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Research Article

Urban Built Environment Planning Factors Associated with Childhood Stunting in Banda Aceh, Indonesia

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Abstract

This study examines the association between urban built environment planning factors and childhood stunting in Banda Aceh, Indonesia. Childhood stunting is commonly addressed as a nutritional and health problem, yet its occurrence in urban areas is also shaped by spatial conditions, service accessibility, sanitation infrastructure, and food vulnerability. Banda Aceh provides an important case because it is the capital city of Aceh Province and functions as a center of government, services, and urban activities. This ecological cross-sectional study used aggregated village-level data for 2023. The data included stunting prevalence, health facility distribution, sanitation index, and food security and vulnerability classification. Spatial analysis was applied to describe the distribution of stunting and built environment variables, while multiple linear regression was used to examine their statistical association. The results show that Banda Aceh recorded 1,062 stunting cases with an overall prevalence of 10.66% in 2023. The regression model indicates that health facility accessibility, sanitation, and food security status collectively explain 18% of the variation in stunting prevalence. The food variable was coded so that higher scores indicate better food security status. Higher food security status was significantly associated with lower stunting prevalence, while health facility accessibility and sanitation were not statistically significant in the partial tests. These findings suggest that urban stunting reduction requires a planning approach that goes beyond physical service provision by integrating food security, sanitation improvement, and equitable access to urban health-supportive infrastructure.

Keywords: Food Insecurity; Health Service Coverage; Multiple Linear Regression; Sanitation Infrastructure; Spatial Analysis.

Introduction

Stunting among children under five years old remains a persistent indicator of unequal human development. It is defined as impaired linear growth, commonly measured as height-for-age below minus two standard deviations from the World Health Organization Child Growth Standards [1,23]. In 2024, the UNICEF, World Health Organization, and World Bank Joint Child Malnutrition Estimates reported that 150.2 million children under five years old, or 23.2% of this age group globally, were stunted [1]. In this manuscript, the dependent variable refers to

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village-level stunting prevalence among children under five years old; therefore, the term under-five stunting is used consistently.

Although under-five stunting is often addressed as a nutritional and public health problem, it is also shaped by the environments in which children live. The UNICEF conceptual framework explains that child nutrition outcomes are influenced not only by immediate determinants, such as diet and care, but also by underlying determinants related to food, health services, sanitation, and broader enabling environments [3]. Evidence from global and environmental health studies further shows that inadequate sanitation, unsafe water, infection exposure, food insecurity, and poor environmental conditions may contribute to impaired child growth [4-6]. These determinants are directly relevant to urban planning because they are mediated through infrastructure, service distribution, settlement quality, and access to food.

In Indonesia, under-five stunting remains a national development priority. The 2023 Indonesian Health Survey reported a national stunting prevalence of 21.5% among children under five years old [7]. Previous Indonesian studies have shown that stunting is associated with household wealth, maternal education, care and feeding practices, sanitation and water supply, food insecurity, health-care access, and community-level disadvantage [8]. However, much of this evidence emphasizes individual, household, or rural determinants, while the role of village-level urban spatial conditions remains less clearly examined.

Urban areas provide an important context for this question because urbanization can create both service advantages and new forms of inequality. The World Health Organization reports that more than 55% of the world's population lives in urban areas, a proportion projected to reach 68% by 2050; it also notes that almost 40% of urban dwellers lack access to safely managed sanitation services [9]. In Indonesia, the World Bank has projected that by 2045 approximately 220 million people, or more than 70% of the national population, will live in urban areas [10]. These trends make urban planning increasingly relevant to child health and nutrition outcomes.

The link between urbanization and under-five stunting is not simply a matter of whether cities have more facilities than rural areas. Intra-urban inequality may limit the ability of households to benefit from urban services. Children may live near health facilities but still face barriers related to service utilization, affordability, transport, health-seeking behavior, or continuity of growth monitoring. Similarly, city-level sanitation coverage may hide household and neighborhood-level exposure to unsafe water, poor drainage, or inadequate hygiene conditions. Urban households also depend heavily on purchased food, making food access, affordability, and local food environments important pathways through which urban conditions can affect child growth.

The built environment is therefore a useful lens for examining under-five stunting in cities. It includes the physical form, infrastructure, land-use pattern, transportation network, public facilities, and service systems that shape everyday access to resources and exposure to health risks. The World Health Organization and UN-Habitat emphasize that health should be integrated into urban and territorial planning because planning decisions influence access to basic services, environmental quality, equity, and opportunities for healthy living [11]. Population-health planning literature similarly argues that upstream planning decisions shape health outcomes through land use, service accessibility, transport, environmental exposure, and social inclusion [12]. Applying this perspective to child undernutrition allows stunting to be examined as a spatially sensitive urban planning issue.

