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Analysis of Potential Food Security Index: A Case Study Development in Bogor Regency Indonesia

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ABSTRACT

Background: Food security is an important issue in development because food is a basic human need. The availability of accurate, comprehensive and well-organized food security information can be used to build an appropriate food security sector in the development policy system. This research aims to analyze the food security condition in Bogor Regency using the food security index, identify factors that affect food security and provide appropriate strategies and policy recommendations based on measurable data. **Methods:** This research used both quantitative and qualitative approaches. Data collection methods in preparing the Bogor Regency Food Security Index include interviews, FGDs and literature studies. Descriptive analysis is used to analyze qualitative and quantitative data and information, especially to examine or evaluate the problems of food security development in Bogor Regency. Hierarchical Process Analysis is used to determine the weight of each indicator when calculating the Bogor Regency Food Security Index. **Results:** The Food Security Index value based on availability, affordability and usefulness is 47.79, 47.79 and 86.41, respectively. Some influential factors include fluctuations in the volume of food available, difficulties in accessing food needs, and limitations in food utilization. **Conclusions:** Policy strategies that the Bogor Regency Government is carrying out to improve the achievements of each indicator include prioritizing interventions and programs based on the impacts of relatively high food insecurity in the form of the food supply chain.

Introduction

Food security was first introduced in the mid-1970s when it was first discussed in the context of international food issues during a worldwide food crisis. The early focus of the effort

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was on food supply issues (Saikia and Dutta, 2018). Food security is related to the food supply and accessibility of foods to individuals (Ahmadi *et al.*, 2020) Food and its related issues are important determinant factors in providing a healthy life for human beings (Rasouli *et al.*, 2018) it is all people's physical and economic access to sufficient food to have an active and healthy life (Hosein *et al.*, 2024).Food security is an important issue in development because it is a basic human need. The Indonesian government has prioritized food security in the national development program (Basundoro and Sulaeman, 2022). Food security can be realized if food is available in both quantity and quality, has adequate intake, and is accessible to all levels of society. Moreover, food security is the second sustainable development goal (SDG) set by the UN to be achieved by all nations by 2030 (Asif and Ali, 2024).

The issue of food safety and security has emerged as a significant global concern following the outbreak of COVID-19 (Ulfa *et al.*, 2024). Ensuring food service safety has significantly challenged producers, customers, and public health officials (Azanaw *et al.*, 2019).

Following their authority, the government and local governments must build, compile and develop an integrated Food and Nutrition Information System as stipulated in the Government Regulation of the Republic Indonesia Number 17 2015 on food security and nutrition. One of the local governments that is intensively developing and strengthening the food security sector in the system as a form of implementation of government regulation is Bogor Regency. Bogor Regency has excellent potential in the agricultural sector due to its abundant fertile land and diverse agricultural product diversity. However, food security issues still face challenges, such as price fluctuations, uneven distribution, and dependence on food supplies from other regions (Kusumaningrum *et al.*, 2021).

Based on this reality, as a regency with a population of around 5.5 million, it is committed to strengthening regional food security to encourage healthy, active, productive, and competitive human resources as mandated by Law No. 18/2012. This commitment is in line with efforts to achieve the second goal in the SDGs, namely, to eliminate hunger (zero hunger) by 2030 (Regional Government of Bogor Regency, 2024.). Food security is multidimensional, so assessing the food security situation in Bogor Regency requires a comprehensive measure involving a series of indicators. Various policies and programs that have been carried out to strengthen regional food security need to be assessed with various and more measurable indicators to reflect the achievements of regional food security development (Basundoro and Sulaeman, 2022).

The Food Security Index (FSI) is one approach to measuring the performance of food security development in a region based on several indicators used to produce a composite score of food security conditions (Sutrisno, 2022). FSI measures the achievement of food security development in a region, measures regional performance in fulfilling mandatory government affairs, and is one of the tools for determining regional development and program intervention priorities (Jakaria and Lutfi, 2022).

The availability of accurate, comprehensive and well-organized food security information can support efforts to prevent and address food and nutrition insecurity in Bogor Regency. As stipulated in the (Law of Republic Indonesia Number 18 2012) and the (Government Regulation of The Republic Indonesia Number 17 2015), food security information mandates the government and local governments to establish, compile and develop an integrated Food and Nutrition Information System by their authority. This information is essential to provide direction and recommendations for decision-makers in the Local Bogor Regency Government in preparing programs, policies, and implementation.

