Journal of Geographical Sciences and Education, Vol. 04, No.3 (2026)

eISSN: 3031-9471 | pISSN: 3032-7245 | DOI: 10.69606/geography.v4i3.543

Pubsains

Journal of Geographical Sciences and Education

https://journal.pubsains.com/index.php/jgs

[Research Article]

Assessing Urban Service Accessibility through Building Density Analysis in Mampang Prapatan District, South Jakarta

Dian Nugraheni[1,*], Muhammad Rafi Devrian[1], Tasya Nabila[1], Anisa Nabila Rizki Ramadhani[1], Vella Ahalla Hulaifah Somantri[2]

[1]*Study Program in Surveying and Geospatial Information, Faculty of Social Sciences Education, Universitas Pendidikan Indonesia, Bandung, Indonesia*
[2]*Geospatial Division, PT Barrakusuma Spatial Teknologi, South Jakarta, Indonesia*
[*]*Correspondence*: diannugraheni03@gmail.com

Article Info:

Received:
9 June 2026

Accepted:
1 August 2026

Published:
1 September 2026

Keywords:
urban services; accesibility; population desinty.

Abstract

Rapid densification in Jakarta has increased pressure on basic urban services and raised concerns about whether high-density neighborhoods enjoy adequate walking access to health, economic, and transport services in Mampang Prapatan District. This study aims to assess this accessibility by combining open building footprints, a simple population estimation method, and network-based accessibility analysis. Building footprints from Google Open Buildings were used to approximate the number of residents per 500 × 500 m grid cell, assuming an average of four inhabitants per residential building. Points of interest for health facilities, small-scale economic activities, and public transport stops were collected from Google Maps, and walking times along the OpenStreetMap street network were calculated using a closest-facility analysis. Each grid cell was classified into one of five accessibility classes—Very Low, Low, Moderate, High, and Very High, and a composite accessibility index was constructed to summarize combined access to all three service types. The results show that most high-density grid cells in the central and north-eastern parts of the district fall into the Moderate, High, or Very High classes, together accounting for 69% of the study area and indicating relatively compact and walkable access to key services. In contrast, 31% of grid cells, concentrated in the southern and south-western areas, remain in the Low or Very Low classes, revealing clear spatial inequalities in access to pedestrian links. The approach is straightforward to implement with open data and can support local planning efforts aimed at promoting more equitable, walkable, and low-carbon urban development.

Informasi Artikel:

Diterima:
9 Juni 2026

Disetujui:
1 Agustus 2026

Dipublikasi:
1 September 2026

Abstrak

Densifikasi yang cepat di Jakarta telah meningkatkan tekanan terhadap layanan dasar perkotaan dan menimbulkan keprihatinan tentang apakah lingkungan berpadatan tinggi memiliki akses jalan kaki yang memadai ke layanan kesehatan, ekonomi, dan transportasi di Kecamatan Mampang Prapatan. Penelitian ini bertujuan untuk menilai aksesibilitas tersebut dengan mengombinasikan open building footprints, metode estimasi populasi sederhana, dan analisis aksesibilitas berbasis jaringan. Building footprints dari Google Open Buildings digunakan untuk mengestimasi jumlah penduduk per sel kisi 500 × 500 m, dengan mengasumsikan rata-rata empat jiwa per bangunan tempat tinggal. Points of interest untuk fasilitas kesehatan, kegiatan ekonomi skala kecil, dan pemberhentian transportasi umum dikumpulkan dari Google Maps, dan waktu tempuh berjalan kaki di sepanjang jaringan jalan

Kata kunci:
layanan perkotaan; aksesibilitas; kepadatan penduduk

OpenStreetMap dihitung menggunakan analisis closest-facility. Setiap sel kisi diklasifikasikan ke dalam salah satu dari lima kelas aksesibilitas, yaitu Sangat Rendah, Rendah, Sedang, Tinggi, dan Sangat Tinggi, serta indeks aksesibilitas komposit disusun untuk merangkum akses gabungan ke ketiga jenis layanan tersebut. Hasil penelitian menunjukkan bahwa sebagian besar sel kisi berpadatan tinggi di bagian tengah dan timur laut kecamatan masuk ke dalam kelas Sedang, Tinggi, atau Sangat Tinggi, yang secara akumulatif mencakup 69% dari wilayah studi dan menunjukkan akses yang relatif kompak serta dapat dijangkau dengan berjalan kaki ke layanan-layanan utama. Sebaliknya, 31% sel kisi yang terkonsentrasi di wilayah selatan dan barat daya berada pada kelas Rendah atau Sangat Rendah, yang mengungkapkan adanya ketimpangan spasial yang jelas dalam akses ke jalur pejalan kaki. Pendekatan ini mudah diimplementasikan dengan data terbuka dan dapat mendukung upaya perencanaan lokal yang bertujuan mempromosikan pembangunan perkotaan yang lebih berkeadilan, ramah pejalan kaki, dan rendah karbon.

