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Beyond food production: unraveling agro-economic drivers of food security in Sulawesi

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ABSTRACT

Purpose: to analyze the dynamics and trends of the Food Security Index (FSI) across six provinces in Sulawesi during 2019–2025 and to interpret the observed variations from a regional agro-economic perspective.
Method: this study employed a quantitative approach using secondary data on the Food Security Index (FSI) for six provinces in Sulawesi during 2019–2025, obtained from the National Food Agency. Data were analyzed using descriptive analysis to classify FSI levels and trend analysis to identify annual changes in food security conditions.
Findings: food security across the six provinces in Sulawesi fluctuated during 2019–2025, with a notable decline in 2025. North Sulawesi, Gorontalo, Central Sulawesi, West Sulawesi, Southeast Sulawesi, and South Sulawesi all experienced declines in FSI in 2025, although their overall food-security levels remained within the "Secure" or "Highly Secure" categories. These findings indicate that regional food security is not determined solely by food production but is also associated with economic access, distribution, purchasing power, and the resilience of regional food systems.
Implications: food-security policies in Sulawesi should integrate production, distribution, market access, purchasing power, and food utilization through region-specific strategies.
Originality: lies in interpreting Food Security Index dynamics across six Sulawesi provinces through an integrated regional agro-economic perspective, linking temporal changes in food security with production, access, distribution, and household economic conditions.

Introduction

Food security is a fundamental component of sustainable development because it reflects the capacity of individuals, households, and regions to obtain sufficient, safe,

nutritious, and sustainable food (Clapp et al., 2022). Rather than being determined solely by the quantity of food produced, food security emerges from the interaction of food availability, economic access, utilization, and the capacity of food systems to withstand shocks and structural change (Naheed & Rukhsana, 2024). The measurement of food security has therefore evolved toward multidimensional approaches that capture both material access to food and the socioeconomic conditions underlying that access (Cafiero et al., 2018; Gallegos et al., 2023; Simelane & Worth, 2020). In this context, the Food Security Index (FSI) provides an important instrument for synthesizing multiple dimensions of food security into a comparable measure across regions and over time. However, index values should not be interpreted simply as reflections of agricultural production, because food security outcomes are also shaped by household economic capacity, food prices, market access, distribution systems, consumption patterns, and institutional conditions. Leroy et al. (2015) emphasize that the food-access dimension requires careful consideration of the economic capacity of households, while Béné et al. (2023) demonstrate that food security is closely associated with the resilience of food-system actors and institutions in responding to pressures and shocks. Consequently, an agro-economic perspective is essential for understanding why similar levels of agricultural potential may produce different food security outcomes across regions.

This issue is particularly relevant in Sulawesi, where substantial differences exist in agricultural production systems, plantation economies, fisheries, coastal livelihoods, infrastructure, market connectivity, fiscal capacity, and regional economic structures. Such heterogeneity creates a potentially important paradox: regions with strong agricultural or natural-resource bases may not necessarily exhibit proportionally stronger food security outcomes. The availability of food at the regional level may fail to translate into adequate and nutritious household consumption when purchasing power, distribution networks, employment opportunities, or access to markets remain constrained. Evidence from household-level studies indicates that food security is associated with livelihood characteristics, household socioeconomic conditions, consumption patterns, and nutritional outcomes (Jayarni & Sumarmi, 2018; Lestari et al., 2025; Rohaedi et al., 2016; Safitri et al., 2017). At the regional level, government policy, fiscal capacity, and institutional performance may further shape food security conditions (Aisyah et al., 2020; Machieu et al., 2026). Therefore, the central research problem is not merely whether Sulawesi produces sufficient food, but why food security levels and their trajectories differ across regions despite differences in agricultural potential, and which agro-economic factors are associated with these variations. Examining FSI dynamics rather than relying on a single-period measurement is particularly important because increases, stagnation, or declines in the index may reveal structural changes in regional food systems that remain hidden in cross-sectional comparisons.

Previous studies provide substantial evidence that food security is multidimensional and closely connected to economic, agricultural, nutritional, and institutional factors. Studies on food security measurement emphasize the importance of integrating multiple dimensions and ensuring that indicators adequately represent access, availability, utilization, and sustainability (Aliyu et al., 2021; Leroy et al., 2015; Sinaga et al., 2022). Research on rural and farming households further shows that food security is embedded in livelihood systems and local economic structures, rather than being determined exclusively by agricultural output (Fitriana et al., 2024; Lestari et al., 2025; Setiawan et al., 2026). At the same time, food-system resilience research

