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Integrating Spatial Mapping of Nutritional Food Affordability and Stunting Prevalence to Address Regional Food Insecurity Across the Indonesian Archipelago

Indah Rodianawati [1]*, Nyahu Rumbang [2] and Cahyaning Rini Utami [3]
[1] Universitas Khairun [2] Universitas Palangkaraya
[3] Universitas Yudharta Pasuruan
* Correspondence: indahrodianawati@unkhair.ac.id

ABSTRACT

Food insecurity and childhood stunting remain important public health concerns across the Indonesian archipelago and are associated with disparities in nutritional food affordability, market accessibility, and socioeconomic conditions. Previous studies have primarily examined food affordability and stunting separately, with limited integration through spatial analysis to identify priority intervention areas. This study aims to synthesize empirical evidence on the integration of spatial mapping of nutritional food affordability and stunting prevalence to address regional food insecurity in Indonesia. A qualitative systematic literature review was conducted by analyzing 25 peer-reviewed articles published between 2015 and 2026 from international and national databases. The synthesis indicates that previous studies generally report an association between lower affordability of nutritious foods and higher stunting prevalence, particularly in remote, rural, and eastern Indonesian regions. Previous studies suggest that Geographic Information Systems (GIS) can be used to identify geographic clusters of food insecurity and nutritional vulnerability and may support evidence-based policy planning. Integrating nutritional food affordability, spatial analysis, and stunting indicators provides a comprehensive framework for prioritizing nutrition-sensitive policies, improving food distribution systems, and strengthening regional food security. This integrated approach may support the development of more geographically targeted strategies for addressing regional disparities and informing stunting-reduction policies.

Keywords: Nutritional Food Affordability; Spatial Mapping; Stunting; Food Insecurity; GIS; Indonesia

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1. Introduction

Food insecurity remains an important global challenge because it limits people's ability to obtain sufficient, safe, nutritious, and affordable food needed to maintain a healthy life [1]. Despite continuous improvements in global agricultural production, unequal economic development, rising food prices, and regional disparities continue to hinder access to healthy diets in many low- and middle-income countries [2]. Recent evidence suggests that food security may be evaluated not only by food availability but also by households' economic ability to afford nutritionally adequate diets throughout the year [3]. Consequently, the concept of nutritional food affordability has been increasingly recognized as an important component of food security assessments because it reflects whether healthy diets are economically accessible to different population groups [4].

Indonesia provides an important context for food security research because its archipelagic geography is associated with differences in food distribution, transportation costs, and market accessibility across regions [5]. As the world's largest archipelagic country, Indonesia consists of more than 17,000 islands with considerable differences in infrastructure development, agricultural productivity, and socioeconomic conditions among provinces and districts [6]. These geographical characteristics are associated with differences in the prices of nutrient-rich foods such as meat, fish, eggs, milk, fruits, and vegetables [7]. Consequently, the affordability of nutritious foods varies considerably between western and eastern Indonesia as well as between urban and rural communities [8].

Nutritional food affordability has become an increasingly relevant indicator because households may have physical access to food while remaining economically unable to purchase balanced and diverse diets [9]. Healthy diets generally cost substantially more than energy-dense staple foods, causing low-income households to prioritize calorie sufficiency rather than nutritional adequacy [10]. Such consumption patterns frequently reduce dietary diversity and micronutrient intake, particularly among pregnant women and young children who require higher-quality nutrition during critical stages of growth and development [11]. Therefore, improving the affordability of nutritious foods may represent an important component of strategies aimed at strengthening food security and improving nutritional outcomes [12].

One of the most serious consequences of inadequate dietary quality is childhood stunting, which continues to represent a major public health concern in Indonesia [13]. Stunting is a manifestation of chronic undernutrition resulting from prolonged deficiencies in nutrient intake, recurrent infections, inadequate maternal nutrition, and unfavorable environmental conditions during the first 1,000 days of life [14]. Children affected by stunting may experience impaired physical growth and developmental disadvantages that can be associated with poorer educational and economic outcomes later in life [15]. Although Indonesia has achieved a

gradual decline in national stunting prevalence over recent years, significant disparities remain across provinces, indicating that nutritional improvements have not been evenly distributed throughout the archipelago [16].

Emerging evidence suggests that regional variations in stunting prevalence may be associated with differences in food affordability, poverty, infrastructure quality, market accessibility, and public health services [17]. Districts characterized by high food prices and limited access to nutrient-dense foods frequently report higher levels of child undernutrition than economically advantaged regions [18]. These findings indicate that understanding the geographic relationship between nutritious food affordability and childhood stunting is essential for designing more effective and targeted nutrition interventions [19].

