



Analysis of Education Quality on the Regional Vulnerability Index to Food Insecurity in Indonesia in 2021

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Abstract: One of the obstacles to Indonesia's development is the region's susceptibility to food insecurity. Enhancing the community's ability to adapt is mostly dependent on educational conditions. Through an analysis of four causal conditions average length of schooling, internet connected households, the ratio of education subsidies per student, and the ratio of schools per population/school-age students this study seeks to determine how educational characteristics can explain regional vulnerability to food insecurity. Fuzzy-set Qualitative Comparative Analysis (fsQCA) is the study methodology employed. This analysis focused on 34 Indonesian provinces in 2021, capturing diverse agro-ecological, economic, and institutional contexts across western, central, and eastern Indonesia. The study's findings indicate that there are three distinct causal pathways through which educational characteristics explain the level of vulnerability of a region to food insecurity in Indonesia, reflecting different combinations of human capital, infrastructure, and fiscal support. Pathway one was discovered in 12 provinces, characterized by a suboptimal average length of schooling and a suboptimal subsidy ratio per student, highlighting chronic underinvestment in human capital and school resources. Pathway two depicts an optimal education subsidy ratio per student as well as an optimal school to population ratio in 12 provinces, suggesting that adequate fiscal support and school availability can partially compensate for other constraints. Pathway three shows an optimal average length of schooling, optimal internet access among households, and a suboptimal ratio of schools per population/school-age students in 10 provinces, indicating that higher educational attainment and digital connectivity may offset limited physical school infrastructure in shaping food-security outcomes.

Keywords: Education; Regional Vulnerability to Food Insecurity; FsQCA

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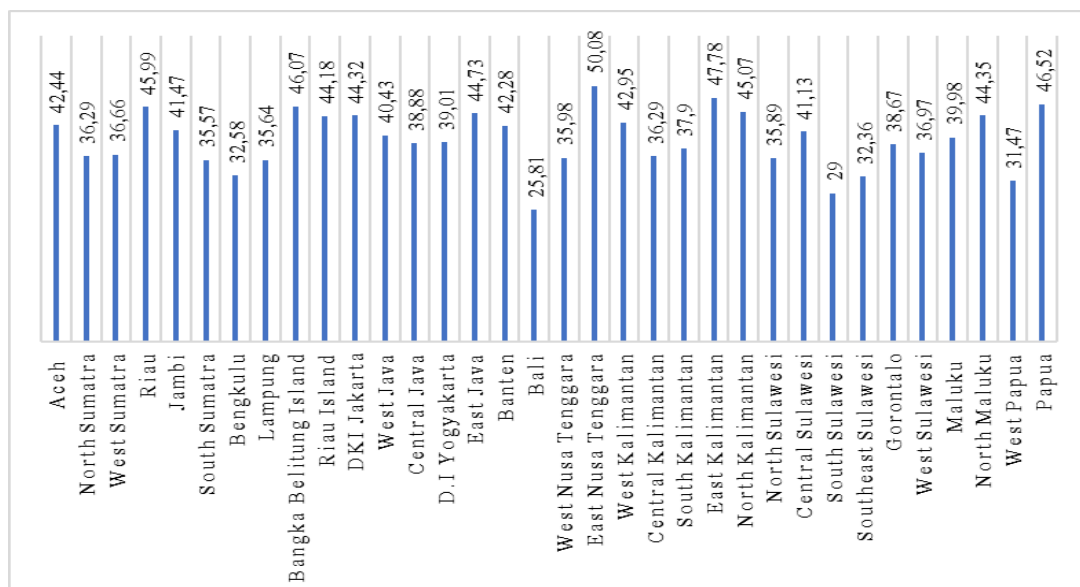


INTRODUCTION

Analysis of regional vulnerability can test the resilience of populations against disasters and natural hazards, whether economic, social, or physical in nature. Several dynamic factors influence vulnerability, namely climate change, urbanization, and human behavior (Juliannisa et al., 2025). One form of regional vulnerability that poses a significant threat to human survival is food insecurity. Food insecurity is a condition in which access to sufficient food for a healthy and active life is limited and irregular, both in terms of quantity and quality (FAO et al., 2024). Indonesia is one of the five

ASEAN countries with the highest levels of food insecurity (The World Bank, 2023). In 2021, Indonesia had a Global Hunger Index (GHI) score of 18, which exceeds the global threshold of concern at 9 and places Indonesia third in ASEAN. The regional vulnerability index for food insecurity is important globally as it contributes to achieving the Sustainable Development Goals (SDGs), particularly SDG 2 on zero hunger, making the addressing of food insecurity a top priority at both national and international levels.

