimally may reduce policy effectiveness and even create distortions in resource distribution. Therefore, strengthening local fiscal capacity should be accompanied by improvements in local public financial management and institutional quality in order to maximize its contribution to sustainable food security (Rehman et al., 2022).

Conclusion

Based on the results of the empirical model estimation and the preceding discussion, several important policy implications can be drawn: (1) Food security constitutes an integrated ecosystem comprising all of its components rather than a set of isolated elements. Therefore, it should be understood holistically, although food availability remains the most fundamental dimension; (2) Agricultural sector productivity, in its

broadest sense, should continue to be enhanced through a careful assessment of existing conditions. This includes identifying the challenges and potential within each agricultural sub-sector so that appropriate policies, programs, and institutional support can be formulated to improve productivity; (3) The purchasing power of the population should be maintained and strengthened to support long-term food security, as confirmed by the positive effect of per capita income on food security. Economic growth needs to be sustained and accompanied by efforts to control population growth; (4) Strategies to reduce poverty should be implemented effectively and efficiently in order to achieve optimal reductions in poverty levels. Poverty has been confirmed as a fundamental factor contributing to lower food security; (5) Educational attainment should be improved to strengthen food security. Policies and programs that support access to education need to be reinforced. Education enhances the quality of human capital, which in turn affects food security through both increased productivity and improved food consumption patterns; (6) Inflation, particularly food inflation, should be maintained at an acceptable level. In other words, inflation should not substantially erode household purchasing power while still providing adequate incentives for the production sector, especially given that the agricultural structure is dominated by smallholder farmers. Inflation has been confirmed as an important factor that can reduce food security; and (7) Strategies aimed at strengthening local taxing power should be implemented optimally, particularly through improved tax collection from existing tax bases. Local fiscal capacity has been confirmed to contribute to the strengthening of food security.

The policy implications of this study highlight the need to strengthen local fiscal capacity through the optimization of locally generated revenue and improvements in the quality of public expenditure that are more strongly oriented toward food security. Strengthening local fiscal capacity is an important prerequisite for supporting sustainable food security at the regional level (Li & Chu, 2024; Schmitt-Sands, 2017). In addition, controlling food inflation, reducing poverty, and improving the quality of education should form integral components of a comprehensive food security policy framework. This study contributes empirical evidence to the literature on aggregate regional food security and provides insights that are relevant for the design of regional development policies (Manikas et al., 2023; Mohamed et al., 2024). These findings are consistent with a growing body of international literature emphasizing the importance of multidimensional approaches to food security policy that integrate economic, fiscal, and social dimensions (FAO et al., 2025; International Monetary Fund, 2022).

Limitation

In addition to the limitations related to potential endogeneity and the relatively short observation period, this study did not conduct robustness tests on the estimation results. The absence of such tests means that the stability and consistency of the findings across alternative model specifications, estimation approaches, and variable definitions have not been fully verified. Therefore, future research is encouraged to conduct robustness tests, for example through the use of alternative models such as random effects or dynamic panel models, variable transformations, or other relevant estimation

approaches. Such efforts would help ensure that the empirical findings are more reliable and less sensitive to changes in model specification.

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Appendix

A1. Scatterplot of the Relationship between Food Security and Several Macroeconomic Performance Indicators of Central Java Province

