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SPATIAL ASSESSMENT OF CHILDREN'S VULNERABILITY TO GREEN SPACE ACCESSIBILITY IN JAKARTA, INDONESIA

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Abstract. Urban green spaces are essential for children's physical, cognitive, and emotional development. However, rapid urbanization often leads to an unbalanced distribution of green spaces across cities, potentially limiting children's access to safe outdoor environments. This study investigates the spatial vulnerability of children under five to green space accessibility in Jakarta, Indonesia, using child population distribution density data and distances to the green space network. The results show that approximately 50–74% of spatial units across municipalities fall into the moderate vulnerability category, while several areas show high or very high vulnerability. The vulnerability map highlights priority areas where urban planning interventions may improve equitable access to green spaces. The study demonstrates the potential of integrating open geospatial data and GIS-based spatial analysis to support evidence-based urban planning. The findings contribute to monitoring progress toward Sustainable Development Goal (SDG) 11.7, which aims to ensure universal access to safe, inclusive, and accessible green and public spaces.

Keywords: Green Space Accessibility; Children's Vulnerability; Spatial Analysis, SDG 11.7

[Judul : PENILAIAN SPASIAL KERENTANAN ANAK TERHADAP AKSESIBILITAS RUANG HIJAU DI JAKARTA, INDONESIA]. *Ruang hijau perkotaan sangat penting bagi perkembangan fisik, kognitif, dan emosional anak-anak. Namun, urbanisasi yang sangat cepat sering kali menyebabkan distribusi ruang hijau tidak merata di seluruh kota, yang berpotensi membatasi kesempatan anak-anak untuk mengakses lingkungan ruang hijau yang aman. Studi ini meneliti kerentanan spasial anak-anak di bawah usia 5 tahun terhadap akses ruang hijau perkotaan di Jakarta, Indonesia, dengan memanfaatkan data distribusi kepadatan populasi anak-anak serta jarak akses ke ruang hijau berdasarkan jaringan. Hasil studi ini menunjukkan bahwa sekitar 50-74% unit spasial di seluruh kotamadya termasuk dalam kategori kerentanan sedang, sementara beberapa area menunjukkan kerentanan tinggi dan sangat tinggi. Peta kerentanan menyoroti area prioritas di mana intervensi perencanaan ruang dapat meningkatkan akses yang adil terhadap ruang hijau. Studi ini juga menunjukkan potensi integrasi data geospasial terbuka dan analisis berbasis SIG untuk mendukung perencanaan kota berbasis bukti. Hasil studi ini berkontribusi pada pemantauan kemajuan menuju Tujuan Pembangunan Berkelanjutan (SDG) 11.7, yang bertujuan untuk memastikan akses universal terhadap ruang hijau dan ruang publik yang aman, inklusif, dan mudah diakses.*

***Kata Kunci**: Aksesibilitas Ruang Hijau; Kerentanan Anak; Analisis Spasial, SDG 11.7*

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1. INTRODUCTION

Urban green spaces are recognized as critical infrastructure for sustainable and livable cities (Wikantiyoso et al., 2021). Parks, urban forests, and other green environments provide numerous ecological and social benefits, including climate regulation, improved air quality, and opportunities for recreation (Jim & Chen, 2003). In densely populated urban environments, green spaces offer residents crucial opportunities to interact with nature (Dabra & Kumar, 2023; Wikantiyoso et al., 2021).

Among urban residents, children are a particularly important population group for green space accessibility (Sikorska et al., 2020). Exposure to natural environments during early childhood has been associated with multiple developmental benefits, such as improved physical health, enhanced cognitive development, and reduced psychological stress (Balseviciene et al., 2014). Green spaces provide opportunities for unstructured play, exploration, and social interaction, which essential for healthy childhood development (Balseviciene et al., 2014). Despite these benefits, access to green spaces remains uneven across many cities worldwide because of rapid urbanization, land scarcity, and competing development pressures. As a result, some communities have abundant green spaces, while others have limited access to recreational spaces (Derdouri et al., 2025).