Based on this premise and as a strategy to build a policy system for food security sector development in Bogor Regency, comprehensive, accurate and up-to-date information on the condition of regional food security is needed through the preparation of

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the FSI Bogor Regency. Therefore, this study aims to analyse the current state of food security in Bogor Regency using the FSI framework, identify the key factors influencing food security performance, and formulate evidence based strategies and policy recommendations that are grounded in measurable data. This study provides a comprehensive analysis of food security in Bogor Regency using the FSI and Food Security and Vulnerability Atlas (FSVA). It identifies specific indicators contributing to food insecurity at the regency and village levels, particularly low local staple food production (NCPR) and inadequate access to clean water. The research highlights the spatial variation in food insecurity within the regency, showing how vulnerabilities are distributed across priority areas. Although the study focuses on a single regency, it demonstrates a bottom-up model for food security monitoring that could inform similar localized assessments not only in other provinces of Indonesia but also in regions with similar or differing characteristics in other countries.

Materials and Methods

This research uses both quantitative and qualitative approaches through descriptive analysis. The quantitative approach was used to analyse statistical data on food security development in Bogor Regency obtained from government agencies and institutions related to the preparation of the FSI. The qualitative approach is used to obtain an overview of the problems and conditions of food security in Bogor Regency through interviews, Focus Group Discussion (FGD), and case study results. The FGD method was chosen because it allows for exploration of group dynamics and direct exchange of ideas, which is relevant to exploring the collective perceptions of participants that are in line with the formulation of the problem and research objectives appropriately.

Analytical hierarchy process (AHP)

This analysis is used to determine the weight of each indicator when calculating the Bogor Regency FSI. Saaty states that there are four stages in AHP: decomposition, comparative judgment, synthesis of priority, and logical consistency as shown in the **Figure 1** (Saaty, 1977).

The weighting method determines the relative importance of indicators to each aspect of food security. The determination of the amount of weight used is obtained through expert judgment (**Table 1**).

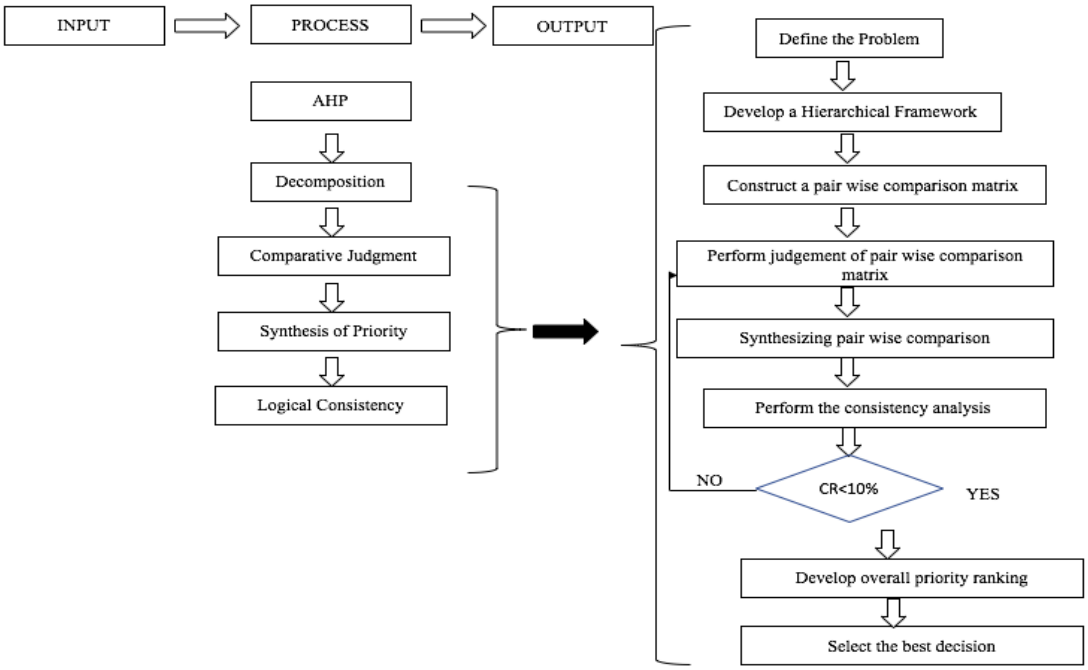

Figure 1. Flowchart of four stages in Analytical hierarchy process (AHP).

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Table 1. The weight for food security index of Bogor Regency.