highlights the importance of understanding how regions and actors respond to shocks and changing conditions (Béné et al., 2023), while Barrett et al. (2022) demonstrate the transformative role of agri-food value chains in shaping economic opportunities and food-system outcomes. Recent Indonesian studies have also explored FSI modeling and prediction, including the use of panel regression and machine-learning approaches (Azhar et al., 2023; Saragih & Wibowo, 2025). Nevertheless, the existing literature remains fragmented: household studies tend to focus on micro-level determinants, while regional studies frequently emphasize index measurement, policy, or prediction without systematically connecting FSI trajectories to the broader agro-economic structure of regions. Moreover, limited attention has been given to the spatial and temporal heterogeneity of food security across Sulawesi and to the extent to which agricultural and economic characteristics jointly explain differences in FSI performance. This gap provides the basis for the novelty of the present study, which moves beyond viewing food security as an outcome of food production alone by examining FSI dynamics through an integrated regional agro-economic lens.

Against this background, this study aims to analyze the dynamics of the Food Security Index across regencies/cities in Sulawesi and to identify the agro-economic factors associated with differences in food security outcomes. The analysis is designed to examine FSI trends over time and to relate these trajectories to the characteristics of regional agricultural production, economic capacity, livelihood structures, market and distribution conditions, and other relevant socioeconomic dimensions. By doing so, the study seeks to distinguish between regions experiencing improvement, stagnation, or deterioration in food security and to identify the economic and food-system dimensions that may underpin these different trajectories. This approach is consistent with the argument that food security should be understood as an interaction between food systems and broader socioeconomic processes rather than as an isolated agricultural indicator (Iannotti et al., 2024; Woodhill et al., 2022). The study therefore positions FSI not merely as a descriptive index, but as an entry point for understanding how regional agro-economic structures influence the capacity of communities to achieve and sustain food security.

The importance of this research lies in its potential to provide a more comprehensive explanation of regional food security disparities in Sulawesi and to strengthen the empirical basis for place-sensitive food-security policies. Understanding the factors associated with changes in FSI can help reveal why improvements in production or economic activity do not always produce corresponding improvements in food security, while also identifying dimensions of the regional food system that may require greater policy attention. The findings are expected to contribute to the literature by integrating food-security measurement with regional agro-economic analysis and by extending existing studies from static assessment toward a more dynamic understanding of food-security trajectories. In practical terms, the results can provide evidence for policymakers in designing interventions that are more closely aligned with regional characteristics, including agricultural development, income and livelihood strengthening, market and distribution infrastructure, and institutional capacity. Such an approach is particularly important in geographically and economically heterogeneous regions such as Sulawesi, where uniform food-security interventions may not adequately address differences in regional constraints and opportunities. Ultimately, this study is expected to contribute both conceptually and empirically to a deeper understanding of food security as an outcome of interconnected agricultural, economic, market, and institutional processes, thereby supporting more targeted and

sustainable regional food-system development.

Literature review

Food security index as a multidimensional measure of food security

Food security is a multidimensional condition that extends beyond the physical availability of food and encompasses the capacity of individuals and households to obtain, access, utilize, and sustain adequate food over time. Accordingly, the Food Security Index (FSI) can be understood as a composite measure that translates several dimensions of food security into an integrated indicator for assessing differences in food-security conditions across geographical areas. Simelane & Worth (2020) argue that food security should be conceptualized through the interrelationships among availability, access, utilization, and stability, because sufficient food supply at the aggregate level does not necessarily ensure that households have adequate purchasing power or the ability to transform food resources into nutritional well-being. In this perspective, the FSI provides an analytical framework for capturing the multidimensional nature of food security rather than reducing it to agricultural production alone. Aliyu et al. (2021) emphasize that food-security measurement needs to accommodate the sustainability of food systems, while Gallegos et al. (2023) highlight the importance of multidimensional indicators for understanding food-security conditions and supporting policy-oriented assessment. Furthermore, Savary et al. (2022) and Iannotti et al. (2024) demonstrate that contemporary food-security challenges are shaped by interconnected agrifood, economic, social, environmental, and institutional factors. Thus, the FSI is not merely a statistical representation of food availability but can be interpreted as an outcome indicator reflecting the interaction between food-system performance and the socioeconomic capacity of a region.

Agro-economic perspective on food security

The agro-economic perspective provides a theoretical foundation for explaining why food security outcomes may differ among regions with comparable agricultural potential. Regional agro-economics examines the relationships between agricultural production and the broader economic structures within which agricultural activities occur, including labor, income, markets, infrastructure, processing, distribution, natural resources, and institutional arrangements. From this perspective, agricultural production represents only one component of a wider regional food system. The quantity of food produced may contribute to availability, but its contribution to food security depends on whether food can move efficiently through markets, generate adequate income for producers and workers, and become economically accessible to consumers. Barrett et al. (2022) demonstrate that transformations in agri-food value chains connect producers with processors, distributors, and consumers while creating economic value and influencing the distribution of opportunities across rural and urban areas. This implies that changes in agricultural production do not automatically translate into improvements in food security when constraints exist in processing, transportation, market access, or the distribution of economic benefits. Therefore, an agro-economic analysis enables food security to be examined as an outcome of interactions among production systems, market mechanisms, and regional economic structures.