Banda Aceh provides a relevant case for examining this issue in a medium-sized Indonesian city. As the capital city of Aceh Province, Banda Aceh functions as an administrative, service, educational, and economic center. The city covers approximately 61.36 km² and consists of 9 districts and 90 villages or gampong [13]. Its compact urban structure and availability of village-level data on under-five stunting, health facilities, sanitation, and food security status make it suitable for an ecological analysis of how planning-related factors are associated with child growth outcomes. The city is also relevant because medium-sized Indonesian cities are less frequently represented in built environment and urban health studies than large metropolitan areas.

The research gap addressed in this study is therefore specific. Previous Indonesian stunting studies have provided important evidence on biological, maternal, household, socioeconomic, and environmental determinants, but they have less often examined how village-level urban planning variables are associated with under-five stunting within compact urban settings. Likewise, built environment studies have commonly focused on adult health, physical activity, transport, pollution, or non-communicable diseases, while child undernutrition has received less attention as a planning concern. This study fills this gap by linking under-five stunting prevalence with three planning-related variables: health facility accessibility, sanitation conditions, and food security status.

Accordingly, this study aims to examine the association between selected urban built environment planning factors and under-five stunting in Banda Aceh, Indonesia. The contribution of the study is primarily conceptual and empirical rather than methodological. Conceptually, it frames under-five stunting as an urban planning issue connected to service accessibility, sanitation infrastructure, and food security. Empirically, it provides village-level evidence from a medium-sized Indonesian city to support nutrition-sensitive urban planning and more integrated local stunting-reduction strategies.

Materials and Methods

Study design and setting

This study was conducted in Banda Aceh, the capital city of Aceh Province, Indonesia. The city consists of 9 districts and 90 villages, covering approximately 61.36 km². Banda Aceh was selected because it represents a compact medium-sized urban area where health service accessibility, sanitation infrastructure, food security status, and under-five stunting coexist as interrelated planning and public health issues. The village was used as the main ecological unit of analysis because the dependent and independent variables were available at this administrative scale.

The study used an ecological, quantitative cross-sectional design supported by spatial analysis. The analysis focused on aggregated village-level data for 2023. Since the study used aggregated administrative data, the findings describe village-level statistical associations and must not be interpreted as individual-level causal relationships among children.

Data sources

The study relied entirely on secondary data obtained from relevant local government institutions. **Table 1** summarizes the datasets, source agencies, year, spatial unit, variable names, measurement units, and data formats used in the analysis.

Table 1. Datasets used in the study

Dataset	Source agency	Spatial unit	Variable name	Measurement unit / coding
Under-five stunting data, **2023**	Banda Aceh Health Office	Village	Stunted children; measured children under five; stunting prevalence	Counts; percentage (%)
Administrative boundary data	Banda Aceh Public Works and Spatial	Village polygon	Village boundary; village area	Polygon; square metres

	Planning Office and geospatial base data			
Health facility distribution, **2023**	Banda Aceh Health Office and related spatial data sources	Point facility	Hospitals; active public health centers; nearest public health center distance	Point location; meters
Adequate sanitation data, **2023**	Banda Aceh Health Office	Village	Adequate sanitation index	Percentage (%), 0-100
Food security and vulnerability data, **2023**	Banda Aceh Food and Agriculture Office	Village	Food Security and Vulnerability Atlas priority score / food security status	Ordinal score 1-6; higher = more food secure

Variable Measurement

The dependent variable was under-five stunting prevalence at the village level. It was calculated as the number of stunted children under five years old in each village divided by the total number of measured children under five years old in the same village, multiplied by 100:

$$Y_i = (S_i / N_i) \times 100$$

where Y_i is under-five stunting prevalence in village i, S_i is the number of stunted children under five years old in village i, and N_i is the total number of measured children under five years old in village i. The unit of Y_i is percentage (%).

Health facility accessibility (X1) was operationalized as a continuous distance variable. For each village, the centroid of the village polygon was used as the origin point, and the nearest active public health center (puskesmas) was used as the destination point. The variable was calculated as:

$$X1_i = \min d(c_i, p_j)$$

where $X1_i$ is the Euclidean distance from the centroid of village i to the nearest public health center j, c_i is the centroid of village i, p_j is the location of public health center j, and d is distance measured in meters. Higher X1 values indicate poorer physical accessibility. Hospitals were mapped to describe the wider health-service environment, but the regression variable used distance to the nearest public health center because public health centers are the primary facility type relevant to village-level preventive and maternal-child health services.

The 3,000-meter service radius was used only for descriptive spatial service-coverage analysis and was not used as the continuous X1 variable in the regression model. The radius was adopted as a planning benchmark based on SNI 03-1733-2004 on urban residential environment planning, which is commonly used to assess the service reach of public health centers in urban settlement planning [24]. In this study, the 3 km threshold was treated as a normative planning standard rather than as a direct measure of travel time or effective access.