These imbalances reflect broader patterns of urban environmental inequality, in which environmental facilities are unevenly distributed across urban populations. Environmental inequality is well documented in cities across developed and developing countries, reflecting socioeconomic disparities, historical urban development patterns, and unequal planning priorities (Venter et al., 2023)(Venter et al., 2023).

In rapidly growing megacities, ensuring equitable access to green spaces has become a critical challenge for urban planners and policymakers. Limited access to green spaces may restrict opportunities for outdoor recreation and reduce exposure to natural environments, particularly for vulnerable population groups such as children (Balseviciene et al., 2014). Recognizing the importance of accessible public spaces, the United Nations (UN) has incorporated green space accessibility into the Sustainable Development Goals. SDG target 11.7 aims to ensure universal access to safe, inclusive, and accessible green and public spaces for all, particularly women, children, older persons, and persons with disabilities (United Nations, 2020).

Although previous studies have examined urban green space accessibility using population data, pedestrian network analysis, and spatial equity indicators, important methodological and contextual differences remain. For instance, Qiu et al. (2019), proposed an age-based two-step floating catchment area approach to account for age-based differences in accessibility, whereas Iraegui et al. (2020), examined equity in access to urban green spaces by population group and green space function. More recently, Xu et al. (2025) distinguished spatial access from accessibility by developing an integrated analytical framework. These studies show that green space accessibility cannot be understood solely through the spatial distribution of green spaces. However, further investigation is needed into how the concentration of very young children coincides spatially with pedestrian access constraints at the metropolitan scale, particularly in rapidly urbanizing cities where fine-scale, age-specific population information and open geospatial data can support spatially targeted planning.

This study evaluates the spatial vulnerability of children under five to limited access to urban green spaces in mainland Jakarta. The analytical framework includes three operational components:

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gridded population estimates of children under five from WorldPop; green space locations and pedestrian-oriented road networks from OpenStreetMap (OSM); and shortest-path network distances from population grid centroids to the nearest mapped green space.

The study then integrates population concentration and accessibility constraints into a spatial vulnerability index to identify areas where high potential demand for green spaces coincides with greater network distances.

The contribution of this study lies in the application of this integrated, child-focused spatial screening approach to identify intra-urban priority areas in Jakarta using open geospatial datasets. Rather than evaluating green space availability or accessibility in isolation, the framework explicitly combines the spatial concentration of children under five with network-based access limitation to distinguish areas requiring further planning attention. The resulting vulnerability map provides a spatially explicit basis for prioritizing neighborhood-level green space interventions and illustrates how open population and infrastructure data can support child-sensitive urban planning in data-constrained metropolitan contexts.

2. METHODS

2.1 Research Location

Jakarta is Indonesia's capital and one of Southeast Asia's most densely populated metropolitan areas. The city covers approximately 660,98 km² and has a population of 10,6 million residents (Badan Pusat Statistik Provinsi DKI Jakarta, 2026). Rapid urban growth and intensive development have significantly altered land-use patterns across the city. As a result, green space availability and distribution have become increasingly uneven across neighborhoods.

Jakarta's administrative structure consists of five municipalities: Central Jakarta, South Jakarta, West Jakarta, East Jakarta, and North Jakarta. These municipalities are highly urbanized, with dense residential development, transportation infrastructure, and commercial activity.

The study excluded Kepulauan Seribu because the WorldPop population raster's spatial resolution (500 m × 500 m) exceeds the extent of several islands in the district, which may inaccurately represent population distribution. This study focuses on mainland Jakarta to evaluate spatial inequalities in accessibility to green spaces for children under five years old.

2.2 Tools and Data

This study used QGIS 3.28 as the primary platform for geospatial analysis and visualization, and Microsoft Excel for data processing and statistical summarization. This research used several open-source geospatial datasets, all downloaded in December 2025.