Agricultural livelihoods, rural well-being, and food access

The relationship between agriculture and food security is also mediated by the livelihood and welfare conditions of households involved in agricultural activities. Agriculture can contribute to food security through direct food production, employment, income generation, and participation in local and regional markets. However, agricultural households may remain vulnerable when their livelihoods are characterized by unstable income, limited market access, low value added, or dependence on a narrow range of commodities. Woodhill et al. (2022) emphasize that food systems are closely connected to rural well-being because agricultural and food-system transformations influence employment, income, livelihood opportunities, and the broader welfare of rural communities. This perspective suggests that the contribution of agriculture to food security should be assessed not only through production quantities but also through its capacity to generate sustainable livelihoods and economic access to food. Similarly, Crescenzi et al. (2022) demonstrate that the territorial embeddedness of agricultural products can influence value creation and local economic development, indicating that regional characteristics and local economic linkages can determine how agricultural resources are converted into economic benefits. Consequently, regions with strong agricultural resources may experience different food-security outcomes depending on the extent to which agricultural activities generate inclusive economic opportunities and strengthen household purchasing power.

Markets, value chains, and regional economic connectivity

Beyond production and household livelihoods, market connectivity and agri-food value chains constitute important mechanisms linking regional economic activity to food security. Food moves through a series of interconnected activities involving production, collection, storage, processing, transportation, wholesaling, retailing, and consumption. Inefficiencies or unequal access within these processes can affect both the availability and affordability of food. Barrett et al. (2022) show that agri-food value-chain transformations can restructure relationships among producers, markets, and consumers, thereby influencing both agricultural returns and food-system outcomes. From a regional perspective, the effectiveness of these value chains depends partly on infrastructure, market connectivity, processing capacity, and the ability of local economic actors to participate in higher-value activities. Crescenzi et al. (2022) further demonstrate that regional embeddedness can strengthen the economic value generated from local commodities, suggesting that agricultural specialization alone is insufficient to explain regional economic and food-security outcomes. A region may produce substantial quantities of agricultural commodities while receiving limited local economic benefits if raw products are poorly integrated with local processing, distribution, and value-creation activities. Therefore, market and value-chain conditions represent important mechanisms through which regional agro-economic structures can influence food-security performance.

Agro-economic drivers of food security: an integrated conceptual perspective

Based on these theoretical perspectives, food security can be conceptualized as the outcome of an interconnected agro-economic system rather than as a direct consequence of food production. Agricultural production primarily contributes to food availability, while income, employment, and livelihood opportunities influence economic access; markets, infrastructure, processing, and distribution determine the movement and affordability of food; and regional economic structures influence the capacity of

communities to sustain these processes over time. The interaction among these dimensions provides a theoretical explanation for why regions with similar agricultural resources may exhibit different levels or trajectories of food security. The literature therefore supports an integrated framework in which the FSI functions as the outcome variable, while regional agricultural capacity, economic conditions, livelihood characteristics, market connectivity, and value-chain structures constitute potential explanatory factors. Such an approach is consistent with the broader understanding of food systems advanced by Simelane & Worth (2020); Barrett et al. (2022); Woodhill et al. (2022); and Iannotti et al. (2024), which emphasizes that food security emerges from interconnected economic, agricultural, social, and institutional processes. In the context of Sulawesi, this framework is particularly relevant because substantial variation in agricultural specialization, natural-resource endowments, rural livelihoods, market accessibility, and regional economic development creates different conditions for translating agricultural potential into actual food-security outcomes. Accordingly, examining the agro-economic drivers of FSI provides a basis for moving beyond a production-centered interpretation of food security toward a more comprehensive explanation of how regional economic structures shape the capacity of communities to achieve and sustain food security.

Method

This study employs a quantitative research approach designed to objectively measure, classify, and examine changes in food security conditions using numerical data. A quantitative approach is appropriate because the study focuses on the measurement of Food Security Index (FSI) values and the identification of changes in food-security conditions across regions and over time. The study adopts a regional longitudinal design by observing the Food Security Index across the six provinces of Sulawesi over the 2019–2025 period. The provinces included in the analysis are North Sulawesi, Central Sulawesi, South Sulawesi, Southeast Sulawesi, Gorontalo, and West Sulawesi. The use of a multi-year regional dataset enables the study to examine not only differences in food-security levels among provinces but also the direction and magnitude of changes in food-security conditions over time.