Sanitation (X2) was operationalized using the adequate sanitation index at the village level. The index reflects the proportion of households meeting adequate sanitation criteria related to toilet facilities, drinking water sources, and water sources for bathing and washing. The measurement was expressed as:

$$X2_i = (Hsan_i / H_i) \times 100$$

where $X2_i$ is the adequate sanitation index in village i, $Hsan_i$ is the number of households meeting the adequate sanitation criteria, and H_i is the total number of households assessed in village i. The unit is percentage (%), with higher values indicating better sanitation conditions.

Food security status (X3) was derived from the Food Security and Vulnerability Atlas classification. To avoid interpretive ambiguity, the variable was coded so that higher values indicate better food security status: 1 = very food vulnerable, 2 = food vulnerable, 3 = moderately food vulnerable, 4 = moderately food secure, 5 = food secure, and 6 = highly food secure. Thus, a negative regression coefficient for X3 indicates that movement toward a more food-secure category is associated with lower under-five stunting prevalence.

Spatial analysis procedure

Spatial analysis was conducted using QGIS 3.x [14]. All spatial layers were checked for geometry validity and reprojected to WGS 84 / UTM Zone 46N (EPSG:32646) so that distance and buffer calculations were expressed in meters. Village-level tabular data were joined to the village boundary layer using village names or administrative identifiers. The GIS workflow consisted of six steps. First, village boundary polygons and health-facility point layers were cleaned and harmonized. Second, village centroids were generated from the village polygons. Third, the distance from each village centroid to the nearest active public health center was calculated to produce the continuous accessibility variable used in the regression model. Fourth, 3,000-meter buffers were generated around public health centers and dissolved to form a single service-coverage layer. Fifth, the service-coverage layer was overlaid with village boundaries and under-five stunting prevalence to identify villages located within or outside the normative service radius. Sixth, thematic maps were prepared for under-five stunting prevalence, sanitation conditions, and food security status.

Map classification followed the nature of each variable. Under-five stunting prevalence was classified using natural breaks (Jenks) to represent the observed village-level distribution. Sanitation was classified using the index categories applied in the dataset: very adequate, adequate, moderate, low, and very low. Food security status was classified using the official Food Security and Vulnerability Atlas priority categories. Spatial overlay was then used to compare the location of high-stunting villages with health-service coverage, sanitation categories, and food-security categories.

Statistical analysis

Multiple linear regression was used to examine the association between urban built environment planning factors and under-five stunting prevalence. The regression model was specified as follows:

$$Y = \beta 0 + \beta 1X1 + \beta 2X2 + \beta 3X3 + \varepsilon$$

where Y represents village-level under-five stunting prevalence, X1 represents distance to the nearest public health center in meters, X2 represents the adequate sanitation index in percentage, X3 represents the food security status score coded from 1 to 6, and ε represents the error term. The empirical model obtained from the analysis was:

$$Y = 17.457 + 0.001X1 - 0.011X2 - 1.695X3$$

The F-test was used to examine the simultaneous association between all independent variables and stunting prevalence. The t-test was used to examine the partial association of each independent variable. The level of significance was set at 0.05. The coefficient of determination was used to assess the proportion of stunting variation explained by the model. Classical assumption tests were conducted before interpreting the regression results. Normality was used to assess residual distribution, multicollinearity was examined using tolerance and variance inflation factor values, and heteroscedasticity was assessed using residual patterns. These tests were conducted to ensure that the regression model met the basic requirements for linear regression analysis [15].

Methodological limitations

Several methodological limitations should be noted. First, the cross-sectional design does not allow causal interpretation. Second, village-level data may mask household-level differences in income, maternal education, feeding practices, hygiene behavior, disease history, and health-service utilization. Third, distance-based accessibility does not fully represent effective access to health care, which may also depend on affordability, service quality, transportation, household decision-making, and continuity of service use. Therefore, the results should be interpreted as ecological associations at the village level.

Results

Spatial distribution of childhood stunting

In 2023, Banda Aceh recorded 1,062 under-five stunting cases, with an overall prevalence of 10.66%. Case counts and prevalence represent different dimensions of the problem. Case counts indicate the absolute burden of under-five stunting, whereas prevalence indicates the proportion of measured children under five years old who were stunted and is therefore more appropriate for comparing health-center service areas. At the health-center service-area level, the highest prevalence was recorded in Meuraxa (20.70%), followed by Jeulingke (20.00%) and Lampaseh (15.25%). In contrast, the lowest prevalence was recorded in Baiturrahman (4.43%). Meuraxa also recorded the largest absolute number of stunting cases, with 243 cases; however, this number should be interpreted cautiously because high case counts may partly reflect a larger measured under-five population (**Figure 2**).

Table 2. Under-five stunting by health-center service area in Banda Aceh, 2023.