INTRODUCTION

Indonesia is an archipelagic country with the fourth-largest population in the world, undergoing rapid transformation toward an urban society. By 2024, approximately 59% of Indonesia's population lived in urban areas, with the highest population density and growth concentrated on the island of Java, which hosts ±55.9% of the national population (World Bank, 2024). The Special Capital Region of Jakarta represents a major metropolitan center with a population density projected to reach ±16,155 people/km² in 2025, reflecting intense spatial activity and high demand for public services (Badan Pusat Statistik Provinsi DKI Jakarta, 2025). Nationally, the estimated population density will reach ±156 people/km², confirming increasing spatial pressure on urban infrastructure and basic services (Worldmeter, 2024).

Population concentration poses fundamental challenges to the availability, affordability, and equitable distribution of public services across social, economic, educational, and transportation sectors. In South Jakarta, this challenge is particularly visible in Mampang Prapatan, where population density reaches approximately ±15,424 people/km² (Badan Pusat Statistik Provinsi DKI Jakarta, 2023), several times the national average. This concentration exerts sustained pressure on the district's health, economic, and transport facilities relative to their limited spatial coverage. Localized imbalances of this nature mirror a broader pattern documented across Indonesian cities, where urbanization outpaces improvements in the coverage and quality of essential public services (World Bank, 2019).

Rapid urbanization in large cities complicates the delivery of accessible public services to residents. Accessibility to urban infrastructure such as public transportation, health facilities, education, and basic services is heavily influenced by building density patterns. Building density analysis serves as a key tool for evaluating how the spatial distribution of structures facilitates or hinders service accessibility. High density in city centers can enhance transportation efficiency, yet it frequently causes localized congestion and physical accessibility barriers for vulnerable groups, including persons with disabilities and the elderly (Obregón-Biosca et al., 2016). Mampang Prapatan subdistrict serves as a clear illustration of this tension, encompassing a total area of ±7.73 km² divided into five urban villages: Bangka, Pela Mampang, Tegal Parang, Mampang Prapatan, and Kuningan Barat. The subdistrict hosts two of South Jakarta's most intensively used corridors: the Kemang commercial and lifestyle district in Bangka, and the Kuningan central business district bordering Kuningan Barat to the north. Agglomeration of commercial functions in Kemang and office-based activities in Kuningan concentrates population movement and service demand along connecting corridors (Badan Pusat Statistik Kota Jakarta Selatan, 2024), making the subdistrict a well-bounded case for testing building-level accessibility methods within a mixed-use urban fabric.

Beyond commercial intensity, Mampang Prapatan maintains high residential density that drives service demand at a finer spatial scale than administrative statistics typically capture. Conventional demographic data in Indonesia are reported at the subdistrict or urban-village level, masking critical internal variations between dense residential blocks and adjacent commercial strips with few residents. Traditional census-based approaches lack the building-level spatial resolution needed to link population pressure directly to nearby service infrastructure. Bottom-up, building-footprint-based population estimation provides a more granular alternative for accessibility analysis in mixed-use districts.

Spatial growth and building concentration determine how residents access essential services in urban environments. In high-density residential and commercial corridors such as Kemang and Kuningan, physical density creates spatial proximity and potential travel efficiency, while simultaneously inducing localized congestion, pedestrian bottlenecks, and access barriers for vulnerable groups. Built-environment travel literature demonstrates that destination accessibility and road network design are primary determinants of travel behavior, meaning building density and connectivity patterns directly govern service reachability beyond simple geometric distance (Ewing & Cervero, 2010).

Frameworks such as the 15-minute city concept rest on this principle, asserting that managed density combined with connected, mixed land uses allows daily needs to be met within a 5-to-15-minute walk or bicycle ride (Moreno et al., 2021). Operationalizing this concept in Jakarta involves distinct local challenges: dense informal settlements featuring narrow, irregular street networks, sidewalks that are frequently limited, obstructed, or absent, and an urban environment dominated by private motorized vehicles. Walkability constraints require spatial equity and justice to remain central when applying this framework to local contexts. Previous urban accessibility studies in Jakarta relied heavily on macro-level census data bounded by administrative borders, leaving fine-scale spatial variations unaddressed. This study addresses that gap by integrating high-resolution, building-footprint-derived population estimates with Geographic Information System (GIS)-based network accessibility analysis, offering a reproducible workflow applicable to other dense Indonesian districts.

Based on these considerations, this study aims to: 1) map the distribution of building-based population density in relation to public services in Mampang Prapatan, South Jakarta; 2) evaluate walking accessibility to health, education, economic, and transportation facilities using network-based methods, including 5–15-minute travel-time analysis; and 3) identify underserved grid areas where population pressure and service accessibility exhibit severe mismatches. These findings aim to highlight gaps in current service-provision policies using building-level demand metrics and provide data-driven guidance for equitable urban planning and investment.