This study relies entirely on secondary data obtained from the official database of the National Food Agency of the Republic of Indonesia particularly the Food Security Index data available through the National Food Agency's data portal (https://satudata.badanpangan.go.id). The observation period covers seven consecutive years, from 2019 to 2025. The unit of analysis is the province-year observation, with each province observed annually during the study period. The dataset therefore provides a longitudinal basis for comparing food-security conditions both across provinces and across years. The use of official secondary data ensures that the FSI values are based on the standardized measurement framework applied by the National Food Agency, allowing consistent classification and comparison across the study area and observation period.

The principal variable in this study is the Food Security Index (FSI), which is used as an aggregate indicator of regional food-security conditions. The FSI values are interpreted using the classification standards established by the National Food Agency of the Republic of Indonesia. The classification divides provincial food-security conditions into six categories, ranging from highly vulnerable to highly secure. This classification provides a descriptive basis for identifying the relative food-security

position of each province in each observation year. The classification criteria are presented in Table 1.

Table 1 provincial-level food security index categories

Nu.	FSI score	Category
1	≤ 37,61	Highly vulnerable
2	> 37,61 - 48,27	Vulnerable
3	> 48,27 - 57,11	Moderately vulnerable
4	> 57,11 - 65,96	Moderately secure
5	> 65,96 - 74,40	Secure
6	> 74,40	Highly secure

Source: national food agency

The classification is applied consistently to all province-year observations. Accordingly, the analysis can identify whether a province remains within the same food-security category or moves toward a higher or lower category during the observation period. Changes in category are interpreted as descriptive evidence of shifts in the overall food-security condition, rather than as evidence of causality. The analysis consists of two complementary stages: descriptive analysis and temporal change analysis. First, descriptive analysis is used to summarize and compare FSI values across the six provinces and seven observation years. This analysis identifies the level and distribution of FSI values and classifies each province-year observation according to the National Food Agency's food-security categories. The descriptive results are used to identify differences in food-security conditions among provinces and to characterize the spatial heterogeneity of food security in Sulawesi.

Second, temporal change analysis is employed to identify the direction and magnitude of annual changes in FSI values. Examining changes over time is important because a single FSI value may not adequately capture whether a region is improving, stagnating, or experiencing deterioration in food security. Previous studies have demonstrated the value of temporal and quantitative approaches for identifying patterns and changes in economic and food-security indicators (Chen et al., 2025; Joshi et al., 2025). In this study, annual percentage change is used as a measure of the relative change in FSI between two consecutive years. The annual change is calculated using the following formula:

$$Annual\ change = \frac{Y_t - Y_{t-1}}{Y_{t-1}} x100\%$$

where Y_t represents the FSI value in the current year or period, and $Y_{t\text{-}1}$ represents the FSI value in the immediately preceding year or period. A positive value indicates an increase in the FSI relative to the previous year, whereas a negative value indicates a decrease. A value close to zero indicates relatively little change between consecutive periods. The annual percentage changes are calculated separately for each province for each year from 2020 to 2025, using 2019 as the baseline year for the first comparison.

The results of the descriptive and temporal analyses are subsequently interpreted together to identify the food-security trajectories of the six provinces. The analysis distinguishes provinces according to their initial FSI levels, their food-security categories, and the direction and magnitude of changes during the observation period. This combined approach makes it possible to move beyond a static comparison of FSI values and provide a more dynamic description of food-security development in

Sulawesi. The results are then discussed in relation to the regional agro-economic context, particularly differences in agricultural characteristics, economic capacity, livelihoods, market connectivity, and other structural conditions that may help explain variations in food-security trajectories.

Results and discussion

The Food Security Index (FSI) results for the six provinces of Sulawesi during 2019–2025 reveal considerable differences in the level, stability, and direction of regional food security. Although most provinces maintained relatively favorable food-security conditions during the early and middle years of the observation period, all six provinces experienced a decline in FSI in 2025. The magnitude of the decline varied across provinces, indicating different trajectories of regional food security. These differences are important because the FSI represents a multidimensional condition that extends beyond food production and incorporates aspects of food availability, access, utilization, and stability. The provincial results are presented sequentially below to identify the distinctive food-security trajectories of each province before examining their broader agro-economic implications.

Food security in North Sulawesi

The annual Food Security Index values and their corresponding categories and percentage changes for North Sulawesi Province during 2019–2025 are presented in Table 2. The table provides the basis for assessing both the level of food security and its year-to-year dynamics.

