



Spatial Analysis of Food Vulnerability and Security in Bengkulu Province Based on Geographic Information Systems (GIS)

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ABSTRACT

Food security is a strategic issue that necessitates a comprehensive understanding of spatial variations across regions to support targeted policy planning. This study aims to analyze the conditions of food security and vulnerability in Bengkulu Province by employing a Geographic Information System (GIS) approach based on the Food Security and Vulnerability Atlas (FSVA). The method utilized is spatial analysis of FSVA indicators, encompassing three main aspects of food security: food availability, food access, and food utilization. The results indicate that food security status across regencies/municipalities in Bengkulu Province varies, with an average index of 1.07 during the 2019–2023 period, comprising an availability index of 1.12, an access index of 1.13, and a utilization index of 0.97. Cluster analysis grouped the regions into three clusters with distinct characteristics. Cluster 1, comprising Kaur, South Bengkulu, and Lebong Regencies, exhibits favorable food security with strong availability and utilization indicators. Cluster 2, consisting of Central Bengkulu, Mukomuko, and North Bengkulu Regencies, excels in food access indicators. Meanwhile, Cluster 3, encompassing Rejang Lebong, Seluma, and Kepahiang Regencies, demonstrates high vulnerability concerning electrification, access to clean water, poverty, and life expectancy. This study recommends location-specific policies based on the food security characteristics of each region to optimize interventions and the allocation of food assistance more effectively and precisely.



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INTRODUCTION

Food security is defined as a condition in which the food needs of the nation are met up to the individual level, reflected by the availability of food in sufficient quantity and quality, safe, nutritious, equitably distributed, and affordable to support an active, healthy, and productive life (Law No. 18 of 2012 concerning Food). This definition emphasizes that food security is not merely a matter of production but also involves accessibility, stability, and food utilization by communities. As one of the provinces with potential as a food granary on Sumatra Island, Bengkulu faces serious challenges in realizing equitable food security across its territory. Data from the Central Statistics Agency (BPS) indicate that Bengkulu Province ranks second as the poorest province on Sumatra Island, with a poverty rate reaching 14.04% in 2023 (Harian Haluan, 2024), which directly affects the purchasing power of communities for food. This poverty condition constitutes a major inhibiting factor in improving food access, as low-income households tend to allocate most of their income to food consumption in limited quantities and of inadequate quality (Rolenza et al., 2025).

Food security is an exceptionally complex issue with interrelated problems encompassing production, distribution, consumption, as well as socio-economic and environmental factors. The Food and Agriculture Organization (FAO) identifies four components of food security: availability,

access, utilization, and stability (Mulyasari, 2024). In Bengkulu Province, rice production as the primary food security commodity has exhibited fluctuating trends and has even tended to decline over the past five years. BPS data for Bengkulu Province show that rice production decreased from 296,472 tons in 2019 to 277,310 tons in 2023 and continued to decline to 272,849 tons in 2024 (Tribunbengkulu, 2025). This production decline is attributable to various factors, including the reduction of agricultural land due to population growth and land-use conversion, which negatively impacts regional food supply and the fulfillment of community food needs (Rolenza et al., 2025). This situation further reinforces the urgency of comprehensively understanding the dynamics of food security at the regional level.

The level of food consumption in Bengkulu Province indicates that average expenditure on food consumption reaches Rp679,166 per month, higher than non-food expenditure of Rp653,392 (Rolenza et al., 2025). However, this high proportion of food expenditure does not necessarily reflect optimal nutritional fulfillment, as communities tend to focus more on food quantity rather than quality and dietary diversity (Rolenza et al., 2025). This is reflected in the food quality index, which remains below 1 (0.97), indicating that although food purchasing power is relatively high, the quality of food consumption has not been optimal (Rolenza et al., 2025). Nevertheless, the condition of a higher proportion of food expenditure than non-food expenditure is not uniform across regencies/municipalities. In Mukomuko Regency and Bengkulu City, non-food consumption levels are actually higher than food consumption, at 3.24% for Mukomuko Regency and 16.5% for Bengkulu City (Rolenza et al., 2025). This variation indicates differences in economic and social characteristics across regions in Bengkulu Province, necessitating differentiated policy approaches.