Indonesia falls into the "alert" category for regional vulnerability to food insecurity. This can be attributed to factors such as food inadequacy and hunger rates that indicate a concerning situation. Data on the prevalence of food consumption inadequacy in Indonesia in 2021 reached 8.49% (Badan Pusat Statistik Indonesia, 2021). Based on the 2021 food security and vulnerability distribution map, there are 74 districts/cities (14.40%) in Indonesia classified under priority categories 1–3, namely areas with high food insecurity levels or alert status (Badan Pangan Nasional, 2022).



Source: Juliannisa et al., 2025

Figure 1. Regional Vulnerability Index for Food Insecurity in Indonesia in 2021

Figure 1 shows that the magnitude of the regional vulnerability index for food insecurity based on provinces in Indonesia in 2021 varies widely. The provinces with the highest regional vulnerability to food insecurity are East Nusa Tenggara (50.08), East Kalimantan (47.78), and Papua (46.52). Regional vulnerability to food insecurity is not solely related to geographic or ecological factors; education can also contribute, as it influences an individual's capacity and perspective in assessing their daily nutritional needs. A person's ability to manage their food requirements improves with increasing levels of knowledge (Andaresta et al., 2024). Higher education levels are associated with healthier eating habits. Individuals with secondary education or higher tend to

consume fewer unhealthy foods (around 22.8%) and more nutritious foods (around 31%) compared to those with lower education levels (Islam & Sim, 2021).

Society can acquire the information, skills, and access to necessary technology and data for sustainable food resource management through improved education (Loofbourrow & Scherr, 2023). On the other hand, inadequate education quality can exacerbate food insecurity because communities face greater difficulties in making informed decisions to meet their food needs (Korir et al., 2021). Beyond enhancing literacy, education can help individuals develop essential knowledge about resource management, nutrition, and health. Food insecurity often occurs in areas with lower education levels because individuals there have limitations in obtaining information, adapting to changes, and making appropriate decisions during food crises. The strong linkage between a region's vulnerability to food insecurity and its population's education level is crucial for understanding a region's characteristics from an educational perspective. This indicates that improving education can serve as a key strategy in reducing regional vulnerability. Therefore, education can be viewed as one of the primary indicators explaining variations in regional vulnerability levels. In this study, education quality is represented by average length of schooling, households with internet access, education subsidy ratio per student, and school to school age population ratio. This research aims to examine how educational characteristics explain the level of regional vulnerability to food insecurity in Indonesia.

LITERATURE REVIEW

Human Capital Theory

Gary S. Becker introduced Human Capital Theory in 1964, arguing that humans are valuable assets that can significantly impact social and economic progress. According to Becker, human capital such as education, skills, and abilities is as important as tangible capital, like machinery, equipment, and technology. Therefore, investments in human development, particularly through education, yield substantial long-term benefits. Becker (1964) states that one form of investment that individuals or societies can make is education. Increases in future productivity, income, and welfare stem from the time, money, and effort invested in education. This aligns with Yuldasheva (2024), who asserts that higher education provides greater opportunities for individuals to secure better jobs, earn higher incomes, and improve their social status. Supported by Sudarwati & Naim (2022), who state that education serves as a primary factor in economic development and human resource building. Public spending on education can aid efforts to sustainably enhance human resource quality (Suwandaru et al., 2021).

Vulnerability Theory

Vulnerability was first defined by Robert Chambers in 1989 as a condition in which individuals, households, and communities are highly susceptible to various shocks but have limited capacity to cope with them. Chambers (1989) distinguishes

between two main elements of vulnerability: exposure (to risks) and capacity to cope. This means that the level of vulnerability in a region varies depending on the community's ability to respond to threats, even if the region faces the same threats. In line with this, Sigit et al. (2023) also emphasize that social and economic conditions influence adaptive capacity, so two regions with similar risk exposure can exhibit different levels of vulnerability. Chambers' approach offers a new perspective that vulnerability arises not only from resource limitations but also from a lack of social protection measures, inadequate access, and uneven distribution.