No.	Health-center service area	Stunting cases	Stunting prevalence (%)
1	Meuraxa	243	20.70
2	Jaya Baru	73	7.35
3	Banda Raya	133	10.86
4	Baiturrahman	62	4.43
5	Batoh	98	10.48
6	Kuta Alam	39	6.90
7	Lampulo	58	7.45
8	Lampaseh	120	15.25
9	Kopelma Darussalam	53	7.95
10	Jeulingke	96	20.00
11	Ulee Kareng	87	9.07
	Total	**1,062**	**10.66**

Note: Source: Banda Aceh Health Office, 2023. Prevalence was calculated as the number of stunted children under five years old divided by the total number of measured children under five years old in the corresponding health-center service area, multiplied by 100.

At the village level, the spatial pattern shows that under-five stunting was distributed across most parts of the city rather than concentrated in a single location. Of the 90 villages in Banda Aceh, 88 recorded at least one stunting case, while Kampung Baru and Pango Deah had no recorded cases. Based on the village-level case-count classification used for the spatial map, Jeulingke, Alue Naga, Tibang, and Lampaseh Aceh were located in the highest case-count class, with approximately 28-45 stunting cases (**Table 2**). This village-level summary describes absolute burden and should not be interpreted as a prevalence ranking unless the number of measured children under five years old in each village is also considered.

The spatial distribution map indicates that under-five stunting in Banda Aceh is an intra-urban issue. Villages with a high absolute burden were not limited to peripheral settlements but appeared in different urban zones, including coastal, central, and service-oriented areas. The spatial interpretation therefore requires attention to both indicators: case counts identify locations with a larger number of affected children, while prevalence is the more appropriate measure for comparing relative risk across areas.

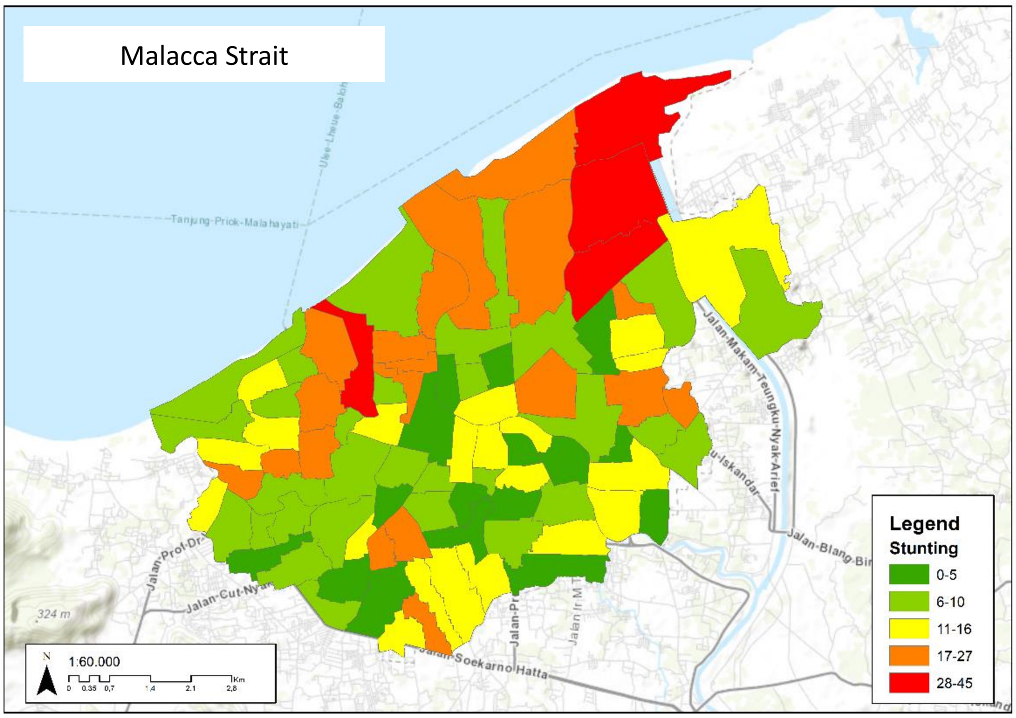

Figure 2. Spatial distribution of childhood stunting in Banda Aceh, 2023 (Source: Author's elaboration based on Banda Aceh Health Office data)

Spatial distribution and accessibility of health facilities

The spatial analysis identified 14 hospitals and 11 active public health centers distributed across Banda Aceh. Each district had at least one public health center. Kuta Alam and Syiah Kuala had two public health centers each, indicating a relatively dense distribution of primary health services in those districts. Based on the 3,000-meter service radius for public health centers, most villages in Banda Aceh were located within the standard health facility coverage area (**Figure 3**).