Table 2 food security in North Sulawesi

Nu.	Year	FSI value	Category	FSI trend
1	2019	81.44	Highly secure	-
2	2020	77.79	Highly secure	-4.48%
3	2021	78.30	Highly secure	0.66%
4	2022	74.30	Secure	-5.11%
5	2023	77.32	Highly secure	4.06%
6	2024	76.32	Highly secure	-1.29%
7	2025	72.49	Secure	-5.02%

Source: secondary data, processed 2026.

As shown in Table 2, North Sulawesi maintained a relatively high level of food security throughout the observation period but exhibited an overall downward trajectory. The highest FSI was recorded in 2019 at 81.44, while the lowest occurred in 2025 at 72.49, with an average of 76.85. The largest annual decline occurred in 2022 at 5.11%, followed by the largest annual recovery in 2023 at 4.06%. Although the province remained in the “Highly Secure” category during most of the period, its classification declined to “Secure” in 2022 and again in 2025. Overall, the FSI decreased by approximately 10.99% between 2019 and 2025. Thus, North Sulawesi retained a relatively favorable food-security position, but the downward movement indicates a weakening of the conditions underlying that position.

Food security in Gorontalo

The FSI development of Gorontalo Province is presented in Table 3. The table shows the substantial improvement that occurred at the beginning of the observation

period, the subsequent period of relative stability, and the marked decline recorded in 2025.

Table 3 food security in Gorontalo

Nu.	Year	FSI value	Category	FSI trend
1	2019	69.06	Secure	-
2	2020	80.40	Highly secure	16.42%
3	2021	80.52	Highly secure	0.15%
4	2022	80.35	Highly secure	-0.21%
5	2023	81.63	Highly secure	1.59%
6	2024	81.47	Highly secure	-0.20%
7	2025	69.75	Secure	-14.39%

Source: secondary data, processed 2026.

Table 3 indicates that Gorontalo experienced a substantial improvement in food security from 2019 to 2020. The FSI increased from 69.06 to 80.40, representing a 16.42% annual increase and a transition from the "Secure" to the "Highly Secure" category. The index subsequently remained relatively stable during 2021–2024, fluctuating within the range of 80.35–81.63 and reaching its highest value of 81.63 in 2023. However, the province experienced a sharp decline of 14.39% in 2025, reducing the FSI to 69.75 and returning the province to the "Secure" category. The average FSI during the observation period was 77.60. Although the 2025 value was approximately 1.00% higher than the 2019 value, the sharp decline in the final year indicates that the earlier improvement was not fully sustained.

Food security in Central Sulawesi

Table 4 presents the annual FSI values, food-security categories, and annual changes for Central Sulawesi Province. These data illustrate a relatively strong improvement after 2019, followed by a marked decline in 2025.

Table 4 food security in Central Sulawesi

Nu.	Year	FSI value	Category	FSI trend
1	2019	68.17	Secure	-
2	2020	75.10	Highly secure	10.17%
3	2021	75.73	Highly secure	0.84%
4	2022	75.92	Highly secure	0.25%
5	2023	75.83	Highly secure	-0.12%
6	2024	76.87	Highly secure	1.37%
7	2025	70.40	Secure	-8.42%

Source: secondary data, processed 2026.

As indicated in Table 4, Central Sulawesi experienced an overall improvement compared with the beginning of the observation period, although this improvement was interrupted by a substantial decline in 2025. The FSI increased from 68.17 in 2019 to 75.10 in 2020, representing a 10.17% increase and a shift from the "Secure" to the "Highly Secure" category. From 2021 to 2024, the FSI remained relatively stable, ranging from 75.73 to 76.87, with the highest value occurring in 2024. In 2025, however, the index decreased by 8.42% to 70.40, returning the province to the "Secure" category. Despite the decline, the 2025 FSI remained approximately 3.27% above its 2019 level. This pattern indicates that Central Sulawesi achieved an improvement over the longer observation period, but the improvement was accompanied by a significant deterioration in the final year.

Food security in West Sulawesi

The FSI trajectory of West Sulawesi Province is presented in Table 5. The table highlights a substantial initial improvement in 2020 followed by a continuous downward movement during 2021–2025.

Table 5 food security in West Sulawesi

Nu.	Year	FSI value	Category	FSI trend
1	2019	60.37	Moderately secure	-
2	2020	76.36	Highly secure	26.49%
3	2021	75.49	Highly secure	-1.14%
4	2022	74.04	Secure	-1.92%
5	2023	73.03	Secure	-1.36%
6	2024	71.99	Secure	-1.42%
7	2025	67.08	Secure	-6.83%

Source: secondary data, processed 2026.