Food Security

Food security, according to FAO (1996), is a condition in which every person, everywhere, has physical, social, and financial access to sufficient, safe, and nutritious food that meets their dietary needs and food preferences for an active and healthy life. FAO later developed four main pillars of food security: stability, availability, access, and utilization. FAO (2008) added two new dimensions to this concept as it evolved: agency and sustainability. These changes have made the FAO framework more comprehensive, now considering community involvement and environmental sustainability in addition to short-term food availability. FAO's theory provides a crucial foundation for understanding how food conditions can influence regional vulnerability and vice versa, how food conditions can increase or decrease a region's vulnerability (Galanakis et al., 2025).

The linkage between education and regional vulnerability to food insecurity has been a focus in various studies. According to Evalia et al. (2025), women's average length of schooling has a significant influence on food security in West Sumatra. In line with this, Harini et al. (2022) also emphasize that women's average length of schooling (ALS) for those over 15 years contributes to good food security in Yogyakarta. Another study by Pratistya et al. (2024) found that internet usage positively affects food productivity in Indonesia. This is supported by Ardianti et al. (2023), who show that internet usage significantly influences efforts to reduce household food insecurity among farmers in Indonesia. Alhussam & Risha (2021) demonstrate that scholarship flows have a significant positive effect on food security. Additionally, Landaverde et al. (2021) emphasize that education significantly improves household resilience.

From these studies, the focus remains on individual education factors separately and within limited regional scopes. Therefore, this research addresses this research gap by examining the relationship between education quality and regional vulnerability to food insecurity across 34 provinces in Indonesia in 2021, using four education indicators: average length of schooling, households with internet access, education subsidy ratio per student, and school to school age population ratio.

METHOD

This study employs a Qualitative Comparative Analysis (QCA) approach. This method is utilized to examine how various conditions interact to produce a specific outcome. The outcome in this study is the regional vulnerability index for food insecurity, analyzed using four causal conditions: average length of schooling, households that have accessed the internet, the education subsidy ratio per student, and the ratio of the number of schools per school age population/student. The population used in this study is Indonesia, while the sample consists of 34 provinces in Indonesia in 2021. The data used is secondary, defined as information collected by third parties that refers to primary sources (Ratnasari et al., 2021). The data used in this study refers to sources from the Central Statistics Agency (BPS), the Directorate General of Fiscal Balance (DJPK) of the Ministry of Finance of the Republic of Indonesia, the Ministry of Primary and Secondary Education of the Republic of Indonesia (Kemendikdasmen), and prior research by Juliannisa et al. (2025). Data collection was conducted through documentation and literature studies.

To identify and analyze the relationship between various educational conditions and the level of regional vulnerability to food insecurity in Indonesia in 2021, this study uses the Fuzzy Set Qualitative Comparative Analysis (fsQCA) method. Through the use of fsQCA, researchers can investigate combinations of conditions that form specific configurations linked to the outcome of regional vulnerability to food insecurity, such as Average Length of Schooling (ALS), households accessing the internet, the education subsidy ratio per student, and the school to school age population ratio. By grouping 34 provinces in Indonesia based on condition configurations, this method enables the identification of patterns that explain the educational characteristics of each province in relation to regional vulnerability to food insecurity. Furthermore, fsQCA helps in understanding the complex relationships between educational conditions that form the level of regional vulnerability to food insecurity and determines the minimal conditions necessary to produce a specific outcome.

To conduct the sustainability analysis using fsQCA, several procedures must be followed. These steps include:

1. Model Specification

In the first step, the researcher selects the outcome to be studied, and the causal conditions suspected of explaining that outcome. This choice is critical as it will determine the direction of subsequent research.

2. Data Availability

The next stage is a vital part of QCA that can be conducted iteratively and based on theory. Data availability means ensuring that the data is appropriate for the research and accessible. Economic, social, and other quantitative indicators can be used as examples of data.

3. Threshold Determination

Boundaries for data calibration must be established by the researcher. In fsQCA, these thresholds are identified as n_1 , n_2 , and n_3 .

4. Necessary Analysis and Sufficient Condition

a. Necessary condition

A condition is necessary if the outcome almost never occurs without that condition being present.

In crisp set terms: "If outcome happens, then condition X must be present".