The buffer analysis shows that physical accessibility to public health centers was generally adequate. Most villages with stunting cases were still located within the 3 km service buffer. This means that the existence of stunting cases in Banda Aceh cannot be explained solely by distance to health facilities. High-stunting areas such as Meuraxa and Jeulingke were not completely isolated from health services. Instead, the overlay between stunting distribution and health facility coverage indicates that physical proximity does not necessarily translate into effective access or optimal service utilization.

This finding is important from an urban built environment planning perspective. It suggests that accessibility should not be interpreted only as distance or service radius. Other dimensions, such as service quality, affordability, household time constraints, transportation availability, health-seeking behavior, and continuity of child growth monitoring, may influence whether nearby facilities are effectively used by households.

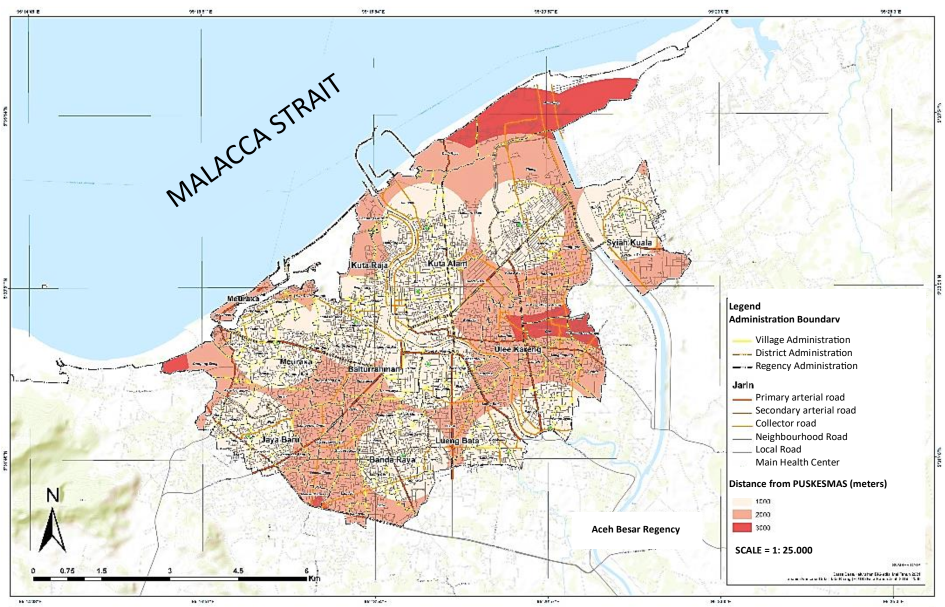

Figure 3. Health facility distribution and 3 km public health-center service coverage in Banda Aceh (Source: Author's elaboration based on Health Office, Public Works and Spatial Planning Office, and geospatial data)

Spatial pattern of sanitation conditions

The sanitation index shows that Banda Aceh generally had adequate sanitation conditions in 2023. The city's overall adequate sanitation index reached 90.36%, indicating that sanitation provision was mostly classified as adequate. The index was constructed from three indicators: access to adequate toilet facilities, drinking water sources, and water sources for bathing and washing (**Table 3**).

The village-level classification shows that 46 villages, or 51% of all villages, were classified as having very adequate sanitation, with an index value of 100%. Another 30 villages, or 33%, were classified as adequate, with index values between 80% and 99%. Meanwhile, 7 villages were classified as moderate, 2 as low, and 5 as very low. Spatially, this means that most of Banda Aceh had relatively good sanitation coverage, while sanitation vulnerability was limited to several village-level pockets.

The overlay between sanitation classification and stunting distribution shows that high-stunting areas did not consistently coincide with low or very low sanitation areas. Some villages with adequate or very adequate sanitation still recorded stunting cases. This pattern helps explain why sanitation did not show a statistically significant partial association in the regression model. At the aggregate village level, sanitation conditions in Banda Aceh may be too generally adequate to explain stunting variation independently.

Table 3. Classification of adequate sanitation index in Banda Aceh, 2023

Sanitation index value (%)	Category	Number of villages	Percentage (%)
100	Very adequate	46	51
80–99	Adequate	30	33
60–79	Moderate	7	8
40–59	Low	2	2
0–39	Very low	5	6
	Total	**90**	**100**

Spatial pattern of food vulnerability

Food vulnerability was assessed using the Food Security and Vulnerability Atlas classification. The index consisted of three dimensions: food availability, food access, and food utilization. These dimensions were represented by indicators such as agricultural land ratio, food-provision facilities, low-welfare population, transport connectivity, access to clean water, and health-worker ratio.

The results show that no village in Banda Aceh was classified as priority 1, or very food vulnerable. However, 9 villages, or 10.00%, were classified as priority 2, meaning food vulnerable. Another 12 villages, or 13.33%, were classified as priority 3, or moderately food vulnerable. In contrast, 40 villages, or 44.44%, were classified as highly food secure, while 24 villages, or 26.67%, were classified as food secure (**Table 4**).