Bengkulu Province possesses considerable potential for food production. South Bengkulu Regency has the highest average production of rice and corn in Bengkulu Province during 2019–2023, amounting to 55,301.73 tons of rice and 47,921.76 tons of corn, thus having the potential to supply food commodities in Bengkulu Province to meet community food needs (Rolenza et al., 2025). However, high food availability in a region does not always guarantee food security in that area, as distribution and access to food remain key factors. Research by Agustina et al. (2023) indicates that household food security in Bengkulu Province based on caloric intake shows that rural areas (54.38%) are more food secure than urban areas (46.33%), while based on food diversity, both urban (94.30%) and rural (96.22%) areas are categorized as food-secure households. These findings suggest differences in food security characteristics between urban and rural areas that require attention in policy formulation.

The utilization of Geographic Information System (GIS) technology for food security analysis is increasingly important in supporting data-driven planning and decision-making. The government has mandated the development of an integrated Food and Nutrition Information System through Law No. 18 of 2012 concerning Food and Government Regulation No. 17 of 2015 concerning Food and Nutrition Security (Bengkulu City Food Security and Agriculture Office, 2024). The Food Security and Vulnerability Atlas (FSVA) serves as a crucial tool capable of detecting food security and vulnerability conditions based on nine indicators encompassing three main aspects: availability, access, and utilization (Mulyasari, 2024). The FSVA is compiled to provide accurate, comprehensive, and well-organized food security information to support prevention and management efforts for food and nutrition vulnerability, thereby offering direction and recommendations to decision-makers in program development, policy formulation, and intervention implementation at both central and regional levels (Bengkulu City Food Security and Agriculture Office, 2024).

Research on food security in Bengkulu Province remains limited and generally only takes data at a single point in time or focuses on one or two indicators, so that temporal dynamics and spatial diversity at the regency/municipality level have not been comprehensively explored (Rolenza et al., 2025). This study fills this gap by analyzing longitudinal food security data (2019–2023) using the Food Security Quotient (FSQ) approach and mapping clusters at the regency/municipality level in Bengkulu Province through a GIS approach. This approach enables the identification of long-term trends and spatial diversity that can serve as a basis for formulating more targeted policies. The objectives of this study are: (1) to identify the status of food security and vulnerability in Bengkulu

Province using FSVA indicators; (2) to map the spatial distribution of food security status at the regency/municipality level; (3) to group regions based on food security characteristics; and (4) to provide location-based policy recommendations for strengthening food security.

RESEARCH METHODS

Research Location and Time

This research was conducted in Bengkulu Province from October to November 2025 (Rolenza et al., 2025). The research location covers all regencies/municipalities in Bengkulu Province, namely South Bengkulu, Rejang Lebong, North Bengkulu, Kaur, Seluma, Mukomuko, Lebong, Kepahiang, Central Bengkulu Regencies, and Bengkulu City (Rolenza et al., 2025). The selection of this location was based on the consideration that Bengkulu Province is the second poorest province on Sumatra Island, making the study of food security in this region highly important to support the formulation of targeted policies (Wibowo et al., 2024). This study employs a secondary data analysis (SDA) approach with quantitative descriptive methods to comprehensively describe food security conditions based on available spatial and temporal data (Isma et al., 2025).

Types and Sources of Data

The data used in this study are secondary data obtained from various official and reliable sources (Rolenza et al., 2025). The main data sources include the Central Statistics Agency (BPS) of Bengkulu Province through the publication of Bengkulu in Figures 2020–2024, the Department of Agriculture and Horticulture of Bengkulu Province, the Department of Health of Bengkulu Province, and the Food Security Agency at both provincial and regency/municipality levels (Rolenza et al., 2025). Additionally, this study utilizes data from the Food Security and Vulnerability Atlas (FSVA) published by the National Food Agency (Wibowo et al., 2024; Bengkulu City Food Security and Agriculture Office, 2024). The collected data encompass nine FSVA indicators grouped into three main aspects of food security: the food availability aspect (normative per capita consumption ratio to food availability), the food access aspect (percentage of the population below the poverty line, percentage of households with food expenditure proportion >65%, and percentage of households without electricity access), and the food utilization aspect (average years of schooling for women over 15 years, percentage of households without access to clean water, ratio of population to health workers, percentage of stunted toddlers, and life expectancy) (Bengkulu City Food Security and Agriculture Office, 2024; Mulyasari, 2016).