In fsQCA, this is assessed statistically using the consistency index for necessity (often requiring a consistency score ≥ 0.9).

b. Sufficient Condition

A condition (or more usually a combination of conditions) is sufficient if, when it is present, the outcome is likely to occur. In fsQCA this is usually a configuration. Consistency (how often the condition/configuration leads to the outcome, typically ≥ 0.8), and Coverage (how much of the outcome cases the configuration explains).

To understand the complexity involving interactions among conditions, this analysis is required in the research. In complex situations, complicated combinations of various conditions may still produce an outcome even when no single condition satisfies the criteria for necessity or sufficiency. A condition is considered a necessary condition when its consistency value is greater than 0.75–0.8, and it is considered a sufficient condition when its coverage value is greater than 0.75 (Ragin, 2008). The following are the steps in fsQCA:

1. Constructing the Truth Table

After that, the researcher can analyze the truth table to identify the conditions present in each configuration and their relationships with the outcome. The researcher can detect recurring patterns by using the truth table.

2. Configuration of the Solution

After data collection and truth table analysis, fsQCA uses Boolean minimization to perform algebraic calculations and produce solution configurations that can generate the outcome. Three types of solution configurations complex solution, parsimonious solution, and intermediate solution will be produced by the fsQCA software.

ANALYSIS

Threshold Setting in Data Calibration

Using the Fuzzy Set Qualitative Comparative Analysis (fsQCA) approach with FsQCA software version 4.1, the calibration process is carried out by setting thresholds for each condition (causal condition) and the outcome. The value of n_1 is derived from the maximum value, n_2 from the mean value, and n_3 from the minimum value. The thresholds used by the researcher in this study are as follows:

Table 1. Threshold Setting in Data Calibration

Threshold	VLR	ALS	INT	SUB	SKL
n1	50,08	11,17	95,44	2677,99	0,0115
n2	39,55	8,71	80.18	1981,51	0,0076
n3	25,81	0	0	1418,86	0

Source: Calibrate writer by Software fsQCA, 2025

Data Calibration

Table 2. Data Calibration Results

Province	fVLR	fALS	fINT	fSUB	fSKL
Aceh	0,69	0,69	0,46	0,52	0,67
North Sumatra	0,33	0,74	0,55	0,13	0,42
West Sumatra	0,35	0,61	0,60	0,42	0,47
Riau	0,86	0,64	0,77	0,12	0,33
Jambi	0,63	0,49	0,54	0,28	0,50
South Sumatra	0,30	0,46	0,54	0,06	0,35
Bengkulu	0,18	0,55	0,48	0,54	0,52
Lampung	0,30	0,45	0,66	0,14	0,38
Bangka Belitung Islands	0,87	0,45	0,63	0,18	0,30
Riau Islands	0,79	0,86	0,94	0,49	0,27
DKI Jakarta	0,80	0,95	0,95	0,89	0,17
West Java	0,56	0,49	0,69	0,10	0,23
Central Java	0,46	0,42	0,63	0,18	0,35
D.I Yogyakarta	0,47	0,76	0,79	0,71	0,37
East Java	0,81	0,43	0,50	0,35	0,44
Banten	0,69	0,57	0,81	0,05	0,23
Bali	0,05	0,61	0,82	0,42	0,31
West Nusa Tenggara	0,31	0,39	0,44	0,21	0,47
East Nusa Tenggara	0,95	0,41	0,39	0,19	0,70
West Kalimantan	0,72	0,39	0,49	0,32	0,73
Central Kalimantan	0,33	0,49	0,50	0,63	0,92
South Kalimantan	0,41	0,47	0,64	0,29	0,68
East Kalimantan	0,91	0,80	0,87	0,40	0,29
North Kalimantan	0,83	0,62	0,82	0,81	0,46
North Sulawesi	0,31	0,75	0,57	0,87	0,94
Central Sulawesi	0,61	0,55	0,47	0,67	0,89
South Sulawesi	0,09	0,48	0,61	0,25	0,54
Southeast Sulawesi	0,17	0,63	0,58	0,65	0,76

Gorontalo	0,45	0,43	0,53	0,59	0,81
West Sulawesi	0,36	0,44	0,45	0,86	0,85
Maluku	0,53	0,83	0,47	0,88	0,88
North Maluku	0,80	0,61	0,40	0,95	0,95
West Papua	0,15	0,41	0,44	0,95	0,90
Papua	0,88	0,34	0,16	0,81	0,52