The spatial distribution of food vulnerability shows clearer differentiation than sanitation. Priority 2 food-vulnerable villages were found in Meuraxa, Banda Raya, Kuta Raja, and Syiah Kuala. Priority 3 villages were found in Meuraxa, Jaya Baru, Lueng Bata, and Kuta Alam. This spatial pattern is important because some food-vulnerable areas overlapped with areas that had high stunting prevalence, particularly in Meuraxa. The overlap suggests that food vulnerability may be a more sensitive spatial indicator for explaining stunting variation than physical health facility access or sanitation infrastructure alone.

Table 4. Food security and vulnerability classification in Banda Aceh, 2023

Priority	Classification	Index value	No. of villages	Percentage (%)
1	Very food vulnerable	< 41.41	0	0.00
2	Food vulnerable	> 41.41–54.56	9	10.00
3	Moderately food vulnerable	> 54.56–57.52	12	13.33
4	Moderately food secure	> 57.52–62.50	5	5.56
5	Food secure	> 62.60–67.50	24	26.67
6	Highly food secure	> 67.50	40	44.44
	Total		**90**	**100.00**

Spatial overlay of built environment planning factors and stunting

The spatial overlay of stunting, health facility accessibility, sanitation, and food vulnerability provides three important findings. First, most villages with stunting cases were already located within the 3 km public health-center service area. Therefore, the spatial pattern does not support a simple interpretation that stunting occurs mainly because villages are physically distant from health facilities. Second, sanitation conditions were generally adequate across the city. Most villages were classified as adequate or very adequate, including several villages that still recorded stunting cases. This suggests that the sanitation index at the village scale may not fully capture household-level exposure, such as hygiene behavior, drainage quality, water contamination, or sanitation maintenance. Third, the spatial distribution of food vulnerability showed a stronger correspondence with stunting. Food-vulnerable and moderately food-vulnerable villages were found in several districts where stunting cases remained notable, especially Meuraxa. This spatial overlap is consistent with the regression result, which identified food vulnerability as the only variable with a statistically significant partial association with stunting prevalence.

Overall, the spatial analysis shows that childhood stunting in Banda Aceh cannot be understood only through the availability of health facilities or the general adequacy of sanitation. Instead, stunting appears to be more closely related to socio-spatial vulnerability, particularly food-related vulnerability. This finding strengthens the argument that stunting reduction in urban areas requires integrated built environment planning that addresses service accessibility, infrastructure quality, and food security simultaneously.

Regression model results

Multiple linear regression was used to examine the association between health facility accessibility, sanitation, food vulnerability, and childhood stunting prevalence. The empirical regression equation was:

$$Y = 17.457 + 0.001X1 - 0.011X2 - 1.695X3$$

where Y represents childhood stunting prevalence, X1 represents health facility accessibility, X2 represents the adequate sanitation index, and X3 represents the food vulnerability index.

The regression coefficients indicate different directions and strengths of association. Health facility accessibility had a positive coefficient of 0.001, meaning that longer distance to health facilities was associated with a slight increase in stunting prevalence (**Table 5**). However, this association was not statistically significant. Sanitation had a negative coefficient of -0.011, indicating that better sanitation was associated with lower stunting prevalence, although this relationship was also not statistically significant. Food vulnerability had a negative coefficient of -1.695 and was statistically significant. This means that improvement in the food security category was associated with a reduction in stunting prevalence.

Table 5. Regression coefficients

Variable	B	Std. error	Beta	t	Sig.	Tolerance	VIF
Constant	17.457	2.935	—	5.947	0.000	—	—
Health facility accessibility	0.001	0.002	0.067	0.680	0.498	0.967	1.034
Adequate sanitation index	-0.011	0.024	-0.047	-0.485	0.629	0.994	1.006
Food vulnerability index	-1.695	0.406	-0.412	-4.177	0.000	0.972	1.028

The simultaneous test showed that the three independent variables jointly had a significant association with childhood stunting prevalence. The model explained 18% of the variation in stunting prevalence. This indicates that selected urban built environment planning variables are relevant to stunting variation in Banda Aceh, although most of the variation is still explained by factors outside the model. The partial test results show that health facility accessibility was not significant, with $t = 0.680$ and $p = 0.498$. Sanitation was also not significant, with $t = -0.485$ and $p = 0.629$. Food vulnerability was statistically significant, with $t = -4.177$ and $p = 0.000$. Therefore, food vulnerability was the strongest planning-related factor associated with childhood stunting in the model.

Model assumption results

The regression model met the main assumptions required for interpretation. The multicollinearity test showed that all independent variables had tolerance values above the minimum threshold and variance inflation factor values below 10. Health facility accessibility had a tolerance value of 0.967 and a variance inflation factor of 1.034. Sanitation had a tolerance value of 0.994 and a variance inflation factor of 1.006. Food vulnerability had a tolerance value of 0.972 and a variance inflation factor of 1.028. These values indicate that there was no multicollinearity problem among the independent variables.