Table 5 shows that West Sulawesi experienced the largest annual improvement among the six provinces in 2020, when the FSI increased by 26.49%, from 60.37 to 76.36. This change shifted the province from the "Moderately Secure" to the "Highly Secure" category. However, the improvement was not sustained. The FSI declined successively from 75.49 in 2021 to 67.08 in 2025, and the province moved from "Highly Secure" in 2020–2021 to "Secure" from 2022 onward. The period average was 71.19. Nevertheless, the 2025 FSI remained approximately 11.11% above the 2019 value. These results demonstrate that a substantial short-term improvement does not necessarily translate into a sustained strengthening of regional food security.

Food security in Southeast Sulawesi

The annual FSI trajectory of Southeast Sulawesi Province is presented in Table 6. The results indicate a relatively stable food-security position during 2019–2024 followed by a substantial decline in 2025.

Table 6 food security in Southeast Sulawesi

Nu.	Year	FSI Value	Category	FSI Trend
1	2019	76.99	Highly secure	-
2	2020	77.06	Highly secure	0.09%
3	2021	76.64	Highly secure	-0.55%
4	2022	75.04	Highly secure	-2.09%
5	2023	74.96	Highly secure	-0.11%
6	2024	76.68	Highly secure	2.29%
7	2025	67.56	Secure	-11.90%

Source: secondary data, processed 2026.

As shown in Table 6, Southeast Sulawesi maintained a relatively stable food-security position during 2019–2024. The FSI remained in the "Highly Secure" category throughout this period, ranging from 74.96 to 77.06. The highest value was recorded in 2020 at 77.06, while the lowest occurred in 2025 at 67.56. The index declined gradually during 2021–2023 before increasing by 2.29% in 2024. This temporary recovery was followed by a sharp decline of 11.90% in 2025, causing the province to move into the "Secure" category. Compared with 2019, the 2025 FSI declined by approximately 12.25%, representing a substantial deterioration in the overall food-security position.

Food security in South Sulawesi

The FSI values and annual changes for South Sulawesi Province are presented in Table 7. The data indicate that the province maintained the highest level of food security among the six provinces for most of the observation period, although a marked decline occurred in 2025.

Table 7 food security in South Sulawesi

Nu.	Year	FSI Value	Category	FSI Trend
1	2019	78.69	Highly secure	-
2	2020	81.81	Highly secure	3.96%
3	2021	80.82	Highly secure	-1.21%
4	2022	81.38	Highly secure	0.69%
5	2023	83.36	Highly secure	2.43%
6	2024	83.82	Highly secure	0.55%
7	2025	74.30	Secure	-11.36%

Source: secondary data, processed 2026.

Table 7 demonstrates that South Sulawesi maintained consistently high food-security conditions during 2019–2024. The FSI increased from 78.69 in 2019 to 81.81 in 2020 and subsequently reached its highest value of 83.82 in 2024. The province remained in the "Highly Secure" category throughout 2019–2024. However, the FSI declined sharply by 11.36% in 2025 to 74.30, resulting in a transition to the "Secure" category. Despite this decline, South Sulawesi recorded the highest average FSI among the six provinces, at 80.60. Nevertheless, the 2025 value was approximately 5.57% lower than the 2019 value, demonstrating that a strong food-security position can still experience considerable short-term deterioration.

Comparative discussion of food security dynamics

The six provincial results reveal three important patterns. First, the provinces differed substantially in their initial food-security positions and their trajectories. Second, the magnitude of annual changes varied considerably, with West Sulawesi recording the largest initial increase in 2020 and Gorontalo recording the largest decline in 2025. Third, and most notably, all six provinces experienced a decline in FSI in 2025. This common movement suggests that the deterioration in the final observation year was not an isolated phenomenon affecting a single province. At the same time, the different magnitudes of decline indicate that the capacity of each regional food system to absorb and respond to pressure was not uniform. Thus, the results point to the importance of examining food security as a dynamic regional outcome rather than as a static measure of food availability.

From the perspective of food-security theory, these findings reinforce the multidimensional nature of food security. Simelane & Worth (2020) conceptualize food security through the interconnected dimensions of availability, access, utilization, and stability. Accordingly, changes in the FSI should not automatically be interpreted as changes in agricultural production. A decline in the composite index may reflect pressure in one or several dimensions of food security. Leroy et al. (2015) similarly emphasize that the food-access dimension requires attention to economic capacity because the physical availability of food does not guarantee that households can obtain it. This theoretical perspective is particularly relevant to the 2025 decline observed across all six provinces: the results demonstrate deterioration in the composite index,

but they do not by themselves identify which underlying dimension was primarily responsible.

The results also provide support for the central proposition of the study that food security should be understood beyond food production. Agricultural production contributes directly to food availability, but its effect on food security is mediated by income, employment, markets, distribution, and consumption. Barrett et al. (2022) demonstrate that agri-food value chains connect producers with processors, distributors, and consumers and determine how economic value is created and distributed throughout the food system. Consequently, a region may possess substantial agricultural production capacity without achieving proportional improvements in food security if market connectivity, processing, distribution, or purchasing power remain constrained. The contrasting trajectories of South Sulawesi and West Sulawesi illustrate the relevance of this perspective: the former maintained a high FSI for most of the period, whereas the latter experienced a large initial improvement followed by a prolonged decline.