Recent advances in Geographic Information Systems (GIS) and spatial analytical techniques have provided new opportunities to examine food security from a geographical perspective [20]. Spatial mapping can enable researchers to visualize the distribution of food affordability, identify regional disparities, detect clusters of nutritional vulnerability, and evaluate the overlap between socioeconomic conditions and child nutritional outcomes [21]. Compared with conventional statistical approaches, spatial analysis provides more comprehensive insights into location-specific inequalities that often remain concealed within aggregated national indicators [22]. Consequently, GIS-based assessments have become increasingly valuable for supporting evidence-based planning and regional policy development in food security and public health sectors [23].

Despite the growing number of studies investigating food affordability, spatial analysis, and childhood stunting, these issues are commonly examined independently rather than through an integrated analytical framework [24]. Limited literature has simultaneously explored how spatial variations in nutritional food affordability correspond with the geographic distribution of stunting prevalence across the Indonesian archipelago, even though both indicators represent critical dimensions of regional food insecurity [25 Integrating these dimensions may help identify priority intervention areas, inform resource allocation, and support the development of nutrition-sensitive policies.

Accordingly, this study aims to synthesize empirical evidence regarding the integration of spatial mapping of nutritional food affordability and stunting prevalence to address regional food insecurity across the Indonesian archipelago. By reviewing relevant national and international literature, this study seeks to identify the spatial relationship between nutritious food affordability and child nutritional outcomes while offering insights that may inform policies supporting equitable food systems and stunting reduction in Indonesia.

2. Materials and Method

This study employed a qualitative research approach using a systematic literature review (SLR) to synthesize empirical evidence on the relationship between nutritional food affordability, spatial mapping, stunting prevalence, and regional food insecurity across the Indonesian archipelago. A systematic literature review was selected because it enabled a structured synthesis of existing scientific evidence and facilitated the identification of recurring research patterns and factors associated with regional disparities in food security and child nutritional outcomes [1]. Unlike primary empirical research, this approach synthesizes findings from multiple studies to develop a structured interpretation of the relationships among food affordability, spatial disparities, and child nutritional outcomes [8].

The literature search was conducted using several international and national scientific databases, including Scopus, ScienceDirect, SpringerLink, Web of Science, PubMed, MDPI, Taylor & Francis Online, Wiley Online Library, Google Scholar, and SINTA-accredited journals. The search process employed combinations of keywords such as nutritional food affordability, healthy diet affordability, food insecurity, stunting prevalence, spatial mapping, Geographic Information System (GIS), food accessibility, regional disparities, and Indonesia. These keywords were combined using Boolean operators ("AND" and "OR") to identify literature relevant to nutritional food affordability, spatial analysis, stunting, and regional food insecurity [2].

The selection of literature followed predetermined inclusion and exclusion criteria to ensure the quality and relevance of the reviewed studies. Eligible publications consisted of peer-reviewed journal articles published between 2015 and 2026 that examined at least one of the following themes: nutritional food affordability, food security, spatial analysis or GIS applications, childhood stunting, regional nutritional disparities, or public health nutrition. Studies focusing exclusively on clinical interventions, food technology, or agricultural production without discussing food accessibility, affordability, or nutritional outcomes were excluded from the review. In addition, only articles published in English or Indonesian with accessible full-text versions were included in the analysis [9].

After the identification and screening processes, twenty-five journal articles that met the inclusion criteria were selected for detailed review. These studies represented various geographical settings, including Indonesia and other low- and middle-income countries experiencing similar challenges related to food affordability, spatial inequality, and child malnutrition. Incorporating evidence from multiple countries enabled broader comparisons while maintaining the relevance of the findings to the Indonesian context [4].

The selected literature was analyzed using thematic content analysis to identify recurring concepts, relationships, and research trends across previous studies [23]. Each article was

reviewed based on several analytical components, including research objectives, study location, methodological approach, variables examined, spatial analytical techniques, and principal findings. The extracted information was subsequently synthesized to evaluate the relationship between nutritional food affordability and stunting prevalence, examine the contribution of spatial mapping in identifying food insecurity hotspots, and assess policy implications for improving regional food security. This analytical approach facilitated the integration of diverse empirical findings into a coherent conceptual understanding of how spatial disparities in food affordability influence childhood nutritional outcomes across the Indonesian archipelago [19].