Planning simulation

The regression model was also used to simulate the potential change in stunting prevalence under improved built environment planning conditions. The simulation assumed that health facility distance was reduced to 3 km, sanitation was improved to 80%, and food security improved to priority 6. Under this scenario, the predicted stunting prevalence decreased to 6.41%. This simulation suggests that improving one planning factor alone may have a limited effect, while integrated improvement across health accessibility, sanitation, and food security may produce a stronger reduction in stunting prevalence. The simulation also reinforces the regression finding that food security improvement has the largest coefficient effect in the model.

Discussion

The findings suggest that selected area-level planning variables have limited but meaningful association with under-five stunting in Banda Aceh, with food security status showing the strongest statistical relationship. This interpretation is consistent with the UNICEF conceptual framework, which explains that child nutrition is shaped by immediate determinants, such as diet and care, and by underlying determinants, including food systems, health services, sanitation, and broader enabling environments [3]. However, because this study used an ecological cross-sectional design, the results should be interpreted as village-level associations rather than causal relationships at the individual child level.

The explanatory power of the model was modest, with health facility accessibility, sanitation, and food security status explaining 18% of the variation in village-level under-five stunting prevalence. This indicates that the selected planning variables are relevant but incomplete predictors of stunting variation. The result is consistent with evidence from Indonesia showing that child growth is influenced by multiple factors, including household wealth, maternal education, birth outcomes, feeding practices, sanitation, food security, health-care access, and broader community disadvantage [8]. Therefore, the Banda Aceh findings should be read as evidence that planning-related conditions matter, but they must be understood together with health, nutrition, poverty reduction, and family-based interventions.

The spatial distribution of under-five stunting also supports a cautious area-level interpretation. Stunting cases were recorded in 88 of 90 villages, indicating that the issue was not confined to a single peripheral or underserved settlement. Nevertheless, absolute case counts should not be interpreted as direct evidence of higher risk because villages with larger measured under-five populations may naturally record more cases. For comparing areas, prevalence remains the more appropriate indicator because it accounts for the denominator of measured children under five years old. This distinction is important for avoiding overinterpretation of high case numbers in densely populated or service-concentrated areas.

Health facility accessibility showed a positive but statistically non-significant association with under-five stunting prevalence. Because the study design does not establish causality, this result should be described as an association rather than as evidence that distance changes stunting prevalence. Spatially, Banda Aceh has a relatively good distribution of health facilities, with 14 hospitals and 11 active public health centers, and most villages are located within the 3 km public health-center service radius. The regression result therefore suggests that distance-based physical accessibility alone was not sufficient to explain village-level differences in under-five stunting prevalence.

One possible explanation is that physical proximity to a health facility may not represent effective access to preventive and curative services. Effective access may depend on service quality, affordability, opening hours, transport convenience, household time constraints, health-seeking behavior, and continuity of child growth monitoring. However, these dimensions were not measured in the present study. Therefore, this interpretation should be treated as a plausible explanation rather than a demonstrated finding. Future research in Banda Aceh should examine service utilization, quality of maternal and child health services, household transport access, travel time, out-of-pocket costs, and the continuity of nutrition counselling and growth-monitoring services.

Sanitation showed a negative but statistically non-significant association with under-five stunting prevalence. The direction of the association is theoretically consistent with evidence that inadequate sanitation, unsafe water, and poor environmental hygiene can increase pathogen exposure, diarrheal disease, and environmental enteric dysfunction, which may impair child growth [5,6]. However, the current study cannot prove these mechanisms directly because it used an aggregated sanitation index rather than household-level exposure data.

The non-significant sanitation result may be due to limited variation, aggregation bias, or incomplete measurement of sanitation quality. In Banda Aceh, most villages were classified as having adequate or very adequate sanitation, which may reduce the ability of the regression model to detect a distinct village-level association. In addition, a village-level index may hide household and neighborhood differences in toilet quality, water safety, drainage performance, wastewater management, solid-waste accumulation, and hygiene behavior. Future studies should therefore use more detailed household or neighborhood-level sanitation indicators, including water quality, drainage condition, sanitation maintenance, and observed environmental exposure.

Food security status was the strongest and only statistically significant partial variable. Because the variable was coded so that higher values indicate better food security status, the negative coefficient indicates that better food security status was associated with lower under-five stunting prevalence. This result is consistent with evidence that household food insecurity is associated with poor dietary diversity, malnutrition, and higher risk of stunting among children under five years old [19]. It is also consistent with urban food-environment literature showing that poor urban households often depend on purchased food and are vulnerable to income instability, food prices, transport costs, and unequal access to affordable nutritious food [20].