The Indonesian Geospatial Agency (BIG) provided administrative boundary data for Jakarta. These data defined the study area and were used to clip spatial datasets. We used OpenStreetMap (OSM) data to obtain spatial information on road networks and green spaces. OSM is a crowdsourced geographic database where spatial data are contributed and edited by volunteers. Although OSM provides extensive coverage in many urban areas, its completeness and accuracy may vary depending on local mapping activities. The minor road OSM datasets were extracted for the analysis of minor road networks connecting residential areas, including residential roads, living streets, paths, footways, and tracks. Moreover, points of interest of green space, including parks, playgrounds, pitches, and schoolyards. All OSM datasets were downloaded from the Geofabrik repository (https://download.geofabrik.de/asia/indonesia.html). Population data were obtained from WorldPop (https://data.humdata.org/dataset/indonesia-high-resolution-population-density-maps-demographic-estimates), specifically the dataset representing children aged under five years. WorldPop provides high-resolution gridded population estimates derived from census data and spatial modeling techniques. Each raster cell represents the estimated number of children under five years in that location.

2.3 Spatial Analysis

2.3.1 Children Population Distribution

The WorldPop population dataset for children under five was first clipped to the Jakarta administrative boundary (Figure 1).

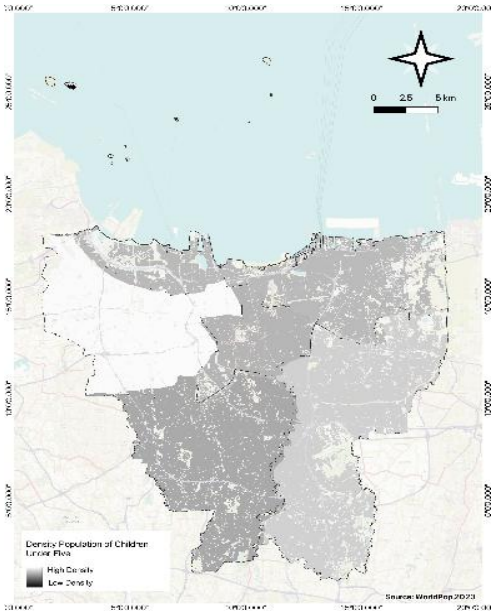


Figure 1. Population of Children Under Five

To analyze the spatial distribution of the child population, we generated a fishnet grid covering the entire study area. Each grid cell represents a spatial unit used for analysis. Zonal statistics were then applied to calculate the total number of children under five within each grid cell. This process aggregates raster population values within each grid polygon. The resulting values represent the spatial distribution of the children population across Jakarta. Areas with higher values indicate a higher concentration of children and therefore potentially greater demand for recreational spaces and environmental amenities such as green spaces.

2.3.2 Point of Interest of Green Space Distribution

Green spaces were extracted from the OSM dataset using several relevant tags, including park, playground, pitch, and schoolyard. These features represent publicly accessible recreational spaces that may provide opportunities for children's outdoor activities. An evaluation of the completeness of green space data was conducted before performing the accessibility analysis. The completeness assessment compares the spatial distribution of mapped green spaces with Bing aerial imagery and evaluates whether the dataset adequately represents (missing or extra data) green spaces across Jakarta. This step ensures that the OSM dataset is sufficiently representative for spatial accessibility analysis.

2.3.3 Accessibility Analysis

Accessibility to green spaces was assessed using a network-based distance approach derived from the road network extracted from OSM. Unlike Euclidean distance, which measures straight-line distance between two locations, network-based analysis considers the actual pathways available for pedestrian movement. This approach more realistically represents accessibility in urban environments by accounting for the configuration and connectivity of transportation infrastructure.

The road network dataset was extracted from OSM and included minor road classes connecting residential areas to public spaces: residential roads, living streets, paths, footways, and tracks (Figure 2). These road types represent neighborhood-scale pedestrian routes that are commonly used to access nearby green spaces.