The relationship between agricultural activity and household welfare provides another explanation for the observed regional differences. Woodhill et al. (2022) emphasize that food systems are closely connected with rural well-being, livelihoods, employment, and economic opportunities. Agriculture therefore contributes to food security not only through the production of food but also through its capacity to generate income and sustain rural livelihoods. Fitriana et al. (2024) similarly demonstrate the importance of strengthening rural household food-security systems through local economic development, while Lestari et al. (2025) show that farmers' food security is associated with their livelihood characteristics. Setiawan et al. (2026) further indicate that household food security needs to be understood in relation to socioeconomic conditions. These studies provide a theoretical basis for interpreting why differences in regional agricultural structures may be associated with differences in FSI trajectories, even when the present study does not directly estimate these causal relationships.

The West Sulawesi trajectory is particularly relevant to the issue of sustainability. The province experienced a 26.49% increase in FSI in 2020, followed by successive annual declines through 2025. This pattern suggests that a rapid improvement in an aggregate food-security indicator does not necessarily indicate a structural transformation of the food system. Crescenzi et al. (2022) emphasize the importance of territorial embeddedness in determining the value generated from agricultural commodities and its contribution to local economic development. This perspective suggests that agricultural resources are more likely to contribute sustainably to regional welfare when they are connected to local processing, markets, and value-creation activities. Therefore, the West Sulawesi trajectory illustrates the analytical importance of moving beyond production quantities toward the economic structures that determine how agricultural resources are transformed into income, employment, and food access.

Gorontalo and Central Sulawesi provide another important pattern. Both provinces moved from the “Secure” category in 2019 to the “Highly Secure” category in 2020 and maintained relatively high FSI values during the following years. However, both experienced substantial declines in 2025. This pattern demonstrates that improvement and resilience are not synonymous. A region may achieve a high food-security level but still face considerable deterioration when underlying food-system conditions change. Béné et al. (2023) distinguish food-system performance from resilience by emphasizing the capacity of actors and systems to absorb and respond to

shocks while maintaining essential functions. The Gorontalo and Central Sulawesi trajectories therefore highlight the importance of evaluating not only whether food security improves but also whether the underlying regional food system can sustain those gains over time.

Southeast Sulawesi provides further evidence for this distinction. The province remained in the "Highly Secure" category throughout 2019–2024, despite gradual fluctuations, but experienced an 11.90% decline in 2025. This finding demonstrates that a prolonged period of favorable FSI values does not necessarily eliminate vulnerability. Ibok et al. (2019) emphasize the importance of households' vulnerability and capacity to cope with food-insecurity risks, while Béné et al. (2023) emphasize resilience at the broader food-system level. These perspectives suggest that food-security assessment should incorporate the capacity of households, markets, and institutions to withstand disturbances. The results therefore provide an empirical basis for considering FSI dynamics not simply in terms of current status but also in terms of stability and vulnerability over time.

North Sulawesi presents a somewhat different trajectory. The province started from a relatively high FSI of 81.44 in 2019 but declined to 72.49 in 2025, with temporary recovery in 2023. The movement between "Highly Secure" and "Secure" categories indicates that a relatively strong initial position does not guarantee a stable trajectory. This finding reinforces Leroy et al.'s (2015) argument that food access needs to be examined in relation to economic capacity and supports the broader food-system perspective of Iannotti et al. (2024), which emphasizes the interaction of economic, social, and food-system factors in addressing food insecurity. Thus, maintaining a high level of food security requires continuous strengthening of the mechanisms that connect production, markets, income, and consumption.

The South Sulawesi results are particularly important because the province recorded the highest average FSI, at 80.60, and maintained the "Highly Secure" category throughout 2019–2024. However, its 11.36% decline in 2025 demonstrates that a strong food-security position can still be exposed to substantial short-term pressure. The finding is consistent with Azhar et al. (2023), who demonstrate that FSI conditions vary across Indonesian regions and that the interpretation of food security requires attention to regional characteristics. South Sulawesi's relatively strong position should therefore not be interpreted simply as evidence that high agricultural production automatically guarantees food security. Rather, its relatively favorable FSI may reflect the interaction of production capacity with economic access, market connectivity, and other dimensions captured by the composite index. The 2025 decline further demonstrates that these conditions require continuous monitoring.