Data Analysis Methods

Data analysis in this study was conducted through three complementary approaches. *First*, the Food Security Quotient (FSQ) analysis was used to measure the food security index based on three main indicators: food availability, food access, and food quality (Rolenza et al., 2025). The FSQ method is an approach that has been widely used in food security studies in Indonesia, where an index value >1 indicates good food security (very food secure), while an index value <1 indicates food vulnerability (Rolenza et al., 2025). The FSQ analysis in this study covers longitudinal data for the 2019–2023 period to observe the temporal dynamics of food security in Bengkulu Province (Rolenza et al., 2025).

Second, cluster analysis using the Biplot Analysis approach was applied to group regencies/municipalities based on food security characteristics (Wibowo et al., 2024). Biplot analysis is a statistical method that depicts regional characteristics and variable correlations in two-dimensional graphs, facilitating the identification of regional grouping patterns based on similar characteristics (Wibowo et al., 2024). This method uses FSVA data from the National Food Agency with three assessment aspects: availability, access, and food utilization (Wibowo et al., 2024). This cluster analysis produced three groups of regions with different characteristics, which can serve as a basis for formulating location-specific policies (Wibowo et al., 2024).

Third, FSVA analysis was used to develop thematic food security maps depicting the geographic visualization of vulnerable areas to food insecurity (Bengkulu City Food Security and Agriculture Office, 2024). The FSVA method uses a weighting system for nine indicators to produce six classifications of food security status: Very Vulnerable, Vulnerable, Somewhat Vulnerable, Somewhat Secure, Secure, and Very Secure (Bengkulu City Food Security and Agriculture Office, 2024). This analysis was conducted at the regency/municipality level in accordance with the National FSVA tier, which aims to provide accurate and comprehensive information to support prevention and management efforts for food vulnerability (Mulyasari, 2016). The sampling technique in this study employed the purposive sampling method, where all regencies/municipalities in Bengkulu Province became analysis samples for access and utilization indicators, while for the availability indicator, Bengkulu City was excluded from the analysis considering that food availability in urban areas originates from interregional trade and is not influenced by local production (Rolenza et al., 2025; Mulyasari, 2016).

RESULTS AND DISCUSSION

1. Food Security Status in Bengkulu Province

The Food Security Quotient (FSQ) analysis shows that the average food security index of Bengkulu Province during the 2019–2023 period is 1.07, indicating that, in general, Bengkulu Province falls into the food-secure category (Rolenza et al., 2025). The indices for each indicator are: food availability 1.12, food access 1.13, and food quality 0.97 (Rolenza et al., 2025; Mulyasari, 2016). The food quality index value below 1 (0.97) indicates that although food purchasing power is relatively high, the quality of food consumption has not been optimal (Rolenza et al., 2025). This finding aligns with research by Wibowo et al. (2024), which shows that the food security index of Bengkulu Province fluctuated, with some regencies experiencing stable index increases while others fluctuated, such as Rejang Lebong, Seluma, and Mukomuko Regencies.

Based on expenditure levels in Bengkulu Province, average expenditure on food consumption reaches Rp679,166 per month, higher than non-food expenditure of Rp653,392 (Rolenza et al., 2025). However, this condition is not uniform across regencies/municipalities. In Mukomuko Regency and Bengkulu City, non-food consumption levels are higher than food consumption, at 3.24% for Mukomuko Regency and 16.5% for Bengkulu City (Rolenza et al., 2025). This phenomenon reflects differences in economic welfare levels across regions, where communities with higher purchasing power tend to allocate a larger proportion of their income to non-food needs, while low-income communities remain concentrated on fulfilling basic food needs (Isma et al., 2025).

Bengkulu Province has areas of high food production potential. South Bengkulu Regency has the highest average production of rice and corn in Bengkulu Province during

2019–2023, amounting to 55,301.73 tons of rice and 47,921.76 tons of corn, thus having the potential to supply food commodities in Bengkulu Province (Rolenza et al., 2025). South Bengkulu Regency even received hybrid corn seed assistance covering 3,150 hectares through the UPSUS (Special Efforts) program for accelerated planting in 2024 (BSIP Bengkulu, 2024). However, rice production in Bengkulu Province decreased from 296,472 tons in 2019 to 277,310 tons in 2023, caused by the reduction of agricultural land due to population growth and land-use conversion (Isma et al., 2025; Rolenza et al., 2025). This production decline poses a serious challenge to efforts to maintain food availability in the future.