Before performing the accessibility analysis, the topological consistency of the road network dataset was evaluated. Because OSM is a crowdsourced geographic database, variations in mapping practices and volunteer contributions may introduce topological errors such as disconnected segments, incomplete intersections, or missing links within the network. Ensuring topological consistency is essential for network analysis because routing algorithms require a properly connected network structure to calculate valid shortest paths. This evaluation examined the road network's spatial continuity and connectivity across the study area to ensure the dataset adequately represents the transportation infrastructure used for pedestrian movement.

The assessment involved visually inspecting the spatial distribution and connectivity of road segments across Jakarta. Areas with dense urban development were expected to have correspondingly dense road networks. The evaluation confirmed that the OSM road dataset provides continuous, well-connected coverage

across Jakarta's five municipalities, indicating that the dataset is sufficiently reliable for network-based accessibility analysis.

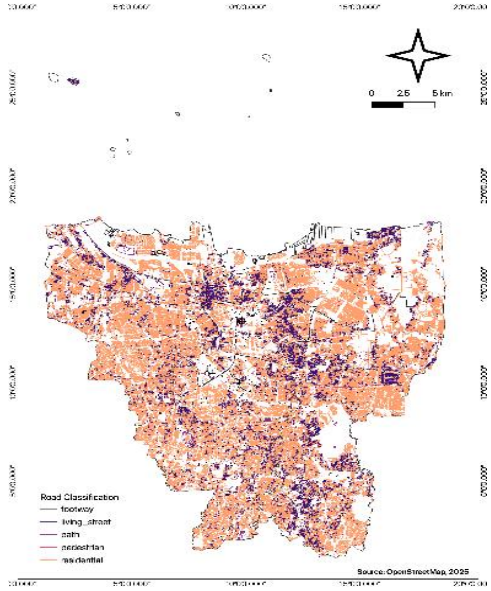


Figure 2. Openstreetmap Residential Roads and Paths Distribution

Following the validation process, accessibility to green spaces was calculated using the QNEAT3 plugin in QGIS, specifically the Origin–Destination (OD) Matrix from Layers as Table tool. In this analysis, origin points represent the centroids of grid cells containing children population values, while destination hubs represent green space locations derived from the OSM dataset. The algorithm computes the shortest path distance along the road network between each origin point and the nearest green space.

The resulting distances represent the minimum travel distance children in each grid cell must travel to reach the nearest green space through the available pedestrian network. These accessibility distances were then incorporated as one variable in calculating the Children Green Space Vulnerability Index.

2.3.4. Children Green Open Space Vulnerability Index

To identify areas where children may experience limited access to urban green spaces, a Children Green Open Space Vulnerability Index was developed by integrating two spatial indicators: children population distribution and accessibility to green spaces. In this study, vulnerability reflects the interaction between population exposure and limited environmental accessibility. Areas with higher child concentrations and longer travel distances to green spaces show greater vulnerability in accessing recreational and environmental resources.

The children population values obtained from zonal statistics were classified into several categories representing the level of population concentration within each spatial unit. Higher population values indicate greater potential demand for recreational green spaces. Second, the network-analysis-derived accessibility distances were classified into accessibility levels. Shorter distances indicate better accessibility to green spaces, while longer distances indicate limited accessibility.

The vulnerability index was then calculated by combining the classified children population values with the accessibility distance values. Conceptually, the vulnerability index can be expressed as Eq. (1).

$$V = P\ x\ A \qquad \text{Eq. (1)}$$

where :
V represents the vulnerability index
P represents the level of children population concentration
A represents the accessibility limitation based on network distance to green spaces

Higher index values indicate locations where many children coincide with limited access to green spaces. The resulting index values were classified into four vulnerability categories using natural breaks (Jenks), classified as Low vulnerability, Moderate vulnerability, High vulnerability, and Very high vulnerability.

This classification highlights spatial disparities in green space accessibility for children across Jakarta and identifies areas where planning interventions may be needed to improve equitable access to urban environmental infrastructure. The final vulnerability map shows the spatial interaction between population distribution and environmental accessibility and provides a basis for identifying priority areas for green space development.