No	Indicator
Aspects of food availability	
1.	The ratio of normative consumption to net production of rice, corn, sweet potato, cassava, and sago, and local government rice stocks
Aspects of food affordability	
1.	Percentage of the population below the poverty line
2.	Percentage of households with a proportion of expenditure on food more than 65% of total expenditure
3.	Percentage of households without access to electricity
Aspects of food utilization	
1.	Average years of schooling for women over 15
2.	Percentage of households without access to clean water
3.	The ratio of population per health worker to the population density level
4.	Percentage of stunted toddlers
5.	Life expectancy at birth

Source: National Food Agency 2024

Individual indicator analysis

Individual indicators are analysed by grouping individual indicators into several classes based on the empirical distribution method. Meanwhile, categorical data follows the grouping standards set by Central Bureau Statistic (CBS). Regencies/cities for each indicator were divided into six priority groups based on cut-off points, except for the stunting indicator, which only used four groups based on cut-off points.

Composite analysis

The composite analysis in the weighting method determines the relative importance of indicators to each aspect of food security. The weighting method in preparing the FSVA refers to the method developed by the Economist Intelligence Unit (EIU) in preparing the Global FSI (Von Grebmer *et al.*, 2017). Goodridge (2007) states that if the variables used in the index calculation are different, it is necessary to do it in a weighted manner (weighting) to form an aggregate index tailored to its purpose. The calculation of the FSI of Bogor Regency detailed description of the FSI calculation is as follows:

1.Standardize indicator scores using z-score and distance to scale (0 - 100);

2.Summing up the results of the multiplication between each standardized indicator value and the indicator weight using the formula:

$$Y = \sum aiXi$$

$$i=1$$

Where:

i = Indicators 1, 2, 3, ... 7, 8, and 9
Y = Bogor Regency Food Security Index
ai = weight of each i-th indicator
Xi = Standardized value of each i-th Indicator

Grouping regions into six groups based on FSI cut-off points

The FSI cut-off point is the sum of each multiplication between the weight of the individual indicator and the individual indicator cut-off point resulting from the z-score standardization and distance to scale (0-100) in **Table 2**.

Table 2. Cut-off point of regencies regarding food security index (FSI).

FSI groups	Regencies
1	≤ 41,52
2	> 41,52 – 51,42
3	> 51,42 – 59,58
4	> 59,58 – 67,75
5	> 67,75– 75,68
6	> 75,68

Sources: National Food Agency 2024.

Results

Based on **Table 3**, the composite FSI value for Bogor Regency in 2023 is 70.57, which is the lowest among all 27 regencies in West Java**.** This places Bogor Regency at 27th out of 27**,** indicating a relatively weaker performance in food security

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compared to its regional counterparts. Although this represents an improvement from its 2022 score of 68.61**,** the progress appears insufficient to elevate its regional standing.

At the national level, Bogor Regency ranks 292nd out of 416 regencies and cities across Indonesia**,** suggesting that despite modest gains in all FSI components, significant challenges remain. The increase in FSI components may reflect initial policy efforts or improved data accuracy; however, the low relative ranking highlights structural issues that still hinder food accessibility, availability, and utilization in the region. These findings underscore the urgent need for targeted interventions and policy reforms at the local level. Without addressing the underlying drivers such as infrastructure deficits, market inefficiencies, and vulnerability to external shocks, Bogor Regency risks further entrenchment at the bottom of regional rankings, with broader implications for public health and socio-economic stability.

Table 3. Food security index of Regencies/Cities in West Java by Aspect in 2023**.**

Regions	indices				Rank in the province
	Availability	Affordability	Utilization	Composite	
Bogor	47.79	86.41	75.78	70.57	27
Sukabumi	87.53	81.65	67.25	77.65	23
Cianjur	87.53	78.98	72.59	78.99	21
Bandung	73.77	89.94	83.43	82.48	13
Garut	91.91	76.06	69.14	78.04	22
Tasikmalaya	86.15	75.16	68.22	75.68	24
Ciamis	88.13	82.48	77.96	82.36	14
Kuningan	89.85	74.97	78.77	80.95	17
Cirebon	84.33	78.87	82.67	82.03	15
Majalengka	93,75	78.01	74.65	81.39	16
Sumedang	91.15	81.35	82.84	84.88	8
Indramayu	97.28	73.37	83.31	84.52	9
Subang	96.29	84.01	78.06	85.31	7
Purwakarta	82.71	82.80	76.92	80.42	18
Karawang	94.28	86.96	85.27	88.48	4
Bekasi	79.91	92.86	90.56	88.05	5
Bandung Barat	67.84	78.56	75.68	74.19	25
Pangandaran	91.11	80.81	79.98	83.57	12
Kota Bogor		89.33	79.24	83.78	10
Kota Sukabumi		86.77	72.80	79.08	20
Kota Bandung		95.02	86.73	90.46	2
Kota Cirebon		83.89	83.67	83.77	11
Kota Bekasi		94.66	92.64	93.55	1
Kota Depok		98.46	82.11	89.47	3
Kota Cimahi		92.87	82.51	87.17	6
Kota Tasikmalaya		78.10	68.30	72.71	26
Kota Banjar		90.07	70.94	79.55	19

Sources: National Food Agency 2024.