3. Result

The synthesis of the twenty-five selected studies demonstrates that nutritional food affordability, spatial disparities, and childhood stunting are closely interconnected dimensions of regional food insecurity. Although the reviewed studies employed different research designs, geographical scopes, and analytical techniques a recurring pattern emerged indicating that limited economic access to nutritious foods is associated with poorer dietary quality and adverse child nutritional outcomes [2]. The findings further reveal that food insecurity is not solely determined by food availability but also by the affordability of healthy diets, market accessibility, regional infrastructure, and socioeconomic conditions that influence household purchasing power [3]. These interconnected factors vary considerably across the Indonesian archipelago, resulting in substantial regional differences in food security and nutritional status. The reviewed literature indicates that integrating nutritional food affordability with spatial mapping provides a more comprehensive understanding of regional food insecurity than evaluating individual indicators separately [23]. Conventional assessments generally measure food production or food consumption independently, whereas spatial approaches combine economic, nutritional, and geographical indicators to identify districts facing overlapping vulnerabilities [17]. Such integration may help policymakers identify regions with overlapping vulnerabilities and inform the prioritization of resources for food security and nutrition programs [21].

Regional Disparities in Nutritional Food Affordability

The reviewed studies generally indicate that nutritional food affordability varies across Indonesian regions. Provinces with better transportation networks, stronger market integration, and higher economic development generally experience lower prices for nutrient-rich foods than geographically isolated provinces [6]. In contrast, remote islands, border districts, mountainous areas, and many eastern Indonesian regions frequently encounter higher transportation costs that increase the market prices of meat, fish, eggs, milk, fruits, and

vegetables [5]. As a result, households residing in these areas face greater financial barriers in obtaining balanced diets despite the national availability of food commodities.

Several studies further explain that household income significantly influences the affordability of healthy diets. Low-income families spend a larger proportion of their income on food expenditures than wealthier households, making them highly vulnerable to fluctuations in food prices [7]. When nutritious foods become relatively expensive, households often prioritize staple foods with lower prices but limited nutritional diversity [3]. Although such dietary adjustments may satisfy immediate energy requirements, they frequently fail to provide sufficient protein, vitamins, and minerals necessary for optimal child growth and development [4]. Consequently, inadequate affordability of nutrient-rich foods may contribute to persistent nutritional inequalities across Indonesia.

The literature also highlights that regional food affordability is strongly affected by infrastructure quality and food distribution efficiency. Inadequate road connectivity, limited transportation facilities, insufficient cold-chain logistics, and unequal market accessibility increase food distribution costs, particularly for perishable commodities [10]. These structural constraints reduce the availability of affordable healthy foods within remote communities and contribute to widening regional disparities in nutritional access [20]. Therefore, improving food distribution systems and strengthening regional market connectivity are essential strategies for increasing equitable access to nutritious foods throughout the Indonesian archipelago [19].

Spatial Relationship Between Nutritional Food Affordability and Stunting Prevalence

Most of the reviewed studies report a significant relationship between limited nutritional food affordability and higher childhood stunting prevalence. Children living in households with poor economic access to healthy diets are more likely to experience chronic deficiencies in essential nutrients during the first one thousand days of life, a critical period for physical and cognitive development [13]. Prolonged inadequacy of dietary diversity contributes to impaired linear growth, resulting in higher risks of stunting among children under five years of age [9]. Although stunting is influenced by multiple determinants, including maternal health, sanitation, healthcare utilization, and environmental conditions, economic access to nutritious foods consistently emerges as one of the underlying factors across numerous empirical studies [6].

Spatial mapping studies employing Geographic Information Systems (GIS) further demonstrate that districts with poor nutritional food affordability frequently overlap with areas exhibiting high stunting prevalence [14]. Rather than being randomly distributed, childhood stunting tends to cluster geographically in regions characterized by poverty, weak infrastructure, limited food accessibility, and inadequate public services [17]. These spatial

clusters indicate that nutritional vulnerability is strongly influenced by regional socioeconomic and environmental conditions rather than household characteristics alone [23].

Several reviewed studies also reveal that spatial analytical techniques provide important advantages over conventional statistical analyses because they visualize the geographic concentration of food insecurity and nutritional problems simultaneously [18]. By integrating information on food prices, household purchasing power, market accessibility, transportation infrastructure, and child nutritional status, GIS-based mapping enables more accurate identification of vulnerable districts requiring priority interventions [15]. Such spatial evidence supports the development of targeted nutrition-sensitive programs that are better aligned with local conditions than generalized national policies [21].