3. RESULT AND DISCUSSION

3.1 Spatial Distribution of Children Population

The spatial distribution of children under five in Jakarta reveals heterogeneous patterns across the metropolitan area (Figure 1). This heterogeneity is also evident between municipalities: the mean WorldPop under-five population per grid cell ranged from 69.25 in North Jakarta (the lowest) to 110.87 in West Jakarta (the highest). Higher concentrations of children are primarily located in residential areas with dense housing development, particularly in East Jakarta, West Jakarta, and South Jakarta. These areas feature extensive residential neighborhoods that accommodate a large share of Jakarta's population. In contrast, children are less concentrated in North Jakarta and Central Jakarta [confirm Central Jakarta's mean value], the latter probably because its dominant land use is commercial and administrative. Earlier work on Jakarta similarly reports insufficient open space for children, with commercial spaces such as malls serving as common activity settings (Aji et al., 2016).

Comparable mismatches between public green spaces and high-density residential areas have been reported elsewhere in Indonesia, leading to inequitable access (Kurniawan & Roychansyah, 2023). Understanding the spatial distribution of children matters because areas with more young residents need greater access to safe outdoor environments, including parks and recreational spaces (Nordbø et al., 2019). Because municipal means summarize many grid cells, they mask variation within municipalities, so the subsequent analysis operates at the grid-cell scale. Likewise, because these values derive from modeled gridded estimates rather than enumerated counts, they approximate relative concentration rather than exact numbers of children. Taken together, these patterns indicate that green-space accessibility should be assessed against where young children live, rather than against municipality-wide population totals alone.

From a spatial planning perspective, the concentration of children under five represents an important indicator of potential demand for child-oriented public space. However, a high concentration of children should not be interpreted as evidence of inadequate green space provision on its own. Instead, it needs to be examined in relation to the location and accessibility of existing green spaces. This distinction justifies integrating child population distribution with network-based accessibility in the subsequent analysis. By considering both components, the study moves beyond identifying where young children live to examine whether the spatial arrangement of mapped green spaces corresponds to their potential residential demand.

This population-based perspective matters for child-sensitive planning because the location of public amenities relative to residential areas can shape the practical opportunities available to young children and their caregivers. Nevertheless, the present analysis uses population concentration as a proxy for potential demand and does not directly measure children's park use, travel behavior, or household preferences. Therefore, consider these dimensions when interpreting the results and translating population patterns into green space planning priorities.

3.2 Accessibility to Green Spaces

The accessibility analysis shows significant spatial variation in access to green spaces across Jakarta. Based on QNEAT3 shortest-path network distances from each analysis grid cell to the nearest mapped green space, Central Jakarta and South Jakarta had the shortest mean distances, 212.16 m and 221.05 m, respectively. In contrast, the mean distances were greater in West Jakarta (287.25 m), East Jakarta (282.62 m), and North Jakarta (375.87 m). The median network distances followed a similar pattern, ranging from 183.99 m in Central Jakarta to 301.31 m in North Jakarta. Maximum distances reached 750.41 m in Central Jakarta, 770.80 m in South Jakarta, 1,620.87 m in West Jakarta, 1,399.06 m in East Jakarta, and 1,432.72 m in North Jakarta. These results indicate that, although some grid cells are located relatively close to mapped green spaces, substantial local variations in network distance remain within several municipalities.

To assess accessibility relative to the spatial distribution of children under five, we calculated the estimated population-weighted proportions within 400 m and 500 m of the nearest mapped

green space using WorldPop population values aggregated within each grid cell. At the 500 m threshold, the estimated proportions were 95.81% in Central Jakarta, 95.87% in South Jakarta, 90.97% in West Jakarta, 91.16% in East Jakarta, and 79.99% in North Jakarta. When the threshold was reduced to 400 m, these proportions declined to 89.78%, 89.99%, 82.76%, 84.04%, and 71.10%, respectively. North Jakarta therefore had the lowest estimated population share within both distance thresholds, with approximately one-fifth of its estimated under-five population located in grid cells more than 500 m from the nearest mapped green space.