METHOD

Study Area

The study area encompasses Mampang Prapatan District, located in South Jakarta, Indonesia. Geographically, the district is bordered by Setiabudi to the north, Pancoran to the east, Kebayoran Baru to the west, and Pasar Minggu to the south (Figure 1). Covering approximately 7.73 km^2, Mampang Prapatan represents one of the most densely built urban environments in Jakarta. High land-use intensity across the district manifests as a complex spatial mixture of residential, commercial, and institutional functions, characteristic of rapidly urbanizing metropolises. Demographic records from Badan Pusat Statistik Kota Jakarta Selatan (2024) indicate that Mampang Prapatan accommodates approximately 152,437 inhabitants, generating elevated population density that exerts substantial pressure on spatial land availability and local public infrastructure.

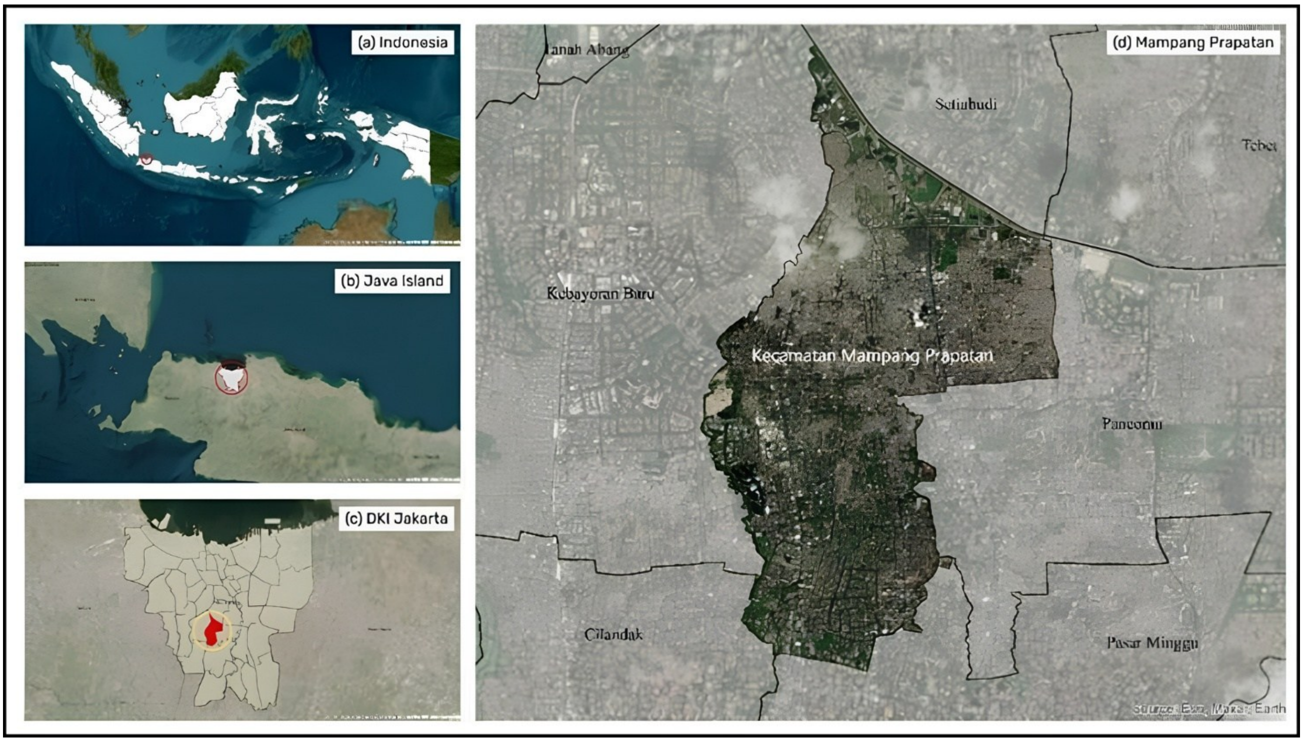

Figure 1. Area of Interest

Types and Sources of Data

This study integrates three main spatial datasets: 1) Points of Interest (POI) representing key public service facilities collected from Google Maps; 2) road network data sourced from OpenStreetMap (OSM) in 2024; and 3) building footprint polygons retrieved from Google Open Buildings and processed through Google Earth Engine (GEE). Demographic data from Badan Pusat Statistik Provinsi DKI Jakarta (2021) complement these layers to support household-based population estimations. All spatial datasets were standardized to the WGS 84 coordinate reference system (EPSG:4326) to ensure spatial compatibility across analytical procedures.

Data Collection Techniques

Collection of Points of Interest Data

The spatial dataset constructed for this study consists of POIs representing key public service facilities, encompassing transportation nodes, health services, educational institutions, and economic activity centers. Primary POI data were gathered using a structured web-scraping workflow on Google Maps, enabling spatial extraction of facility coordinates, site names, spatial categories, and associated operational attributes (Maghfira et al., 2025). Raw POI entries were subjected to systematic preprocessing: duplicate geometry and attribute records were purged, categorical classifications were standardized across facility types, and records containing missing values were resolved through contextual imputation or structured exclusion based on data completeness. Attribute tables were harmonized into a standardized schema capturing facility name, operational type, geographic coordinates, and overarching service sector. All coordinate reference systems were unified under the EPSG:4326 projection to maintain rigorous spatial alignment across analytical layers.