Source: Calibrate writer by Software fsQCA, 2025

To construct a fuzzy set with values ranging between 0 and 1, the researcher must calibrate the variables in fsQCA (Ragin, 2008). In a fuzzy set, values between 0 and 1 indicate the degree to which a case belongs to the set or not. A case with a fuzzy membership score of 1 is a full member of the fuzzy set (fully inside the set), whereas a case with a membership score of 0 is a full non-member of the set (fully outside the set), since all values lie between 0 and 1. A case can simultaneously be a member and not a member of a fuzzy set if its membership score is 0.5, because it lies exactly in the middle and is therefore called an intermediate set.

Test of Necessary and Sufficient Conditions

This test is used as a basis to determine whether a condition satisfies the criteria to be a necessary condition, a sufficient condition, or neither.

Table 3. Result of Necessary and Sufficient Condition

Causal	Consistency	Coverage
~fALS	0,642897	0,780257
~fINT	0,627298	0,815351
~fSUB	0,700836	0,695412
~fSKL	0,670195	0,781169

Source: Data processed by Software fsQCA, 2025

In Table 3, the consistency value for the condition of average length of schooling (RLS) is 0.642897, for households that have accessed the internet is 0.627298, for the education subsidy ratio per student is 0.700836, and for the school-to-school-age population/student ratio is 0.670195. These values fall within the range of 0.6–0.7, which means the consistency for each condition is not sufficiently strong. This indicates that none of the conditions qualifies as a necessary condition (necessary condition). In other words, no single condition is required to be present to produce the outcome of regional vulnerability to food insecurity. Based on the coverage test results, three out of the four conditions have values above 0.75: ~fALS (0.780257), ~fINT (0.815351), and ~fSKL (0.781169). This means that these three conditions qualify as sufficient conditions.

Intermediate Solution Based on Truth Table Analysis

Table 4. Result of Intermediate Solution Based on Truth Table Analysis

Pathway	Causal				Raw Coverage	Unique Coverage	Consistency	Province
	fALS	fINT	fSUB	fSKL				
1	~fals		~fsub		0,550975	0,0551533	0,809329	West Nusa Tenggara, West Kalimantan, East Nusa Tenggara, Central Java, East Java, Lampung, Bangka Belitung Islands, South Sumatra, South Kalimantan, South Sulawesi, Jambi, and West Java
2			fsub	fskl	0,533705	0,135933	0,699781	North Maluku, West Papua, Maluku, North Sulawesi, West Sulawesi, Central Sulawesi, Southeast Sulawesi, Central Kalimantan, Gorontalo, Papua, Aceh, and Bengkulu
3	fals	fint		~fskl	0,616156	0,121449	0,829085	DKI Jakarta, Riau Islands, East Kalimantan, Riau, D.I Yogyakarta, Bali, Banten, North Sumatra, North Kalimantan, dan West Sumatra
Solution Coverage: 0,854039								
Solution Consistency: 0,711039								

Source: Writer use *Software fsQCA*, 2025

Based on the intermediate solution from the truth table analysis, the solution coverage value of 0.854039 indicates that almost 85% of all cases can be explained by the resulting causal conditions. A solution coverage of 0.85 (85%) in fsQCA analysis is considered good because it indicates that the identified configuration of causal conditions is able to explain most of the variation in the outcome under study. This means that approximately 85% of membership in the outcome can be explained by the combination of causal conditions in the solution (Ragin & Davey, 2026).

This suggests that the conditions/causal factors have broad coverage and can explain a large portion of the variation in the occurrence of the outcome of regional vulnerability to food insecurity. At the same time, the solution consistency value of 0.711039 indicates that the association between the causal configuration and the outcome is not sufficiently strong. This figure shows that although not all, a substantial

share of provinces with similar condition configurations tend to produce the same outcome.