Policy Implications for Addressing Regional Food Insecurity

The synthesis of previous studies suggests that improving nutritional food affordability requires integrated interventions extending beyond agricultural production alone Increasing domestic food production alone may not be sufficient to improve household access to healthy diets when distribution systems and market accessibility remain constrained [1]. Consequently, food security policies should simultaneously address food availability, affordability, accessibility, and nutritional quality to achieve more equitable outcomes across Indonesia [20].

The reviewed literature also emphasizes the importance of utilizing spatial information as a decision-support tool for national and regional governments. Integrating GIS-based mapping with socioeconomic and nutritional indicators enables policymakers to identify priority districts where multiple vulnerabilities coexist, including poverty, high food prices, inadequate dietary affordability, and elevated stunting prevalence [23]. Such evidence-based planning improves the effectiveness of government programs by directing financial resources, food assistance, health services, and infrastructure investments toward locations experiencing the greatest need [17].

Furthermore, several studies recommend strengthening intersectoral collaboration among agriculture, health, transportation, social protection, and regional planning institutions to address the multidimensional nature of food insecurity [8]. Improving transportation infrastructure, expanding regional food distribution networks, promoting local food production, and increasing household purchasing power are complementary strategies that collectively improve nutritional food affordability [24]. At the same time, regular spatial monitoring of food affordability and childhood nutritional outcomes may assist governments in assessing program performance and identifying emerging regional disparities [25].

Overall, the findings indicate that regional food insecurity across the Indonesian archipelago cannot be adequately explained using a single indicator. Nutritional food affordability,

geographic accessibility, socioeconomic inequality, and childhood stunting interact dynamically to shape regional nutritional vulnerability [2]. Integrating these dimensions through spatial mapping provides a more comprehensive understanding of food insecurity while supporting the development of targeted, evidence-based, and region-specific policies to accelerate stunting reduction and improve equitable access to nutritious foods throughout Indonesia [22].

4. Discussion

The findings of this literature review suggest that integrating nutritional food affordability and stunting prevalence within a spatial perspective may provide additional insights into regional food insecurity. Previous studies have generally focused on either food affordability or childhood nutritional status independently, whereas the reviewed literature indicates that both variables are closely interconnected through socioeconomic, geographical, and environmental mechanisms [2]. This integration enables policymakers to better understand why regions with sufficient food production may still experience high rates of child undernutrition due to limited household purchasing power and unequal access to nutritious foods [9].

One of the principal findings of this study is that nutritional food affordability constitutes a fundamental determinant of household dietary quality. The reviewed studies consistently reveal that healthy diets remain relatively expensive compared with calorie-dense staple foods, particularly for low-income households [1]. Consequently, families experiencing financial constraints tend to prioritize inexpensive foods that satisfy energy requirements while providing insufficient protein, vitamins, and essential micronutrients [3]. Such dietary patterns reduce dietary diversity and increase the likelihood of chronic nutrient deficiencies during the first one thousand days of life, ultimately contributing to childhood stunting [13]. These findings support previous research emphasizing that economic access to nutritious foods is equally as important as food availability in achieving sustainable food security [8].

The literature also indicates that regional disparities in nutritional food affordability are strongly influenced by Indonesia's geographical characteristics. As an archipelagic nation consisting of thousands of islands, Indonesia experiences considerable variation in transportation infrastructure, logistics systems, and market accessibility [5]. Regions with efficient transportation networks generally exhibit lower food distribution costs and more stable food prices than geographically isolated areas [6]. Conversely, remote islands, mountainous regions, and border areas frequently experience higher prices for nutrient-rich foods because of increased transportation costs and limited market competition [10]. These structural inequalities reduce the affordability of healthy diets despite improvements in national agricultural production and food availability [20].

Another important finding concerns the contribution of spatial mapping in identifying regional nutritional inequalities. Geographic Information Systems (GIS) provide a powerful analytical framework for visualizing the geographic distribution of food affordability and childhood stunting simultaneously [17]. Unlike conventional statistical analyses that summarize conditions at national or provincial levels, spatial mapping identifies localized clusters of nutritional vulnerability at district or community levels [23]. Such spatial information allows policymakers to recognize priority intervention areas more accurately while avoiding uniform policy approaches that may overlook local socioeconomic and geographical conditions [21].