Acquisition of Road Network Data from OpenStreetMap

Road network data were extracted from OSM for the 2024 calendar year, providing vector-based representations of spatial geometry and network connectivity (Wang & Niu, 2018). Raw OSM features were filtered to isolate walkable thoroughfares within the study area boundaries, followed by topological cleaning to repair line segment gaps, harmonize street attribute tables, and establish node connectivity across intersections (Morales et al., 2019). Cleaned vector geometries were transformed into a network dataset with topology suitable for shortest-path algorithm execution. This structured network serves as the analytical foundation for spatial accessibility calculations, incorporating edge impedance parameters such as network distance and walking duration.

Extraction of Building Footprint Data from Google Open Buildings

Building footprint polygons were extracted from the Google Open Buildings dataset (v3, released 2023) and processed through GEE to execute cloud-based vector operations. This dataset provides high-resolution, machine-generated building outlines that support fine-scale population estimation workflows. Initial preprocessing within GEE involved filtering misclassified features, removing minor geometric artifacts, and repairing invalid polygon structures via automated topology operators. The refined building layer was subsequently clipped to the study boundary and exported for local spatial processing. Processed building polygons were intersected with a standardized 500 × 500 meters spatial grid to calculate total building counts per cell, providing the baseline for population density estimations across the district (Wang et al., 2026).

The Google Open Buildings dataset lacks structural land-use attributes to differentiate residential from non-residential buildings. This study applied a uniform conversion heuristic (1 building = 4 residents) across all identified building footprints. In mixed-use zones, nighttime residential population estimates may be upward biased (overestimated). This operational constraint should be considered when evaluating population density patterns and spatial accessibility metrics within commercially dominated grid cells. Future research iterations could integrate land-use classifications such as OpenStreetMap land-use tags or local Detailed Spatial Planning, alongside POI filtering to isolate residential structures prior to population estimation, thereby improving daytime–nighttime demographic differentiation in mixed-use urban contexts.

Data Analysis Techniques

Fishnet Grid

This study employs a regular fishnet grid approach to establish standardized spatial analytical units for evaluating urban service accessibility across Mampang Prapatan District. A uniform spatial grid of 500 × 500 meters was generated using the Create Fishnet tool in ArcGIS Pro, yielding square cells with identical geometry that operate independently of irregular administrative boundaries. Grid-based spatial frameworks enhance analytical consistency and mitigate modifiable areal unit problem biases by partitioning the study domain into homogeneous, comparable analytical units (Ojeda Casares et al., 2024). Each grid cell was assigned a geometric centroid, serving as the representative origin point for population activities within that spatial unit. Centroids function as origin nodes within subsequent network analyses, facilitating calculations of travel distance and duration to nearest service facilities along actual street networks. Integrating grid centroids as origin nodes within accessibility modeling aligns with established methodologies in urban service and transport geography research (Silalahi et al., 2020). Beyond standardizing spatial units, this fishnet structure streamlines the synthesis of population estimates, building footprints, and road network geometries into a unified analytical system.

Population Estimation

A fine-scale demographic representation was constructed by estimating resident counts within each 500 × 500 meters grid cell through building footprint conversions. The calculation framework assumes an average occupancy of four residents per building structure. Demographically, the 2020 Population Census established an average household size of 3.83 persons, justifying a conservative rounding to four residents per structure for subdistrict-level analysis (Badan Pusat Statistik Provinsi DKI Jakarta, 2021). Household-based spatial population disaggregation relies on known structural relationships between residential footprints and resident capacities.

Spatial processing commenced by intersecting the building footprint layer with the fishnet grid matrix, followed by extracting total structural counts per cell. The estimated population for each individual grid cell was derived using the following Equation 1:

$$P_i = N_{buildings} \times 4 \quad (1)$$

where P_i represents the estimated population in grid cell i, and $N_{\text{buildings}}$ represents the total count of detected structural footprints within a given grid unit.

This conversion of structural counts into demographic units aligns conceptually with spatial disaggregation logic utilized in WorldPop frameworks, where population counts are distributed across building units to prevent underrepresenting high-density informal or compact urban developments. Population density was subsequently calculated by dividing the estimated population by the geometric surface area of each grid cell. Given that each cell measures 500 × 500 meters, the unit area (A) equals 0.25 km^2, allowing density metrics to be standardized in terms of persons per square kilometer (people/km^2) using the following Equation 2:

$$D_i = \frac{P_i}{A} \quad (2)$$

where D_i represents the population density of grid cell i, P_i is the estimated population in cell i, and A denotes the grid cell area (A=0.25 km^2).

Standardizing population concentration across uniform grid cells facilitates comparative spatial density modeling and aligns demand weighting with network accessibility analysis. Continuous population density values were converted into a categorical Population Density Index using a four-level classification scheme established in spatial planning literature (Koomen et al., 2023; Zhang et al., 2024). This classification facilitates consistent spatial comparison across the study area. Aligning with Indonesian urban demographic standards, density values were categorized into explicit operational thresholds are Low, Moderate, High, and Very High. These categorical thresholds are summarized in Table 1 below.