According to **Table 4**, the NCPR for Bogor Regency in 2023 is 2.66, reflecting a decline from 2.87 in 2022. This decreasing trend signals a worsening deficit in the region's ability to produce sufficient staple crops namely rice, corn, cassava, sweet potato, and sago to meet local consumption needs.

An NCPR ratio below three generally indicates a high dependency on external food sources and insufficient local production capacity, both in

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terms of volume and resilience. The consistently low ratio also suggests limited local government rice stocks, which may hinder the region's ability to respond to price volatility or supply chain disruptions. This deficit poses serious implications for food security planning, particularly in terms of availability and stability. It emphasizes the need for strategic investment in local agricultural productivity, post-harvest infrastructure, and sustainable farming practices. Strengthening local production systems and diversifying staple crops may help reduce the region's vulnerability and improve its long-term food self-sufficiency.

Table 4. Development of food security index Bogor Regency 2018 – 2023.

Indices	Composite indicators	2018	2019	2020	2021	2022	2023	Criteria indicators
		4	5	4	5	5	5	
Availability								
	low local staple food production (NCPR)	2.42	2,.90	2.84	2.53	2.87	2.66	Value >1 deficit , Value<1 surplus
Affordability								
	Poverty (%)	8.57	7.14	6.66	7.69	8.13	7.73	The lower, the better
	Food expenditure (%)	27.20	35.48	30.35	27.27	25.27	25.63	The lower, the better
	Without electricity (%)	0	0	0	0	0.13	0.05	The lower, the better
Utilization								
	Without clean water (%)	48.48	36.61	39.88	33.39	25.75	31.34	The lower, the better
	Females' years of schooling (years)	7.57	7.94	8.49	8.12	8.48	8.21	The lower, the better
	Ratio of health workers	0.56	0.53	0.68	0.39	0.29	0.40	The lower, the better
	Life expectancy Rate (year)	70.70	70.86	71.01	71.17	71.36	71.65	The lower, the better
	Stunting (%)	28.50	32.86	34.96	0	28.60	18.70	The lower, the better
Food security index		67.56	69.11	66.64	68.90	68.61	70.57	
Food security index rank		291	291	317	300	297	292	

Sources: National Food Agency 2024.

A closer examination of the individual indicators used in the construction of the FSI, as presented in **Table 5,** reveals a more nuanced understanding of Bogor Regency's performance. Out of the nine core indicators**,** only one NCPR remains in the "very low" categor**y**, signifying a critical deficit in staple food production. This aligns with previous findings that highlight the regency's dependence on external food sources and limited local reserves.

Another indicator with room for improvement is the average length of female schooling**.** Although this metric is currently categorized as "relatively good", further improvement is both possible and desirable, especially considering its broader impact on food utilization, nutritional awareness, and intergenerational human development outcomes.

The remaining indicators fall within the "outstanding" performance category, suggesting that in these areas such as child health, access to clean water, or economic access to food Bogor Regency has achieved strong outcomes. However, sustaining these high-performing indicators is equally important, requiring continued investment, policy support, and monitoring to avoid regression.

In summary, while the overall picture of food security in Bogor Regency shows promising elements, strategic attention must be directed toward low-performing indicators, particularly local food production and education for women**,** to ensure balanced and sustainable improvements across all dimensions of food security.

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Table 5. Achievement of individual indicators of food security index Bogor Regency.