These findings highlight the uneven distribution of urban green spaces within Jakarta. According to Dunton et al. (2014), although children's use of neighborhood parks was generally low, it increased substantially when parks were closer to children's homes and had greater vegetation density. The network-distance results align with the importance of proximity to children's potential access to green spaces, although this analysis measures spatial proximity rather than actual park use. The comparatively longer distances observed in North Jakarta indicate that proximity-based accessibility may be more constrained there than in other municipalities. West and East Jakarta also show large maximum network distances, suggesting that municipality-wide averages can mask locations with limited proximity to mapped green spaces.

Our finding highlights the uneven distribution of urban green spaces within Jakarta. Furthermore, children living in high-density informal settlements face compounded vulnerability because they lack local recreational zones, forcing them to rely on precarious public infrastructure (Simanjuntak et al., 2022). This spatial inequity is further underscored by Jakarta's current green space provision, which declined to approximately 5.31% by 2019 and falls significantly short of the 30% mandate required by national spatial planning legislation (Soemarko et al., 2023). This policy gap is compounded by the fact that even existing facilities often fail to meet the full range of needs for child-friendly infrastructure, such as adequate playgrounds and secure recreational environments. Nevertheless, the present network-distance analysis does not independently establish the absence of green spaces in informal settlements or determine whether mapped spaces provide safe, inclusive, and child-appropriate facilities. Such conditions require additional spatial or field-based assessment. The 400 m and 500 m thresholds should therefore be interpreted as analytical scenarios for comparing proximity patterns, rather than universal standards for accessibility among children under five.

3.3 Spatial Vulnerability of Children to Green Space Accessibility

The spatial vulnerability map (Figure 3) illustrates the interaction between children population concentration and accessibility to green open spaces across Jakarta. Vulnerability reflects areas where high child population density coincides with limited access to nearby green spaces. Locations classified as very high vulnerability therefore represent areas where children face the greatest constraints in accessing recreational environments.

The results reveal clear spatial disparities in green space accessibility across Jakarta. While many spatial units fall within the moderate vulnerability category, several clusters of high and very high vulnerability appear across the city. These patterns indicate that the spatial distribution of green spaces does not always correspond with the distribution of the child population.

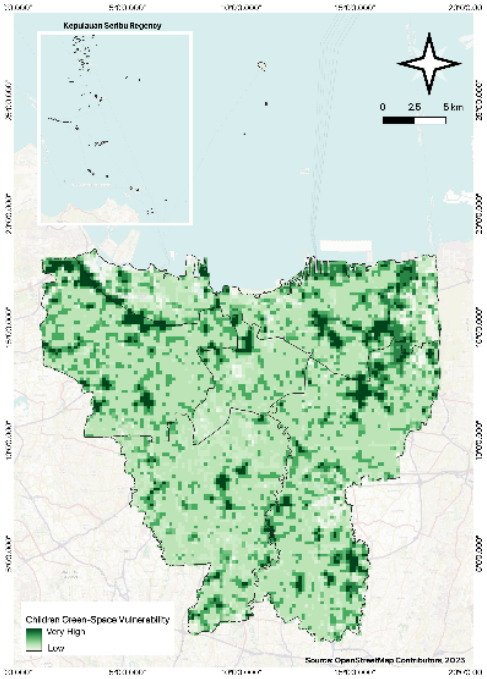


Figure 3. Spatial Vulnerability Map

Table 1 shows the proportion of vulnerability levels for each municipality. North Jakarta has the highest proportion of very high vulnerability areas (16.23%), likely reflecting limited green space availability and high population density in coastal and industrial districts. East Jakarta also shows relatively high vulnerability, with 21.40% of areas classified as high vulnerability and 8.40% as very high vulnerability. Rapid residential expansion in this municipality may have increased population concentration without proportional development of green infrastructure.