Table 1. Population Density Index Categories

Parameter (people/km²)	Class	Category
< 5,000	1	Low
5.000 – 10,000	2	Moderate
10,000 – 15,000	3	High
> 15,000	4	Very High

Source: BPS, 2019.

Network Analysis

Network-based spatial accessibility was evaluated using the Closest Facility solver within the ArcGIS Pro Network Analyst framework, identifying optimal least-cost paths from each grid cell centroid to the nearest public service facility along the street network (Alamri, 2023). Network distance provides a more accurate representation of pedestrian travel behavior than Euclidean distance by incorporating street geometry, connectivity, turning restrictions, and walkable paths.

A routable network topology was built from the refined OSM vector road layer. Preprocessing steps involved topological validation, removal of dangling line segments, definition of travel modes, and configuration of edge impedance values based on network distance in meters. Walking served as the primary mode of travel, aligning with localized short-range mobility patterns characteristic of dense urban environments (Tariverdi et al., 2023). A standardized walking speed of 4.3 km/h (1.2 m/s) was applied to convert network path distances into walking duration metrics, consistent with international pedestrian standards (Bajracharya & Paudyal, 2025). Each grid centroid was snapped to the nearest road network edge using a controlled snapping tolerance of 2 meters. Public service facilities were categorized into functional destination layers—health services, transportation nodes, and economic activity centers, and designated as facility points within the network solver.

Accessibility Index

The accessibility index quantifies pedestrian ease of reachability from each grid centroid to essential public services within reasonable walking thresholds. Network distance was prioritized over straight-line spatial metrics to capture real-world pedestrian movement constrained by the physical street layout (Alam et al., 2025). This approach accounts for micro-scale physical barriers, pedestrian route choices, and network circuity, which strongly influence destination accessibility in compact urban environments.

The closest facility solver in ArcGIS Pro evaluated least-cost network paths between origin centroids and target destinations across three core service domains: health facilities, public transportation nodes, and economic activity centers. Integrating individual travel times across multiple service sectors allow the index to capture fine-scale spatial variations in urban service availability effectively. Similar network-based formulations have been successfully deployed to quantify fine-scale urban service reachability and spatial equity in high-density metropolitan contexts (Alam et al., 2025). The detailed accessibility scores are presented in Table 2 below.

Table 2. Accessibility Score

Distance (m)	Walk Time (minute)	Accessibility	Score
≤ 300	≤ 5	8 – 10	4
300 – 900	5 – 15	5 – 7	3
900 – 1,500	15 – 25	3 – 4	2
> 1,500	> 25	0 – 2	1

Source: Alam et al. 2025.

Multi-Criteria Accessibility Weighting

This study applies a multi-criteria weighting framework combining network-based accessibility, service availability, and population demand indicators to integrate multiple dimensions of accessibility into a single evaluative metric. Five parameters were selected to represent key components of urban accessibility: health accessibility, transportation accessibility, economic accessibility, number of POIs within each grid, and population density (Table 3).

Table 3. Number of Locations

Group	Category	Number of Locations
Economic	Banks, ATMs, Small Shops, Markets	41
Health	Public Hospitals, Pharmacies, Community Centers, Clinics	13
Transportation	Bus Stops and Bus Terminals	46
Economic	Banks, ATMs, Small Shops, Markets	41

Normalized weights were derived by scaling raw importance scores across all evaluated criteria (Arliani et al., 2024). Linear normalization was executed by dividing each parameter score by the total score sum using Equation 3:

$$w_i = \frac{S_i}{\sum_{i=1}^{n} S_i} \tag{3}$$

where w_i represents the normalized weight of parameter i, and S_i denotes the raw importance score assigned to parameter i.

Continuous variables were standardized using triangular or trapezoidal fuzzy membership functions prior to weighting to ensure numerical comparability across distinct spatial criteria. The Composite Accessibility Index (CAI) for each grid cell was subsequently calculated using the Weighted Linear Combination (WLC) formulation using Equation 4:

$$CAI = \sum_{i=1}^{n} w_i \times S_i \tag{4}$$

where w_i corresponds to the normalized weight of parameter i, and S_i represents the standardized fuzzy-scaled score of parameters i. This WLC formulation adheres to standard multi-criteria decision analysis and geographic information systems (MCDA-GIS) protocols (Arliani et al., 2024; Table 4; Figure 2).

Final CAI values were grouped into five distinct classes reflecting relative accessibility performance across the study area to support spatial interpretation (Alamanos & Papaioannou, 2020). Class labels applied throughout comprise Very Low, Low, Moderate, High, and Very High. The classification interpretations are presented in Table 5.