Indicator	2023	Range		Sources
Composite	5			
low local staple food production (NCPR)	2,66	≥ 1,50	High deficit	
		1,25 - <1,50	Medium deficit	
		1,00 - <1,25	Low deficit	
		0,75 - <1,00	Low surplus	
		0,50 - <0,75	Medium surplus	
		< 0,50	High surplus	
Poverty (%)	7,73	≥ 35	Very bad	Central Bureau Statistic (CBS) Bogor Regency
		25 - < 35	Bad	
		20 - < 25	Rather bad	
		15 - < 20	Rather good	
		10 - < 15	Good	
		<10	Very good	
Food expenditure (%)	25,63	≥ 70	Very bad	Central Bureau of Statistics (CBS)
		60 - <70	Bad	
		50 - <60	Rather bad	
		40 - <50	Rather good	
		30 - <40	Good	
		< 30	Very good	
Without electricity (%)	0,05	≥ 50	Very bad	Central Bureau of Statistics (CBS)
		40 - < 50	Bad	
		30 - < 40	Rather bad	
		20 - < 30	Rather good	
		10 - < 20	Good	
		< 10	Very good	
Years of schooling for women (year)	8,21	< 6	Very bad	Central Bureau of Statistics (CBS)
		6 - < 6,5	Bad	
		6,5 - < 7,5	Rather bad	
		7,5 - < 8,5	Rather good	
		8,5 - < 9	Good	
		≥ 9	Very good	
Without clean water (%)	31,34	≥ 70	Very bad	Public Works and spatial planning Agency of Bogor Regency
		60 - <70	Bad	
		50 - <60	Rather bad	
		40 - <50	Rather good	
		30 - <40	Good	
		< 30	Very good	
Ratio of health workers	0,4	≥30	Very bad	Health Agency of Bogor Regency
		20 - <30	Bad	
		15 - <20	Rather bad	
		10 - <15	Rather good	
		5 - <10	Good	
		<5	Very good	
Stunting (%)	18,7	≥ 40	Very bad	Indonesian Health Survey, Ministry of Health
		30 - < 39	Bad	
		20 - < 29	Poor	
		< 20	Good	
Angka Harapan Hidup (tahun)	71,65	≤58	Very bad	Public works and spatial planning Agency of Bogor Regency
		>58 – 61	Bad	
		>61 – 64	Very bad	
		>64 – 67	Rather good	
		>67 – 70	Good	
		> 70	Very good	
Food security index	70,57			
Food security index ranking	292			

Sources: National Food Agency 2024.

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Vulnerability to food insecurity at the national, provincial, and regency levels has its characteristics, so not all national or provincial indicators can be used to map its vulnerability at the district level. The indicators used in the FSVA of Bogor Regency consist of 6 (six) indicators that reflect three aspects of food security, as presented in **Table 6**.

Table 6. Bogor Regency food security and vulnerability atlas (FSVA) indicators for 2023.

	Indicator	Data source
	Food availability	
1	The ratio of agricultural land area to total population	CBS; Ministry of Agriculture Data and Information Center; Food Crops, Horticulture and Plantation Agency; Population and Civil Registration Agency; Other official data sources issued by relevant technical Regional Apparatus Organizations.
2	The ratio of the number of food provision facilities and infrastructure to the number of households	Village Potential CBS; Trade Agency; Population Census (projection) CBS; Population and Civil Registration Agency; Other official data sources issued by relevant technical Regional Apparatus Organizations.
	Food access	
1	The ratio of the population with the lowest welfare level to the total population	Integrated Social Welfare Data, Ministry of Social Affairs or Social Affairs Office; Targeting the Acceleration of the Elimination of Extreme Poverty; CBS Population Census (projection); Population and Civil Registration Agency; Other official data sources issued by relevant technical Regional Apparatus Organizations.
2	Villages that do not have adequate access to connectivity	CBS Village Potential; Public Works Agency; Transportation Agency; Other official data sources issued by relevant technical Regional Apparatus Organizations.
	Food utilization	
1	The ratio of households without access to clean water to total households	Regional Planning Research and Development Agency; Health Agency; CBS Population Census (projection); Population and Civil Registration Agency; Other official data sources issued by relevant technical Regional Apparatus Organizations.
2	The ratio of the number of villagers per health worker to population density	Health Office; CBS Population Census (projection); Population and Civil Registration Agency; Other official data sources issued by relevant technical Regional Apparatus Organizations.

Source: Regional Government of Bogor Regency 2023.

The results of the composite food vulnerability and insecurity analysis in Bogor Regency at the village level can be seen in **Table 7**. Based on the analysis results, of the 435 villages in Bogor Regency, no village is included in priority 1. However, 118 villages (27.13%) are included in the food insecurity priority (priorities 2 and 3), while 317 villages (72.87%) are included in the food security category (priorities 4, 5 and 6).

Table 8 shows that there are no less than seven sub-districts in Bogor Regency that have a proportion of priority for food- insecure and vulnerable villages (priority 2 and 3) of more than 50%. Some of them have a proportion of more than 70%, such as in Kecamatan Cijeruk and Kecamatan Tamansari. Overall, almost all sub-districts in Bogor District (75%) have villages with priority 3 for food insecurity management. This condition needs attention to reduce the number of food-insecure and vulnerable villages.