The dynamics of food security in Bengkulu Province were also influenced by the impact of the COVID-19 pandemic. Research by Wibowo et al. (2024) shows that the food security index of Bengkulu Province declined from 70.77 in 2018 to 68 in 2022. Further analysis revealed that significant differences between pre- and post-pandemic conditions were particularly evident in the food quality aspect, with a p-value of 0.032, lower than the 5% alpha level (Wibowo et al., 2024). This indicates that the pandemic had a tangible impact on the quality of community food consumption, although the percentage of the poor population in Bengkulu Province was not significantly affected and even tended to decline during that period (Wibowo et al., 2024). This finding suggests that macroeconomic poverty indicators do not always reflect real food security conditions at the household level.

2. Spatial Mapping of Food Security

The Food Security and Vulnerability Atlas (FSVA) is a thematic map depicting the geographic visualization of areas vulnerable to food insecurity (Bengkulu City Food Security and Agriculture Office, 2024; National Food Agency, 2024). The FSVA is compiled to provide accurate, comprehensive, and well-organized food security information to support prevention and management efforts for food and nutrition vulnerability, thereby offering direction and recommendations to decision-makers in program development, policy formulation, and intervention implementation at both central and regional levels (National Food Agency, 2024; Mulyasari, 2016). The provision of this information is mandated by Law No. 18 of 2012 concerning Food and Government Regulation No. 17 of 2015 concerning Food and Nutrition Security, wherein the Government and Regional Governments are obligated to build, compile, and develop an integrated Food and Nutrition Information System in accordance with their authority (Bengkulu City Food Security and Agriculture Office, 2024). In 2025, the National Food Agency updated the FSVA methodology through a series of national consultations, scientific and technical reviews, and finalization workshops involving stakeholders from provincial and regency levels, considering indicator modernization and referring to international food security measurement concepts such as the Global Food Security Index (GFSI) and FAO measurements (National Food Agency, 2024).

The FSVA is compiled based on the three pillars of food security: availability, access, and utilization, while integrating nutrition and food safety (National Food Agency, 2024; Mulyasari, 2016). In the 2025 update, these three pillars are represented by 12 indicators: the availability aspect includes the normative per capita consumption ratio to food availability, the ratio of energy availability per capita per day to standard requirements, the ratio of animal protein availability per capita per day to standard requirements, and the ratio of Regional Government Rice Reserves (CBPK) held to CBPK based on statutory provisions (National Food Agency, 2024). The food affordability aspect includes the percentage of the population living below the poverty line, the coefficient of variation of staple food commodity prices, and the Prevalence of Undernourishment (PoU), while the food utilization aspect encompasses the average years of schooling for women over 15 years, the percentage of

households without access to clean water, the percentage of food safety meeting standards, the Desirable Dietary Pattern (PPH) consumption score, and the percentage of stunted toddlers (National Food Agency, 2024). The FSVA uses a uniform color scheme in gradients of red (for vulnerability) and green (for security), grouped into six categories with composite cut-offs: Priority 1 – Very Vulnerable, Priority 2 – Vulnerable, Priority 3 – Somewhat Vulnerable, Priority 4 – Somewhat Secure, Priority 5 – Secure, and Priority 6 – Very Secure (National Food Agency, 2024; Bengkulu City Food Security and Agriculture Office, 2024). The FSVA analysis consists of three levels: National FSVA analyzing at the regency/municipality level, Provincial FSVA analyzing at the sub-district level, and Regency FSVA analyzing at the village level (Bengkulu City Food Security and Agriculture Office, 2024).

Based on cluster analysis using the Biplot approach, the regions of Bengkulu Province can be grouped into three clusters with different characteristics (Wibowo et al., 2024). Biplot analysis is a statistical method that depicts regional characteristics and variable correlations in two-dimensional graphs, facilitating the identification of regional grouping patterns based on similar characteristics (Wibowo et al., 2024; Sativa, 2018). The grouping results based on FSVA data from the National Food Agency with three assessment aspects of availability, access, and food utilization resulted in three clusters reflecting the diversity of food security conditions across regions in Bengkulu Province (Wibowo et al., 2024). This clustering is important to support the formulation of more optimal and targeted policies, given that Bengkulu Province remains the second poorest province on Sumatra Island as of 2023, which impacts food affordability as a component of food security (Wibowo et al., 2024).