Table 4. Rulebase Weights

Criterion	Symbol	Qualitative Importance	Score	Normalized Weighted
Health accessibility	H	Very important (basic services, equity concern)	5	0.294
Transportation accessibility	T	Important (enable access to all facilities)	4	0.235
Economic accessibility	E	Important (daily commercial and work activities)	3	0.176
POI per grid (urban service richness)	P	Important (reflects functional diversity)	3	0.176
Population density	D	Moderately important (service demand pressure)	2	0.118
		Total	**17**	**1**

Table 5. Accessibility Index Classification

Class	Value Range	Category	Interpretation
5	0.80 – 1.00	Very High	Travel distance and time to facilities/activity nodes are very short, allowing pedestrian mobility to occur optimally without hindering daily activities.
4	0.60 – 0.80	High	Most pedestrian mobility needs can be met with relatively short travel distances, though not as optimal as the Very High class.
3	0.40 – 0.60	Moderate	Pedestrians can still reach facilities, but with greater travel distance and time, causing mobility to be constrained under certain conditions.
2	0.20 – 0.40	Low	Travel distance to facilities is considerable, making pedestrian mobility less efficient and more dependent on other transportation modes.
1	0.00 – 0.20	Very Low	Access to facilities is highly limited, indicating significant barriers to pedestrian mobility in the area.

RESULT AND DISCUSSION

Spatial Distribution of Population Density

The estimated population density across the 500 × 500 meters spatial grid of Mampang Prapatan District (Figure 3). Values derived from Google Open Buildings using the peanut-butter allocation rule range from approximately 1,800 to 24,600 people/km^2, yielding a district-wide mean close to 15,424 people/km^2 (Badan Pusat Statistik Kota Jakarta Selatan, 2024). Very High density (>10,000 people/km^2) is concentrated in the central-to-northeastern grid units, where urban kampung settlements interlock with commercial frontages along Jalan Mampang Prapatan Raya and Jalan Kapten Tendean. A secondary High-density cluster (6,000 - 10,000 people/km^2) extends westward toward the Kemang corridor, reflecting the mixed residential–commercial character of the neighborhood.

Low and Moderate density cells dominate peripheral grid rows in the far north (rows 1–2) and south (rows 10–11). These boundary areas correspond to gated housing developments, embassy compounds, and institutional land-use zones. Densities reported along the Mampang-Kuningan commercial spine reflect an upper-bound estimate rather than precise nighttime population totals, owing to the uniform four-person occupancy assumption that does not differentiate residential from non-residential structures.

Walking Accessibility to Healthcare Facilities

Accessibility was evaluated across 13 health facilities, including public hospitals, community health centers, pharmacies, and private clinics (Figure 4). Approximately 42% of grid cells lie within a 300 meters network distance (≤ 5 minutes walk at 4.3 km/h) of the nearest facility, corresponding to Score 4 in the interpretation scheme adapted from Alam et al. (2025). A further 34% of grids fall within the 300 – 900 meters band (Score 3), while 17% and 7% record walking distances of 900 - 1,500 meters and > 1,500 meters, respectively. High healthcare accessibility clusters around central grid units (D4–E5), where the Mampang Prapatan Puskesmas and several private clinics are co-located along the main arterial corridor. A secondary node emerges near Kemang (grids B5–C5). Northern boundary rows (A1–C2) and southernmost grid cells (D10–E11) exhibit the lowest accessibility scores, requiring residents to traverse more than one kilometer to reach the nearest health facility. Spatial disparity patterns of this nature align with empirical observations documented by Silalahi et al. (2020) and Bajracharya & Paudyal (2025).