Table 8 shows that there are no less than seven sub-districts in Bogor Regency that have a proportion of priority for food-insecure and vulnerable villages (priority 2 and 3) of more than 50%. Some of them have a proportion of more than 70%, such as in Kecamatan Cijeruk and Kecamatan Tamansari. Overall, almost all sub-districts in Bogor District (75%) have villages

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Table 7. Distribution of composite villages by priority scale**.**

Priority	Composite index range	Number of villages
1	≤ 40,12	0
2	40,12 – 50,11	18
3	50,11 – 56,15	100
4	56,15 – 62,43	154
5	62,43 – 67,92	89
6	> 67,92	74

Source: Regional Government of Bogor Regency 2023.

Discussion

FSI measures several indicators to produce a composite score of food security conditions in a region. The FSI value can indicate the achievement of food security and nutrition in the region and the relative ranking of one region compared to another. FSI is measured based on three aspects of food security (availability, affordability, and utilization) (Jaya, 2018). In accordance with **Table 3**, especially three aspects of FSI measurement, one aspect falls into the vulnerable category, namely the availability aspect. The value of this aspect is the lowest among other regions in West Java. In 2023, food availability in Bogor Regency is low, as seen from the availability index value of 47.79. This value is the lowest among other regencies/cities in West Java and the smallest among the FSI calculation components. The low availability index value is influenced by the condition of Bogor Regency, which has the largest population and little agricultural land. The population reaches more than 5 million people, and it is a buffer zone for the capital city of Jakarta (Central Bureau Statistics of Bogor Regency 2023). Meanwhile, food agricultural land is not extensive due to hilly geographical conditions. Agricultural production for food is low, so food availability is still in a low surplus condition.

Food affordability is one of the important aspects of the sustainability of the food system and community welfare. Food affordability covers several factors that affect the ability of individuals or households to obtain sufficient food in sufficient quantity and quality without sacrificing other basic needs (Mutia and Astriani, 2022). The affordability index value of Bogor Regency is 86.41. This index value is the highest among the Bogor Regency FSI components. The affordability index value shows that people in Bogor Regency still have difficulty buying food.

Another index forming FSI is the utilization index, which has a value of 75.78 in Bogor Regency. This figure illustrates the welfare condition of the Bogor Regency community in the health sector. It indicates that there are still limitations in food utilization, which can be caused by limited knowledge of food and nutrition, parenting patterns, poor sanitation and access to clean water. Food utilization in households is influenced by food storage and processing facilities owned by the household, knowledge and practices related to food preparation, provision of food for toddlers and other family members who are sick or old; it is influenced by low knowledge of mothers and caregivers, customs/beliefs, food distribution in the family, and the health conditions of each community that may be declining.

As detailed in **Table 4**, FSI conditions at the district level highlight specific areas of vulnerability within Bogor Regency. Among the nine FSI indicators, the NCPR is the only indicator that falls into the "high vulnerability" category. This metric reflects the ratio between normative per capita consumption and the net local production of key staple foods like rice, corn, cassava, sweet potatoes, and local government rice reserves**.**

The low NCPR score is closely linked to constraints on food availability**,** primarily driven by limited agricultural land within the regency. As urbanization and land-use competition intensify, the capacity to produce sufficient staple food locally continues to decline. Despite this, Bogor Regency has been able to meet community food needs through inter-regional trade and imports

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from neighboring areas, such as other parts of West Java and surrounding provinces.

Table 8. Data regarding food-insecure and vulnerable villages in Bogor Regency by sub-district in 2023.

Total	Priority			Villages total	Proportion of priority Villages (%)
	2	3	2 and 3		
Cijeruk	3	4	7	9	78
Pamijahan	2	5	7	15	47
Jasinga	2	4	6	16	38
Tamansari	2	4	6	8	75
Leuwisadeng	2	3	5	8	63
Sukajaya	2	3	5	11	45
Megamendung	1	7	8	12	67
Leuwiliang	1	5	6	11	55
Nanggung	1	4	5	11	45
Ciawi	1	3	4	13	31
Sukamakmur	1	2	3	10	30
Rumpin	0	10	10	14	71
Sukaraja	0	5	5	13	38
Caringin	0	4	4	12	33
Cisarua	0	4	4	10	40
Parung Panjang	0	4	4	11	36
Rancabungur	0	4	4	7	57
Cigombong	0	3	3	9	33
Ciomas	0	3	3	11	27
Ciseeng	0	3	3	10	30
Dramaga	0	3	3	10	30
Ciampea	0	2	2	13	15
Cibungbulang	0	2	2	15	13
Tajur Halang	0	2	2	7	29
Tenjolaya	0	2	2	7	29
Bojong Gede	0	1	1	9	11
Cibinong	0	1	1	13	8
Cigudeg	0	1	1	15	7
Cileungsi	0	1	1	12	8
Citeureup	0	1	1	14	7

Source: Regional Government of Bogor Regency 2023.