Cluster 1 consists of Kaur, South Bengkulu, and Lebong Regencies, which have good food security characteristics as they are relatively close to the availability and food utilization indicators (Wibowo et al., 2024). South Bengkulu Regency, as a food granary, has the highest rice and corn production in Bengkulu Province, supporting the food availability indicator (Rolenza et al., 2025). This cluster region has advantages in food production and resource utilization aspects, reflected in high average rice and corn production and relatively good food utilization indicators such as women's education levels and access to health services (Wibowo et al., 2024; Rolenza et al., 2025). These advantages make Cluster 1 regions relatively more resilient to food security shocks compared to other clusters.

Cluster 2 includes Central Bengkulu, Mukomuko, and North Bengkulu Regencies, which have strong attributes as food access indicators (Wibowo et al., 2024). In Mukomuko Regency, non-food consumption levels are higher than food consumption (3.24%), indicating better community purchasing power (Rolenza et al., 2025). According to Engel's law, the higher a household's income, the smaller the proportion of income allocated to food consumption, so that high non-food consumption in this region reflects relatively better economic welfare (Wibowo et al., 2024). Consumption tends to increase along with changes in income, and social welfare improves when the proportion of income spent on food declines (Wibowo et al., 2024). This characteristic indicates that although food production in Cluster 2 may not be as high as in Cluster 1, better community purchasing power enables easier food access through market mechanisms.

Cluster 3 consists of Rejang Lebong, Seluma, and Kepahiang Regencies, which have characteristics reflecting deficiencies in electricity, clean water, poverty levels, and life expectancy (Wibowo et al., 2024). These regions require more intensive interventions in the utilization and food access aspects (Wibowo et al., 2024). This condition is exacerbated by the geographical characteristics of several areas located in coastal regions, where the needs of farmers and fishers also constrain food security (Wibowo et al., 2024). The research results of

Wibowo et al. (2024) indicate that the food security indices of Rejang Lebong, Seluma, and Mukomuko Regencies fluctuated during the analysis period, unlike other regencies that tended to increase. This suggests that Cluster 3 regions have higher vulnerability to changes in economic and environmental conditions, thus requiring special attention in food security policy formulation. Nationally, FSVA results for 2024 show that the number of food-insecure vulnerable regions (priorities 1–3) in Indonesia decreased by 12% from 74 regencies/municipalities in 2021 to 62 regencies/municipalities in 2023, reflecting improvements in the national food security situation through synergy and cross-sectoral collaboration (National Food Agency, 2024). However, spatial diversity at the provincial level, as seen in Bengkulu, emphasizes the importance of location-specific policy approaches.

3. Analysis of Food Security Based on FSVA Dimensions

Food Availability Aspect

Food availability is a fundamental dimension of food security that measures a region's capacity to provide food for its population through local production, imports, or food reserves (National Food Agency, 2024; Mulyasari, 2016). Food availability is measured through the provision of food sources such as strategic commodity production, agricultural land area, productivity, and population density of a region (Rolenza et al., 2025; National Food Agency, 2024). Rice production in Bengkulu Province has declined over the past five years, from 296,472 tons in 2019 to 277,310 tons in 2023 (Isma et al., 2025; Rolenza et al., 2025). The decline in production and productivity is due to the reduction of agricultural land due to population growth and land-use conversion, which negatively impacts regional food supply and the fulfillment of community food needs (Rolenza et al., 2025; Isma et al., 2025). BPS data indicate that the harvested area of rice in Bengkulu Province has fluctuated with a declining trend, directly affecting total rice production (Isma et al., 2025).

Corn production conditions in Bengkulu Province show different dynamics. Based on the BSIP Bengkulu (2024) report, South Bengkulu Regency is the area with the highest corn production and received hybrid corn seed assistance covering 3,150 hectares through the UPSUS (Special Efforts) program for accelerated planting in 2024. This program aims to increase national corn production through expanded planting area and increased productivity. However, dependence on incentive programs remains a challenge in achieving long-term food self-sufficiency. Research by Isma et al. (2025) also shows that the growth rate of rice production in Bengkulu Province is not always aligned with the growth rate of harvested area, indicating other factors such as land productivity, climate, and cultivation technology influencing rice production.

Efforts to increase food availability have been made through the Additional Planting Area (PAT) program and the Optimization of Swamp Land (OPLAH). Bengkulu Province successfully exceeded the set target by recording an achievement of planted area of 16,034 hectares (Tribun-Timur, 2024). This achievement requires strengthening information in the form of accurate geospatial mapping, which has been conducted through a geospatial data compilation workshop involving 10 regencies/municipalities in Bengkulu (Tribun-Timur, 2024). This geospatial mapping is important to support the accuracy of agricultural land data, planting planning, and evaluation of food production enhancement programs. The National Food Agency (2024) also emphasizes the importance of accurate spatial data in FSVA compilation, where food availability indicators include the normative per capita consumption ratio to food availability, the ratio of energy availability per capita per day to standard requirements, and the ratio of Regional Government Rice Reserves (CBPK).