The comparative evidence also supports the argument that food access and economic conditions are central components of regional food security. Cordero-Ahiman et al. (2018) demonstrate the relationship between food access, poverty, and multidimensional food security, while Cafiero et al. (2018) emphasize the importance of directly measuring experiences of food access. Allee et al. (2021) further show that different food-security indicators can identify different drivers and dimensions of food security. These findings are relevant to the interpretation of Sulawesi because the FSI provides an aggregate measure, while the underlying mechanisms may differ substantially between provinces. Consequently, an increase or decline in FSI should be interpreted as a signal requiring further examination of the economic, agricultural, and social conditions underlying that change.

Taken together, the six provincial trajectories demonstrate that food security in Sulawesi is characterized by regional heterogeneity, temporal fluctuation, and vulnerability to deterioration despite relatively favorable conditions in previous years. The results provide empirical support for an agro-economic interpretation in which food security emerges from interactions among agricultural production, livelihoods, economic access, market connectivity, distribution, and food-system resilience. This interpretation is consistent with Barrett et al. (2022); Woodhill et al. (2022); Béné et al. (2023); and Iannotti et al. (2024), who emphasize the interconnected nature of contemporary food systems. Importantly, however, the present analysis is descriptive and does not statistically establish that any particular agro-economic factor caused the observed changes in FSI. The findings should therefore be understood as identifying regional patterns and theoretically plausible mechanisms that warrant further empirical investigation.

From a policy perspective, the results imply that food-security strategies in Sulawesi should be differentiated according to regional characteristics rather than relying exclusively on increasing food production. Regions with relatively strong production bases require mechanisms that ensure efficient distribution, market integration, price stability, and equitable access to food. Regions with weaker or less stable trajectories require broader interventions involving agricultural productivity, livelihood diversification, processing, infrastructure, market access, and household purchasing power. This interpretation is consistent with Iannotti et al. (2024), who emphasize integrated approaches to addressing food insecurity, and with Fitriana et al. (2024), who highlight the importance of strengthening rural food-security systems through local economic development. Therefore, the central implication of the findings is that strengthening food security in Sulawesi requires a shift from a production-centered approach toward an integrated regional agro-economic strategy that connects food production with economic access, value chains, livelihoods, distribution, and resilience.

Conclusions

The findings show that food security in the six provinces of Sulawesi exhibited distinct temporal dynamics during 2019–2025, with a common pattern of weakening in 2025. North Sulawesi experienced an overall decline from 81.44 in 2019 to 72.49 in 2025, while Gorontalo declined from 81.47 in 2024 to 69.75 in 2025. Central Sulawesi also decreased from 76.87 to 70.40 over the same period, West Sulawesi declined from 76.36 in 2020 to 67.08 in 2025, Southeast Sulawesi fell from 76.68 in 2024 to 67.56 in 2025, and South Sulawesi decreased from 83.82 in 2024 to 74.30 in 2025. Although the six provinces generally remained within the “Secure” or “Highly Secure” categories, the simultaneous decline in 2025 indicates that relatively strong food-security conditions do not necessarily imply sustained resilience. The findings therefore reinforce the agro-economic perspective that food security is shaped not only by food production, but also by the interaction of availability, economic access, distribution, purchasing power, and food utilization.

The study contributes by demonstrating the importance of interpreting provincial FSI dynamics within their regional agro-economic contexts rather than relying solely on the level of food production or a single-year index value. The observed differences among the six provinces indicate that food-security strengthening requires context-specific strategies involving agricultural production, supply-chain efficiency, market connectivity, household purchasing power, diversification of livelihoods, and

consumption quality. This finding is consistent with the multidimensional perspective of Simelane & Worth (2020), the food-access perspective of Leroy et al. (2015) and Cordero-Ahiman et al. (2018), and the resilience perspective of Béné et al. (2023) and Ibok et al. (2019). However, the study is limited by its reliance on secondary provincial-level FSI data for 2019–2025 and descriptive and trend analyses. Consequently, the analysis identifies patterns of change but does not statistically establish the causal effects of specific agro-economic factors, such as agricultural productivity, food prices, household income, infrastructure, fiscal capacity, or market accessibility, on FSI changes.

Future research should therefore extend the analysis by integrating FSI data with disaggregated agro-economic, socioeconomic, infrastructure, market, and environmental indicators at the provincial and, where possible, district/city levels. Panel-data or spatial econometric approaches could be employed to examine the determinants and causal relationships underlying differences in food-security performance across Sulawesi, while spatial analysis could capture interregional spillovers associated with production centers, distribution networks, and consumer markets. Further research could also incorporate household-level data to examine how regional FSI dynamics are translated into actual food-access, consumption, and resilience conditions among different socioeconomic groups. Such extensions would provide a stronger empirical basis for developing more targeted and evidence-based food-security policies that simultaneously strengthen regional food systems and agro-economic welfare.

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