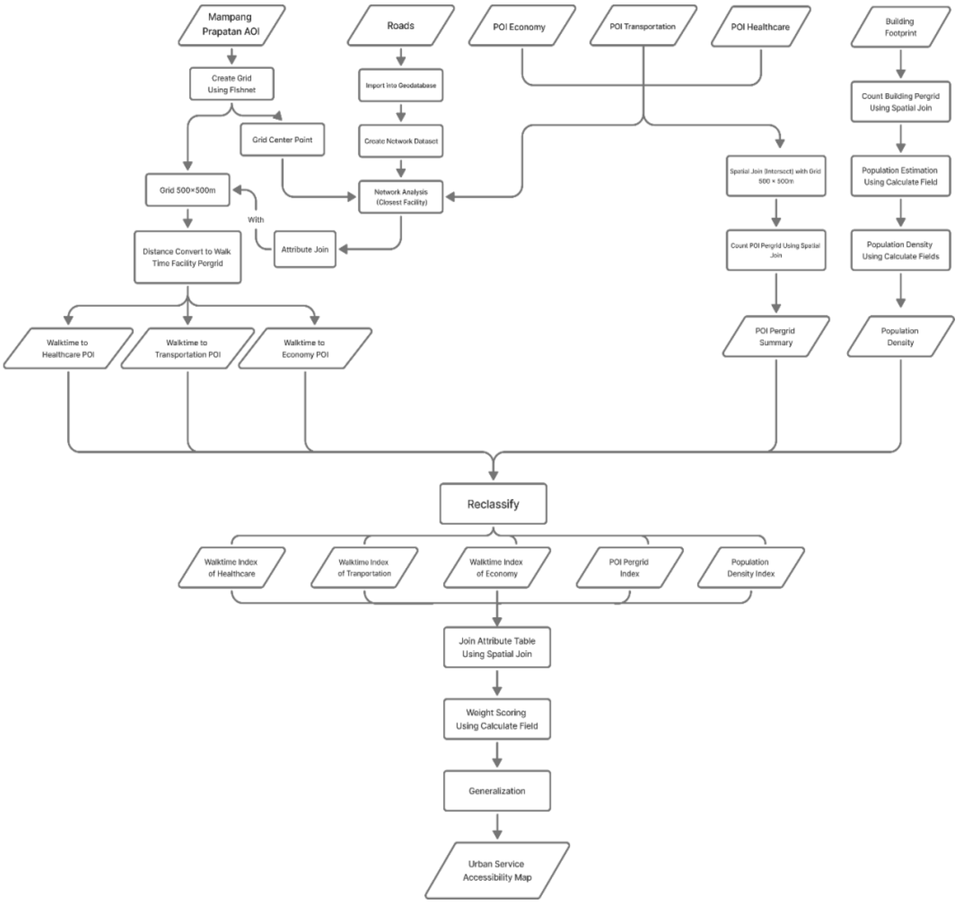

Figure 2. Workflow of the Methodology

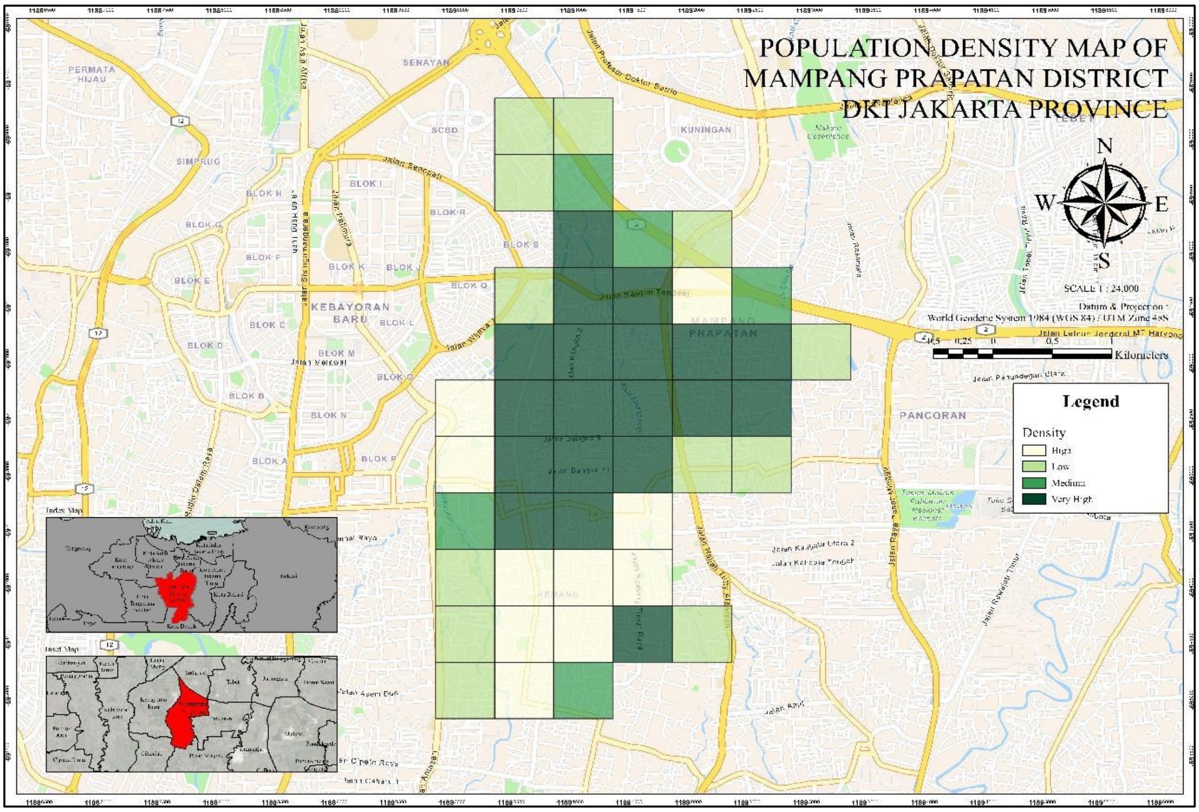

Figure 3. Population Density of Mampang Prapatan District

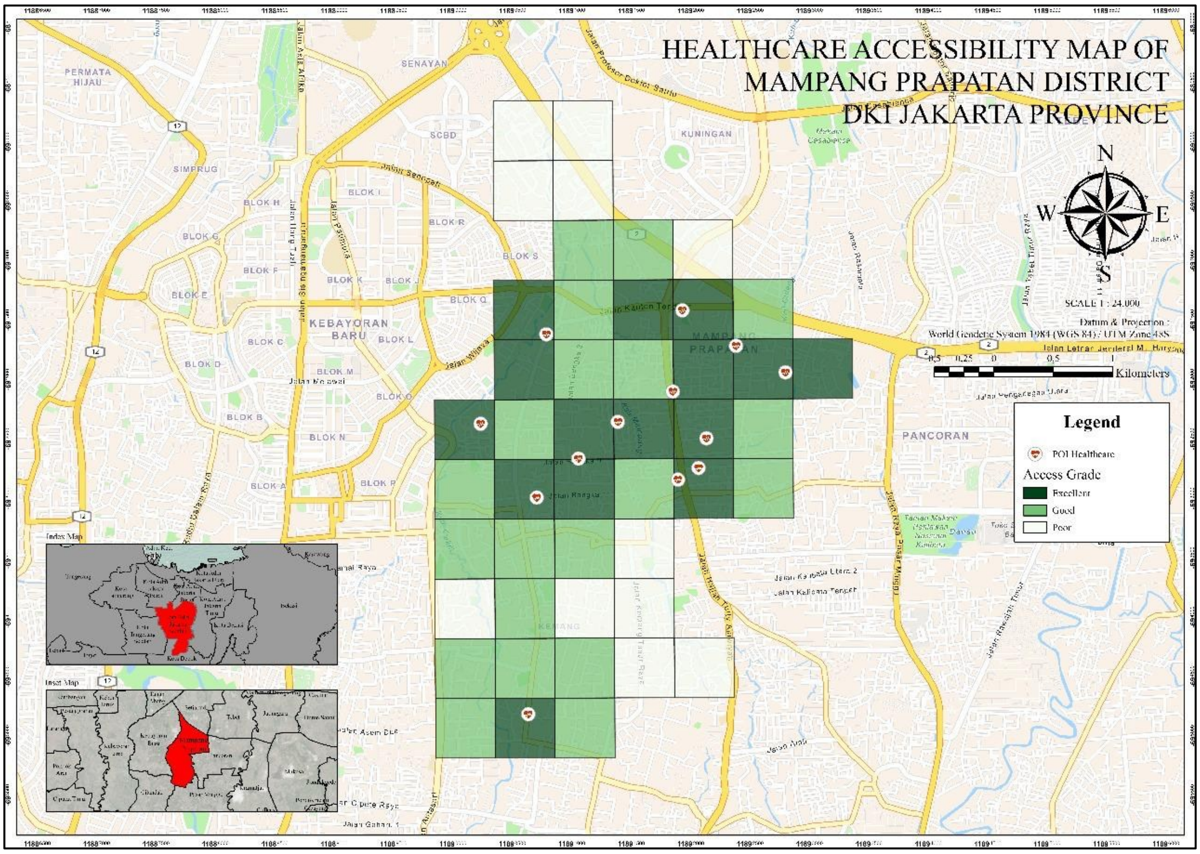

Figure 4. Healthcare Accessibility of Mampang Prapatan District

Walking Accessibility to Economic Services

The economic facility layer incorporates 41 service points, including commercial banks, automated teller machines (ATMs), traditional markets, and neighborhood retail stores (stall and convenience stores; Figure 5). Roughly 58% of grid cells register the highest accessibility score (300 m network distance), whereas only 9% record Score 1 (> 1,500 m). Economic facilities exhibit the most pervasive spatial coverage among the evaluated service domains—an outcome consistent with the dense distribution and fine spatial grain of retail activities characteristic of inner-city Jakarta (Maghfira et al., 2025).

A near-continuous belt of high economic accessibility extends along the Mampang–Kuningan commercial axis and continues westward along Jalan Kemang Raya. Grid units situated within this primary corridor (C4–F5) lie within a 5-minute walk of multiple banking services, ATMs, and retail outlets. Reduced economic accessibility remains confined to peripheral northern grid rows (A1–B2) and isolated grid units along the southern boundary.

Walking Accessibility to Transportation