Food Access Aspect

Food access pertains to the level of community purchasing power for food commodities, reflecting the economic capacity of households to obtain sufficient and nutritious food (National Food Agency, 2024; Rolenza et al., 2025). Communities with relatively low income have lower purchasing power and will consume low-priced goods in smaller quantities, ultimately affecting the quality and quantity of food consumption (Rolenza et al., 2025). Small incomes result from a lack of purchasing power for education and information access, creating an intergenerational cycle of poverty (Rolenza et al., 2025). According to Engel's law, the higher a household's income, the smaller the proportion of income allocated to food consumption, so that the proportion of food expenditure can serve as an indicator of economic welfare level (Sativa, 2018; Rolenza et al., 2025).

The poverty condition in Bengkulu Province as the second poorest province on Sumatra Island, with a poverty rate of 14.04% in 2023, impacts community food access (Harian Haluan, 2024; Wibowo et al., 2024). This high poverty rate has implications for low purchasing power for nutritious food, which in turn can cause malnutrition and stunting. Food access indicators in the FSVA include the percentage of the population living below the poverty line, the coefficient of variation of staple food commodity prices, and the Prevalence of Undernourishment (PoU) (National Food Agency, 2024). However, several regencies such as Mukomuko and Bengkulu City show higher non-food consumption levels compared to food consumption, at 3.24% for Mukomuko Regency and 16.5% for Bengkulu City (Rolenza et al., 2025), indicating variations in purchasing power across regions in Bengkulu Province. Consumption tends to increase along with changes in income, and social welfare improves when the proportion of income spent on food declines (Rolenza et al., 2025).

Food Utilization Aspect

Food quality or food utilization is a dimension of food security related to the ability of communities and individuals to obtain and digest nutrients from the food consumed (National Food Agency, 2024; Rolenza et al., 2025). Effective food quality depends not only on the amount of food expenditure but also on how communities select, process, and consume nutritionally balanced foods (Rolenza et al., 2025). High expenditure on food needs may focus more on quantity rather than quality, so that the potential for community nutritional intake may not be optimally met (Rolenza et al., 2025). Food utilization indicators in the FSVA include the average years of schooling for women over 15 years, the percentage of households without access to clean water, the percentage of food safety meeting standards, the Desirable Dietary Pattern (PPH) consumption score, and the percentage of stunted toddlers (National Food Agency, 2024).

The food quality index in Bengkulu Province, which stands at 0.97 (below 1), indicates the need for particular attention to the food utilization aspect (Rolenza et al., 2025). Stunting and life expectancy are important indicators in this aspect that require intervention through public health and nutrition policies. Stunting prevalence data in Bengkulu Province show that several regencies such as Rejang Lebong, Seluma, and Kepahiang still face serious challenges in stunting management (Wibowo et al., 2024). Furthermore, access to clean water and proper sanitation is also a determining factor in food utilization, as clean water is needed to process and prepare hygienic food, while poor sanitation can cause infectious diseases that interfere with nutrient absorption (National Food Agency, 2024). Research by Mulyasari (2016) indicates that the food utilization aspect in Bengkulu Province still faces various obstacles, including low average years of schooling for women, which impacts nutritional knowledge and child-rearing practices.

4. Policy Implications

The results of the spatial analysis indicate that food security in Bengkulu Province exhibits significant spatial variation across regencies/municipalities (Rolenza et al., 2025; Wibowo et al., 2024). This implies the need for location-specific policies to optimize interventions and the allocation of food assistance more precisely (National Food Agency, 2024). A one-size-fits-all approach would be ineffective given the diversity of food security characteristics across regions, thus requiring intervention strategies tailored to the specific conditions of each cluster. Wibowo et al. (2023) also showed that the COVID-19 pandemic has impacted the change in the food security index of Bengkulu Province from 70.77 in 2018 to 68 in 2022, emphasizing the importance of continuous monitoring of food security dynamics.