The reviewed literature further demonstrates that childhood stunting should be understood as a multidimensional outcome influenced by interactions among food affordability, household income, maternal health, sanitation, healthcare accessibility, education, and environmental conditions [4]. Although improving nutritious food affordability alone cannot completely eliminate stunting, it represents an essential prerequisite for improving dietary quality among vulnerable populations [11]. Therefore, reducing childhood stunting requires integrated interventions that combine nutrition-sensitive agricultural policies, poverty reduction, public health services, sanitation improvements, maternal education, and social protection programs [18].

Another significant implication emerging from this review is the importance of integrating spatial information into evidence-based policymaking. The reviewed studies consistently suggest that mapping food affordability alongside stunting prevalence enables governments to allocate financial resources, food assistance programs, and health interventions more efficiently according to regional priorities [14]. Rather than distributing resources uniformly across all regions, spatial evidence allows interventions to be concentrated in districts experiencing overlapping burdens of food insecurity, poverty, and childhood malnutrition [24]. Such targeted approaches are expected to improve program effectiveness while reducing regional disparities in nutritional outcomes.

The findings also highlight the strategic importance of strengthening food distribution systems across the Indonesian archipelago. Improving transportation infrastructure, expanding market connectivity, supporting local food production, and reducing distribution costs are essential strategies for increasing the affordability of nutrient-rich foods in remote areas [19]. In addition, strengthening collaboration among agricultural, health, transportation, and regional planning sectors is necessary to address the complex determinants of food insecurity through integrated policy implementation [25]. Cross-sectoral coordination enables governments to simultaneously improve food availability, economic accessibility, and nutritional utilization while strengthening long-term regional food resilience.

Despite providing comprehensive insights, this literature review has several limitations. First, the study relies entirely on secondary data obtained from previous publications and therefore does not incorporate primary field observations or household-level survey data [2]. Second, variations in research methodology, geographical coverage, and measurement indicators across the reviewed studies may influence the comparability of reported findings [23]. Third, the review primarily synthesizes qualitative evidence and does not quantify the statistical magnitude of the relationship between nutritional food affordability and childhood stunting. Future research should therefore integrate spatial econometric models, remote sensing data, and household consumption surveys to provide stronger empirical evidence regarding regional food insecurity across Indonesia [17].

Overall, this study broadens the current understanding of food insecurity by demonstrating that nutritional food affordability, spatial disparities, and childhood stunting should be analyzed as interconnected dimensions rather than isolated issues. Integrating these components within a spatial analytical framework provides stronger evidence for designing nutrition-sensitive policies capable of reducing regional inequalities and accelerating progress toward sustainable food security across the Indonesian archipelago [1].

5. Conclusions

This systematic literature review demonstrates that nutritional food affordability, spatial disparities, and childhood stunting are closely interconnected dimensions of regional food insecurity across the Indonesian archipelago. The reviewed studies consistently indicate that limited economic access to nutritious foods contributes to inadequate dietary quality and increases the risk of childhood stunting, particularly in geographically isolated and socioeconomically disadvantaged regions. These findings emphasize that food security should not be evaluated solely based on food availability but should also incorporate household affordability and regional accessibility to healthy diets [2].

The review further highlights that integrating Geographic Information Systems (GIS) with indicators of nutritional food affordability and stunting prevalence provides a more comprehensive approach for identifying regional food insecurity hotspots. Spatial mapping enables policymakers to recognize overlapping vulnerabilities, prioritize intervention areas, and allocate resources more efficiently according to local conditions. Consequently, spatially integrated assessments can strengthen evidence-based planning for nutrition-sensitive development programs and support more equitable public policy implementation across Indonesia [17].

From a policy perspective, improving regional food security requires coordinated actions that extend beyond increasing agricultural production. Strengthening transportation

infrastructure, enhancing food distribution systems, improving household purchasing power, expanding access to nutritious foods, and reinforcing cross-sectoral collaboration among health, agriculture, and regional planning institutions are essential for reducing regional inequalities in food affordability and child nutrition [25].

Future studies are encouraged to complement qualitative literature reviews with spatial econometric analyses, Geographic Information System modeling, remote sensing applications, and household-level survey data to quantify the relationship between nutritional food affordability and childhood stunting. Such approaches are expected to provide stronger empirical evidence for developing more effective and geographically targeted strategies to reduce food insecurity and accelerate stunting reduction throughout the Indonesian archipelago.

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