The cases of West Nusa Tenggara, West Kalimantan, East Nusa Tenggara, Central Java, East Java, Lampung, Bangka Belitung Islands, South Sumatra, South Kalimantan, South Sulawesi, Jambi, and West Java are described in the first pathway. Regional vulnerability to food insecurity in this pathway can be explained by non-optimal average length of schooling ($\sim$ fALS) and also non optimal education subsidy ratio per student ($\sim$ fSUB). This indicates that the ability of communities in these provinces to adapt to food-security threats remains limited due to low education levels and low education-budget support per student. This illustrates how a region may become vulnerable to food insecurity because of a combination of low-quality human resources and minimal education funding. With a consistency value of 0.809329, this combination shows a relatively high level of consistency in explaining the outcome.

The cases of North Maluku, West Papua, Maluku, North Sulawesi, West Sulawesi, Central Sulawesi, Southeast Sulawesi, Central Kalimantan, Gorontalo, Papua, Aceh, and Bengkulu are described in the second pathway. Here, the school-to-school age population ratio (fSKL) and the education subsidy ratio per student (fSUB) are in an optimal state. This means that regional vulnerability to food insecurity occurs in provinces where the school-to-school age population ratio and the education subsidy ratio per student are optimal. This combination has a consistency value of 0.699781; although it does not strongly guarantee regional vulnerability to food insecurity, it indicates a certain link between education fiscal support and the distribution of school facilities and the state of vulnerability in food insecurity in some regions.

The cases of Jakarta Special Capital Region (DKI Jakarta), Riau Islands, East Kalimantan, Riau, Yogyakarta Special Region (D.I. Yogyakarta), Bali, Banten, North Sumatra, North Kalimantan, and West Sumatra are described by the third pathway. There are three causal condition combinations: average length of schooling (fALS) and households accessing the internet (fINT) are in an optimal state, whereas the school-to-school age population ratio is non optimal ($\sim$ fSKL). This means that regional vulnerability to food insecurity occurs in provinces with high average length of schooling and high internet access by households, but a low or non-optimal school to school age population ratio. This combination has a consistency value of 0.829085, which indicates a relatively high level of consistency in explaining the outcome.

DISCUSSION

Education is critically important for addressing food-security vulnerability in provinces such as West Nusa Tenggara, East Nusa Tenggara, West Kalimantan, Central Java, East Java, Lampung, Bangka Belitung, South Sumatra, South Kalimantan, South Sulawesi, Jambi, and West Java because it simultaneously strengthens agricultural productivity, diversifies livelihoods, improves nutrition, and enhances local institutional capacity in contexts where exposure to climate shocks, poverty, and uneven

development is high (Renggo & Rewa, 2023). Empirical evidence from Indonesia shows that higher educational attainment and agricultural training significantly increase the probability of household food security, while at the provincial level, average years of schooling have a positive and significant effect on the Food Security Index, especially in lower-HDI and high-poverty districts that characterize many parts of NTT, NTB, Kalimantan, Sulawesi, and Sumatra (Hunggurami & Renggo, 2022). In these regions, educated farmers are more likely to adopt climate-smart practices, diversify crops and livestock, and engage in agriprocessing and marketing, thereby reducing dependence on rain-fed monocultures and buffering against droughts, floods, and price shocks that drive food insecurity. Education also expands access to nonfarm employment and entrepreneurship, stabilizing household income and food access in areas where unemployment and underemployment remain key vulnerabilities identified in fsQCA pathways of food insecurity. Moreover, schools and teachers are now explicitly leveraged to improve nutrition and food-safety literacy, which is essential in provinces with high stunting and poor dietary diversity, while vocational schools (SMK) can serve as local innovation hubs for sustainable, place-specific food systems. By building human capital, education directly raises the adaptive capacity that spatial analyses show is critically low in eastern Indonesia and uneven across Java, Sumatra, Kalimantan, and Sulawesi, making it a cornerstone of any strategy to reduce regional food-security vulnerability (Sidik & Yuliawati, 2023).