Table 1. Percentage of vulnerability by municipality

City	Low	Moderate	High	Very High
Central Jakarta	5.37%	73.39%	17.43%	3.80%
South Jakarta	4.01%	74.27%	17.88%	3.84%
West Jakarta	2.33%	63.85%	24.83	8.99%
East Jakarta	6.05%	64.14%	21.40%	8.40%
North Jakarta	9.33%	50.54%	23.90%	16.23%

In contrast, Central Jakarta has the lowest proportion of very high vulnerability areas (3.80%), which may reflect the presence of several established urban parks despite its dense urban environment. South Jakarta and West Jakarta show moderate patterns, with most areas in the moderate vulnerability category, indicating that green spaces are relatively accessible but unevenly distributed across neighborhoods.

These findings highlight spatial inequality in green space accessibility across Jakarta. Areas with high population densities do not necessarily receive a proportional share of green open space, resulting in unequal environmental benefits for urban residents. Competing land uses such as commercial, industrial, and transportation infrastructure often intensify this imbalance by limiting opportunities for green space development. A comparable planning constraint emerged in Bandung, where land availability was reported as a major obstacle to more evenly distributing thematic parks (Widyahantari & Rudiarto, 2018). Although this evidence comes from another Indonesian city, it illustrates how competition for urban land can constrain the spatial distribution of public green spaces.

Green space accessibility also depends on the quality of pedestrian connections, not proximity alone. Cahyono and Suwandono (2021), in their study of green-space connectivity in Semarang, highlighted the importance of safe, comfortable, and shaded pedestrian routes connecting parks. Improving the proximity of green spaces to residential areas and enhancing pedestrian connectivity are therefore essential to reduce accessibility gaps and support healthier urban environments.

3.4 Planning Implications

The vulnerability map provides valuable insights for urban planners and policymakers. Prioritize areas classified as high and very high vulnerability for green space development, following the verification steps described below. Potential interventions may include developing neighborhood parks, converting vacant land into pocket parks, and improving pedestrian access to existing parks (Gorrell et al., 2023; Rostang et al., 2021; Zhang et al., 2022). In densely populated urban neighborhoods, where acquiring large parcels for new parks may be difficult, screening vacant or underutilized land could help identify feasible locations for small-scale green spaces. Dewi and Mussadun (2024), demonstrated an approach to identifying potential pocket-park locations in Central Semarang using spatial criteria that included vacant-land availability, population characteristics, and surrounding land use. This provides a practical planning precedent for evaluating potential sites, although local assessment would be required to determine the suitability of individual sites in Jakarta.

The results support a spatially targeted and tiered planning strategy. As a first priority, local verification should be conducted for spatial units

classified as very highly vulnerable, particularly those in North Jakarta, to confirm whether the mapped green spaces, street-network connections, and residential conditions accurately reflect on-the-ground access. This verification should assess the presence and suitability of nearby green spaces, pedestrian connectivity, road-crossing conditions, and facilities appropriate for young children. Locations confirmed to have substantial access constraints can then be evaluated for targeted interventions, including improving routes to existing parks, upgrading neighborhood green spaces, or developing small-scale green spaces where land availability and feasibility permit.

Second, include high-vulnerability locations in North Jakarta, West Jakarta, and East Jakarta in a secondary intervention tier. West Jakarta has the highest proportion of high-vulnerability areas (24.83%), followed by North Jakarta (23.90%) and East Jakarta (21.40%). These findings indicate that policy prioritization should consider both the very high and high categories, rather than focusing exclusively on the single municipality with the largest proportion of very high vulnerability. Local authorities should compare the mapped priority areas with land availability, the distribution of existing public green spaces, population needs, and planned infrastructure investments before selecting specific sites.

Third, monitor implementation using measurable indicators. Appropriate indicators include the number and proportion of priority locations field-verified, changes in network distance to the nearest suitable green space, the number of high- and very-high-vulnerability spatial units before and after interventions, and the estimated number of children under five living in areas that meet a locally adopted accessibility target. Calculate baseline values before interventions are implemented, and set targets by the relevant planning authorities according to local conditions. This would make the vulnerability map useful not only for identifying priorities, but also for tracking subsequent changes in spatial accessibility.