While this approach provides short-term food access**,** it also exposes the region to supply chain vulnerabilities, price volatility, and external shocks. Thus, improving local food production capacity, including through innovations such as urban farming, vertical agriculture, or strategic land use planning, could serve as long-term solutions to reduce reliance on external sources and enhance food availability sustainability.

The limited agricultural land in Bogor Regency indicates the need to increase productivity, which can be done by using technology in the form of agricultural tools and machinery, which also requires strong Human Resources. On the other side, environmental changes cause pollution of the environment itself, which can threaten food security (Davidovic and Buheji, 2020).

In general, over the past five years, the development trend of the FSI of Bogor Regency has fluctuated relatively, both in terms of value and ranking nationally. The characteristics of Bogor Regency, an urban area, significantly affect the achievement of values in several aspects, such as

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availability. However, the overall value per indicator tends to improve in other aspects. In the aspects of affordability, poverty and food expenditure share tend to improve. In the utilization aspect, the percentage of people without clean water is also decreasing, the length of schooling is increasing, the ratio of health workers is getting better, and life expectancy is getting higher, including a decrease in stunting. This condition shows that the efforts made by the Bogor Regency Government and other relevant stakeholders have improved each indicator's achievements. Regarding ranking, Bogor Regency's position in the last five years has been 300 out of all districts in Indonesia. Although this ranking is in Indonesia's lower group of 416 districts, almost all other indicators except availability are pretty good.

A more detailed assessment of the FSI components, as presented in **Table 5**, reveals that Bogor Regency has demonstrated relatively strong performance across most indicators**.** Of the nine indicators used in the FSI framework, only one NCPR remains in the "very low" category, reflecting a significant deficit in the local production of staple crops. As previously discussed, this is mainly due to the limited availability of agricultural land, which constrains food production capacity.

Another indicator that warrants further attention is the average length of female schooling**.** While currently categorized as "relatively good"**,** this indicator has not yet reached its optimal value**.** Improving this dimension could have important multiplier effects, particularly in enhancing food utilization through better nutrition knowledge, child care practices, and overall household decision-making.

In contrast, the remaining indicators are already in the "outstanding" category**,** reflecting strong institutional, health, and infrastructure support in Bogor Regency. These achievements should be carefully maintained through continued investment and regular monitoring, as regression in these areas could undermine overall food security gains. In conclusion, while the FSI performance in Bogor Regency is encouraging in several respects, addressing key vulnerabilities in food production and female education remains essential for achieving holistic and resilient food security in the region.

Furthermore, the FSVA map, the basis for preparing FSI, is carried out in stages from the national to the district/city levels. In contrast, the FSVA unit of analysis at the provincial level is the sub-district, and the FSVA unit at the district level is the village. This tiered information provision is expected to detect food insecurity problems to the lowest level quickly. Like the National and Provincial FSVA, the District FSVA provides a means for decision-makers to quickly identify more vulnerable areas, where interventions from various sectors such as services, human development and infrastructure related to food security can have a better impact on livelihoods, food security and nutrition of people at the village.

Information on food security and vulnerability is important to inform policymakers in preparing programs and activities at the central and regional levels to prioritize interventions and programs based on the needs and potential impacts of high food insecurity.

Vulnerability to food insecurity at the national, provincial, and regency levels has its characteristics, so not all national or provincial indicators can be used to map its vulnerability at the district level. The indicators used in the FSVA of Bogor (Central Bureau Statistics of Bogor Regency 2023) consist of 6 (six) indicators that reflect three aspects of food security, as presented in **Table 6**.

According to the 2023 FSVA Map analysis produced by the Bogor Regency Food Security Agency, the average composite index score for villages classified as food-insecure (priority categories 1, 2, and 3) is 52.90. In comparison, villages falling under less severe food insecurity categories (priorities 4, 5, and 6) show a higher average composite index of 63.52. Despite this difference, both averages remain relatively low, indicating that structural vulnerabilities persist across a broad range of communities within the

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regency. The main contributing factors to this low composite index are:

1.A low ratio of agricultural land area to population, which limits local food production capacity and increases dependency on external food sources.

2.A high proportion of households without access to clean water, which negatively affects food utilization, hygiene, and public health—further compounding food insecurity risks.

These findings highlight the importance of localized vulnerability mapping and the need for targeted interventions that address specific weaknesses at the village level, such as improving water infrastructure and optimizing land use for food production.