Education is equally critical in the additional provinces you listed—North Maluku, West Papua, Maluku, North Sulawesi, West Sulawesi, Central Sulawesi, Southeast Sulawesi, Central Kalimantan, Gorontalo, Papua, Aceh, DKI Jakarta, Riau Islands, East Kalimantan, Riau, D.I. Yogyakarta, Bali, Banten, North Sumatra, North Kalimantan, West Sumatra, and Bengkulu because their food-security conditions range from extremely vulnerable (Papua, West Papua, Maluku, North Maluku, parts of Sulawesi and Kalimantan) to relatively secure but still exposed to shocks (Java, Bali, Sumatra, urban centers), and in all cases education strengthens the adaptive capacity needed to manage these risks. Provinces such as Papua, West Papua, Maluku, and North Maluku consistently rank among the lowest in Indonesia's provincial Food Security Index, with weak performance especially in affordability and utilization pillars, high food-consumption inadequacy in mountainous and remote districts, and persistent stunting and poverty that make households highly sensitive to price and climate shocks. In Sulawesi, clustering analyses show that while many districts in the "Sulampua" region have moderate food security, a distinct cluster of districts in Papua exhibits severe insecurity, and several Sulawesi provinces (Central, Southeast, West, Gorontalo) still contain regencies with high vulnerability linked to poverty, unemployment, and limited infrastructure. Kalimantan provinces (Central, East, North) face mixed conditions, with some areas relatively better off but others constrained by low agricultural diversification, infrastructure gaps, and dependence on extractive sectors, while Sumatra provinces (Aceh, North Sumatra, West Sumatra, Riau, Bengkulu) and Java–

Bali–Banten–Yogyakarta generally show higher average food-security scores yet still harbor pockets of inadequacy in rural, coastal, or peri-urban areas. DKI Jakarta and the Riau Islands, despite higher incomes, remain sensitive to supply disruptions and price volatility because of heavy reliance on food imports from other regions, so education that supports urban agriculture, logistics, and nutrition literacy is still important. Across all these provinces, empirical studies confirm that average years of schooling, agricultural training, and vocational education significantly improve the Food Security Index by raising productivity, enabling livelihood diversification, improving diet quality, and strengthening local institutions, making education a central strategy to reduce both chronic and shock-driven food insecurity.

CONCLUSION

Conclusion

Referring to the analysis results, the educational characteristics reflected through average length of schooling (ALS), households that have accessed the internet, the education subsidy ratio per student, and the school-to-school age population/ratio of schools per student in explaining the level of regional vulnerability to food insecurity in Indonesia show three pathways.

1. Pathway one describes regions with a non-optimal average length of schooling (ALS) and a non-optimal education subsidy ratio per student. This condition indicates limitations in educational achievement and education budget support, which ultimately lowers the quality of human resources. This weak human capital capacity constrains employment opportunities, productivity, and households' ability to manage resources, leading to regional vulnerability to food insecurity in the provinces of West Nusa Tenggara, West Kalimantan, East Nusa Tenggara, Central Java, East Java, Lampung, Bangka Belitung Islands, South Sumatra, South Kalimantan, South Sulawesi, Jambi, and West Java
2. Pathway two shows that provinces with an optimal education subsidy ratio and an optimal school to school age population ratio exhibit adequate overall education budget support and the availability of educational institutions. However, the utilization of education is not yet evenly distributed across all population groups, so education capacity improvement does not occur comprehensively. This limitation affects some segments of the population in managing and maintaining food access, causing these regions to remain vulnerable to food insecurity in the provinces of North Maluku, West Papua, Maluku, North Sulawesi, West Sulawesi, Central Sulawesi, Southeast Sulawesi, Central Kalimantan, Gorontalo, Papua, Aceh, and Bengkulu.
3. Pathway three indicates that some provinces have an optimal average length of schooling, optimal household internet access, and a non-optimal school to school age population ratio. This pathway shows that high education attainment

and information access are not fully matched by the equitable distribution of education infrastructure. Disparities in education access and utilization constrain the capacity improvement of certain population groups, which in turn weakens the region's ability to ensure adequate and sustainable food access. Regional vulnerability to food insecurity under this condition appears in the provinces of Jakarta Special Capital Region (DKI Jakarta), Riau Islands, East Kalimantan, Riau, Yogyakarta Special Region (D.I. Yogyakarta), Bali, Banten, North Sumatra, North Kalimantan, and West Sumatra.

Suggestions

It is hoped that future studies can develop additional education variables using different methods, so that the most dominant causal patterns in explaining regional vulnerability to food insecurity can be identified more comprehensively. Subsequent research may also consider using an ordered probit method to analyze educational conditions in relation to the level of regional vulnerability to food insecurity, classified on an ordinal scale from low to high. Given the limitation of QCA, which only explains condition configurations, future studies are encouraged to integrate other approaches to measure the exact magnitude of the impact of each variable on the level of regional vulnerability to food insecurity.

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