The food security finding has direct relevance for urban planning because food security is shaped not only by household income but also by the spatial organization of the city. Planning can influence food access through the distribution of markets and fresh-food outlets, transport connectivity between neighborhoods and food sources, walkability and public transport access to markets, land-use allocation for local food retail, and the location of social infrastructure that supports vulnerable households. In this sense, food security should be treated as part of the urban built environment rather than solely as an agricultural or household welfare issue.

For Banda Aceh, this means that food-vulnerable and moderately food-vulnerable villages should become priority locations for integrated stunting-prevention planning. The Food Security and Vulnerability Atlas can be used as a spatial targeting instrument to identify villages requiring more intensive intervention [18,22]. Planning agencies could integrate FSVA maps into local spatial planning, neighborhood infrastructure programs, and development-priority setting. Practical interventions may include improving market connectivity, ensuring affordable access to fresh and nutritious food, coordinating food assistance with maternal and child health programs, strengthening community-level food distribution points, and aligning social protection with stunting-risk areas.

These recommendations support a more integrated planning approach for Banda Aceh. Health facility provision remains important, but it should be linked with outreach, growth monitoring, and service utilization. Sanitation infrastructure remains relevant, but it should be assessed through quality, maintenance, and household-level environmental exposure. Food security status should become a central planning concern because it showed the strongest statistical association with under-five stunting prevalence. Therefore, the appropriate policy direction is not merely to add more facilities, but to improve the equity, functionality, and integration of urban systems that support child growth.

This study has several limitations. The cross-sectional design does not allow causal interpretation. Because the analysis uses aggregated village-level data, the findings should not be interpreted as individual-level causal relationships. This creates a risk of ecological fallacy if village-level associations are assumed to apply directly to individual children or households. The model may also be affected by omitted-variable bias because important determinants such as household income, maternal education, feeding practices, birth history, disease history, hygiene behavior, service utilization, and food affordability were not included. In addition, the measurement of health accessibility through distance does not fully capture effective access. Future research should combine spatial analysis with household surveys, travel-time modelling, food affordability indicators, health-service utilization data, and qualitative interviews. Such approaches would provide a stronger explanation of why under-five stunting persists in urban areas where basic infrastructure and health facilities appear relatively available.

Conclusion

This study examined the association between selected urban built environment planning factors and village-level under-five stunting prevalence in Banda Aceh, Indonesia. Using ecological cross-sectional village-level data, spatial analysis, and multiple linear regression, the model including health facility accessibility, sanitation, and food security status explained 18% of the variation in under-five stunting prevalence. This explanatory power indicates that the selected planning variables have a limited but meaningful association with stunting variation. The findings indicate that selected spatial and environmental variables, particularly food security classification, are associated with village-level stunting prevalence.

The spatial analysis showed that under-five stunting was distributed across most villages in Banda Aceh, including areas located within the standard service radius of public health centers. This suggests that distance-based physical proximity to public health centers alone is insufficient to explain village-level stunting variation. Sanitation showed a negative but statistically non-significant association, suggesting that aggregate sanitation coverage may not fully capture household-level environmental health risks. Food security status, coded so that higher values indicate better food security, was the only variable with a statistically significant partial relationship in the model. Higher food security classification was associated with lower village-level under-five stunting prevalence.

The study contributes to built environment planning literature by positioning under-five stunting as a spatially sensitive issue that can be examined through area-level planning indicators. However, the findings should be interpreted cautiously because the model explains only a modest share of stunting variation and does not establish individual-level causality. For

Banda Aceh, planning implications should focus on prioritizing food-vulnerable villages, integrating Food Security and Vulnerability Atlas information into spatial and development planning, and linking stunting prevention with neighborhood-level infrastructure, sanitation improvement, health-service outreach, and food-security programs. Future studies should incorporate household-level socioeconomic, nutrition, service-utilization, and environmental exposure data to explain the remaining variation more comprehensively.

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Conflict of Interest

The authors declare no conflicts of interest.

Author Contribution Statement

Resi Selvi Yanti: Conceptualization, methodology, data curation, formal analysis, spatial analysis, visualization, and writing-original draft preparation. **Evalina Zuraidi**: Conceptualization, supervision, methodology, validation, and writing-review and editing. **Farisa Sabila:** Supervision, validation, interpretation of results, and writing-review and editing. **Issana Meria Burhan:** Writing-review and editing.

Data Availability Statement

The data used to support the findings of this study were derived from secondary data obtained from relevant government institutions in Banda Aceh, including data on childhood stunting, health facility distribution, sanitation conditions, food vulnerability, and administrative spatial boundaries. The data used to support the findings of this study are included within the article. Additional supporting data may be available from the corresponding author upon reasonable request, subject to permission from the relevant data-providing institutions.

Ethics Approval

Ethical approval was not required because the study used aggregated secondary data without individual identifiers

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