Fourth, the assessment and design of interventions should include community participation. Consulting caregivers and local residents can help identify barriers that geospatial data alone cannot capture, such as unsafe crossings, restricted access, inadequate playground facilities, or maintenance problems. This matters because a shorter network distance does not automatically mean a green space is safe, suitable, or usable for young children.

By integrating spatial analysis into urban planning processes, decision-makers can identify priority locations for green infrastructure investments. These efforts can support progress toward Sustainable Development Goal 11.7, which emphasizes universal access to safe, inclusive, and accessible green and public spaces (Pattanakiat et al., 2024). By explicitly addressing the needs of a vulnerable group, the vulnerability map can also help prioritize new parks, improve existing green spaces, and distribute urban amenities more equitably (Alderton et al., 2022; Elderbrock et al., 2024; Fernandes et al., 2023).

Regarding SDG Target 11.7, the proposed framework contributes in three specific ways. First, it supports a spatial assessment of green space access in relation to where young children live. Second, it reveals differences in how vulnerability categories are distributed across Jakarta's municipalities, helping identify locations that warrant further investigation. Third, it provides a screening tool that can inform the prioritization of new or improved green spaces and associated pedestrian connections. These contributions should be understood as support for planning and monitoring, rather than evidence that the city already meets the target's broader requirements for safe, inclusive, and accessible public spaces. Assessing progress toward those requirements would also require data on safety, inclusivity, quality, and actual use.

Taken together, identifying high-vulnerability concentrations in North, West, and East Jakarta suggests that the challenge is not merely green space availability, but also equitable access for vulnerable groups. Integrating geospatial datasets with vulnerability measures provides a strategic basis for targeted interventions that enhance inclusiveness and accessibility, particularly for children, to support social justice in urban public space planning.

4. CONCLUSION

This study assessed the spatial vulnerability of children under five years old to limited access to urban green spaces in Jakarta by integrating age-specific population estimates from WorldPop with green space locations and network-based accessibility analysis using OpenStreetMap (OSM). The resulting Children Green Open Space Vulnerability Index combines the spatial concentration of young children with shortest-path distances to the nearest mapped green space to identify areas where potential demand for green spaces coincides with greater spatial access constraints.

The results reveal spatial disparities in children's access to green spaces across Jakarta. Moderate vulnerability was the predominant category, while clusters of high and very high vulnerability were identified particularly in North Jakarta, West Jakarta, and East Jakarta. North Jakarta had the highest proportion of areas classified as very highly vulnerable, at 16.23%. These patterns indicate that the spatial distribution of children and their network distance to mapped green spaces do not always align, highlighting areas that warrant further investigation and planning attention.

The study's main contribution is an integrated, child-focused spatial screening framework that combines age-specific population concentration with network-based accessibility limitations. Rather than examining population distribution and green space accessibility separately, the framework identifies locations where high potential demand from young children coincides with longer network distances to mapped green spaces. Its application in Jakarta shows how open geospatial datasets can identify intra-urban disparities and inform the spatial prioritization of green space planning interventions. Interpret the resulting index as a relative spatial screening indicator rather than a comprehensive measure of children's social vulnerability or actual access to and use of green spaces.

Beyond recreation, urban green spaces can help regulate microclimates and support climate adaptation. Future research should therefore incorporate additional dimensions of accessibility and environmental quality, including green space size and quality, vegetation density, pedestrian infrastructure, walking conditions, and travel time. Integrating environmental indicators such as land surface temperature and urban heat island intensity could further clarify how green space accessibility intersects with urban environmental stress.

Overall, this study provides spatial evidence to support more child-sensitive and equitable green space planning in Jakarta. By identifying areas where concentrations of young children coincide with greater network-based access constraints, the proposed framework can help guide further local assessment and the prioritization of interventions. This approach aligns with Sustainable Development Goal (SDG) 11.7, which calls for universal access to safe, inclusive, and accessible green and public spaces, while recognizing that additional indicators are needed to assess safety, inclusivity, quality, and actual use.

5. ACKNOWLEDGMENT

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