The results of the composite food vulnerability and insecurity analysis in Bogor Regency at the village level can be seen in **Table 7**. Based on the analysis results, of the 435 villages in Bogor Regency, no village is included in priority 1. However, 118 villages (27.13%) are included in the food insecurity priority (priorities 2 and 3), while 317 villages (72.87%) are included in the food security category (priorities 4, 5 and 6).

According to the results of a deeper analysis of the distribution of villages in priority two and priority three categories, several sub-districts in Bogor Regency have a high proportion of food-insecure and vulnerable villages. This condition indicates that based on the results of the FSVA analysis, the food-insecure and vulnerable villages dominate in these sub-districts. Table 8 shows that there are no less than seven sub-districts in Bogor Regency that have a proportion of prioritized food-insecure and vulnerable villages (priority 2 and 3) of more than 50%. Some of them have a proportion of more than 70%, such as in Kecamatan Cijeruk and Kecamatan Tamansari. Overall, almost all sub-districts in Bogor District (75%) have villages with priority 3 for food insecurity management. This condition needs attention to reduce the number of food-insecure and vulnerable villages.

The results of identifying the causal factors of food vulnerability and insecurity at the village level include four indicators, namely households without access to clean water, the ratio of food supply infrastructure facilities, the number of people with the lowest welfare level and the size of agricultural land. Households without access to clean water are one of the leading causes of food insecurity, and the vulnerability of villages in Bogor Regency is relatively high in priority sub-districts. That informs and shows that most villages in the two districts (Cijeruk and Tamanasari) are priority 1 for households without access to clean water. This condition indicates that there is still a need for intervention in providing clean water in the villages in this district. In addition, indicators related to food supply infrastructure in the ratio of the number of markets to households also need attention. As for the proportion of land to the population, the main priority is only in the Tamansari sub-district.

Food security in Bogor Regency still faces significant challenges, especially in terms of food distribution, price accessibility, and agricultural production circles. If left without strategic intervention, this condition can lead to inequality in access to food, especially in rural areas and pockets of poverty.

The policy implications of these findings are quite broad. The Bogor Regency Government needs to consider a data-based approach in designing food security policies. For example, data on the vulnerability of certain areas to instability can be used as a basis for forming buffer stocks or local food subsidy programs. In addition, strengthening agricultural and logistics infrastructure (village roads, storage warehouses, irrigation) must be a priority in the regional development plan (RPJMD).

This study has several limitations that need to be acknowledged. First, potential bias in data collection could arise because most of the information was obtained through interviews and FGDs involving limited respondents. This could affect the representativeness of the data to the entire population in Bogor Regency. Second, there are external factors that cannot be fully controlled in this study, such as climate change,

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national policies, and global market dynamics that impact food prices and distribution. For example, a long dry season or natural disaster can drastically change food security conditions, but these aspects are only discussed in general in the study.

For further research, it is recommended that a mixed-methods approach be used, including secondary quantitative data collection (such as BPS or BMKG data) and climate impact modeling to enrich the analysis. In addition, the reach of participants in qualitative data collection should be expanded to be more inclusive of the voices of vulnerable groups such as female farmers or indigenous peoples.

Conclusions

FSI value based on availability, affordability and usefulness is 47.79, 47.79 and 86.41, respectively. Some influential factors include fluctuations in the volume of food available, difficulties in accessing food needs, and limitations in food utilization. In general, over the last five years, the development trend of the FSI of Bogor Regency has fluctuated in terms of both FSI value and national FSI ranking. The characteristics of Bogor Regency, some of which are urbanized areas, greatly influence the achievement of values in several aspects, such as availability. However, the overall value per indicator tends to improve in other aspects (affordability, poverty and food expenditure). In the utilization aspect, the percentage of people without clean water is also decreasing, the length of schooling is increasing, the ratio of health workers is getting better, and life expectancy is getting higher, including a decrease in stunting. Policy strategies that the Bogor Regency Government has carried out to improve the achievements of each indicator include prioritizing interventions and programs based on the needs and potential impacts of relatively high food insecurity in the form of increasing the productivity of the agricultural sector, building agricultural infrastructure, improving public health services, optimizing clean water treatment systems and improving aspects of the food supply chain.

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Authors' contributions

Fahmi Iqbal F conceived the research idea, designed the study framework, conducted data analysis, and prepared the initial manuscript draft. Indrayani P assisted in data interpretation and contributed to writing and revising the manuscript. Ferianto F supervised the overall research process, provided conceptual and methodological guidance, and critically reviewed the manuscript for intellectual content. Hendrix T collected and processed field data, developed the dataset, and contributed to data visualization and validation. Anggraini K provided research resources, and participated in the manuscript review and final approval.

Conflict of interest

All the authors declared no conflict of interest.

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