For Cluster 1, consisting of Kaur, South Bengkulu, and Lebong Regencies, policies should focus on increasing production and strengthening food utilization systems, including agricultural product processing and reducing post-harvest losses (Wibowo et al., 2024; Rolenza et al., 2025). This region has high potential as a food granary, especially South Bengkulu Regency with the highest rice and corn production in Bengkulu Province, so policies should be directed at increasing the added value of agricultural products through processing and strengthening food supply chains (Rolenza et al., 2025). Agro-industry development programs based on coffee, cocoa, palm oil, and corn in this region can serve as strategies to increase farmers' income and reduce post-harvest losses (BSIP Bengkulu, 2024). Additionally, strengthening farmers' institutions and access to modern agricultural technology should be prioritized to increase productivity and farming efficiency.

For Cluster 2, encompassing Central Bengkulu, Mukomuko, and North Bengkulu Regencies, policies should focus on improving food access through strengthening marketing infrastructure, market development, and enhancing community purchasing power (Wibowo et al., 2024). This region has advantages in the food access aspect, reflected in higher non-food consumption levels compared to food consumption in Mukomuko Regency (Rolenza et al., 2025). Necessary policies include developing transportation and logistics infrastructure to facilitate food distribution, strengthening local and regional markets, and income enhancement programs through developing micro, small, and medium enterprises (MSMEs) and job creation. Social protection programs such as non-cash food assistance and family hope programs should also be strengthened to protect vulnerable groups from economic shocks (Wibowo et al., 2024).

For Cluster 3, consisting of Rejang Lebong, Seluma, and Kepahiang Regencies, policies should focus on integrated interventions covering improving electricity and clean water access, poverty alleviation, increasing life expectancy, and strengthening food utilization (Wibowo et al., 2024). This region has high vulnerability characteristics in electrification, clean water access, poverty levels, and life expectancy (Wibowo et al., 2024). Required interventions include developing basic infrastructure such as village electrification and clean water provision, integrated poverty alleviation programs, improving access to health and education services, and community nutrition improvement programs including stunting management (National Food Agency, 2024). Specific intervention programs such as Supplementary Feeding (PMT), nutritional supplementation, and child-rearing education also need to be intensified in this region considering the high prevalence of stunting and low life expectancy.

Previous research by the National Food Agency (2024) and Afrizah et al. (2023) also shows that food security is greatly influenced by poverty, limited infrastructure, and dependence on certain commodities. Afrizah et al. (2023) grouped food-insecure areas in Bengkulu Province using the K-Means Clustering method into three clusters with low,

medium, and high vulnerability levels, reinforcing findings on spatial variation of food vulnerability in Bengkulu Province. These findings strengthen the importance of a data-driven approach and the use of geospatial technology for monitoring and mitigating food crises. The FSVA is an important tool for early detection of areas potentially experiencing food vulnerability, so interventions can be carried out before more severe food crises occur (National Food Agency, 2024; Mulyasari, 2016). These policy recommendations align with research by Wibowo et al. (2024), which emphasizes the importance of cross-sectoral coordination in strengthening food security and the involvement of various stakeholders in the formulation and implementation of food security policies in Bengkulu Province.

CONCLUSION

This study analyzed food security and vulnerability conditions in Bengkulu Province using a Geographic Information System (GIS) approach utilizing the Food Security and Vulnerability Atlas (FSVA). Based on the research results, it can be concluded that:

1. The average food security index of Bengkulu Province during the 2019–2023 period is 1.07, with an availability index of 1.12, an access index of 1.13, and a quality index of 0.97. The food quality index, which remains below 1, indicates the need for particular attention to the aspect of food utilization.
2. Cluster analysis grouped the regions into three clusters with distinct characteristics: Cluster 1 (Kaur, South Bengkulu, Lebong) exhibits good food security; Cluster 2 (Central Bengkulu, Mukomuko, North Bengkulu) excels in food access; and Cluster 3 (Rejang Lebong, Seluma, Kepahiang) demonstrates high vulnerability in infrastructure and health aspects.
3. Efforts to increase food availability through the PAT and OPLAH programs have achieved their target with a planted area of 16,034 hectares, requiring the strengthening of geospatial mapping to support data accuracy and performance transparency.
4. The GIS and FSVA approaches have proven effective in identifying spatial diversity of food security and providing direction for targeted policy interventions.

Further research is recommended to develop analyses at the sub-district and village levels for more detailed intervention planning, as well as to integrate projection analyses to anticipate future food security dynamics.

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