Accessibility was evaluated against 46 public transport points comprising TransJakarta BRT stations, feeder bus stops, and Mikrotrans/JakLingko pick-up locations (Figure 6). Approximately 49% of grid cells lie within a 5 minute walk of the nearest node (Score 4), while an additional 31% fall within a 15 minute walking radius (Score 3). The remaining 20% of grid cells record walking times exceeding 15 minutes, with 8% categorized under Score 1 (>25 minutes).

Grid cells with high transportation accessibility align closely with the TransJakarta Corridor 6 trunk route along Jalan Mampang Prapatan Raya and feeder network routes serving the Kemang area. High accessibility also extends along Jalan Warung Buncit and Jalan Kapten Tendean. Service gaps are primarily concentrated within dense interior kampung blocks, where fine-grained street networks are fragmented by dead-end alleys, pushing pedestrian distances to the nearest arterial transit stop beyond 900 meters. This spatial disparity aligns with findings by Fan et al. (2024), demonstrating that Euclidean proximity to transit infrastructure does not ensure walkable accessibility when street network connectivity is discontinuous.

Urban Service Accessibility Index

Combining healthcare, economic, and transportation accessibility layers with population density and POI richness using the Weighted Linear Combination (WLC) framework (Malczewski, 2000, 2011; Figure 7) yields the composite accessibility pattern. CAI scores

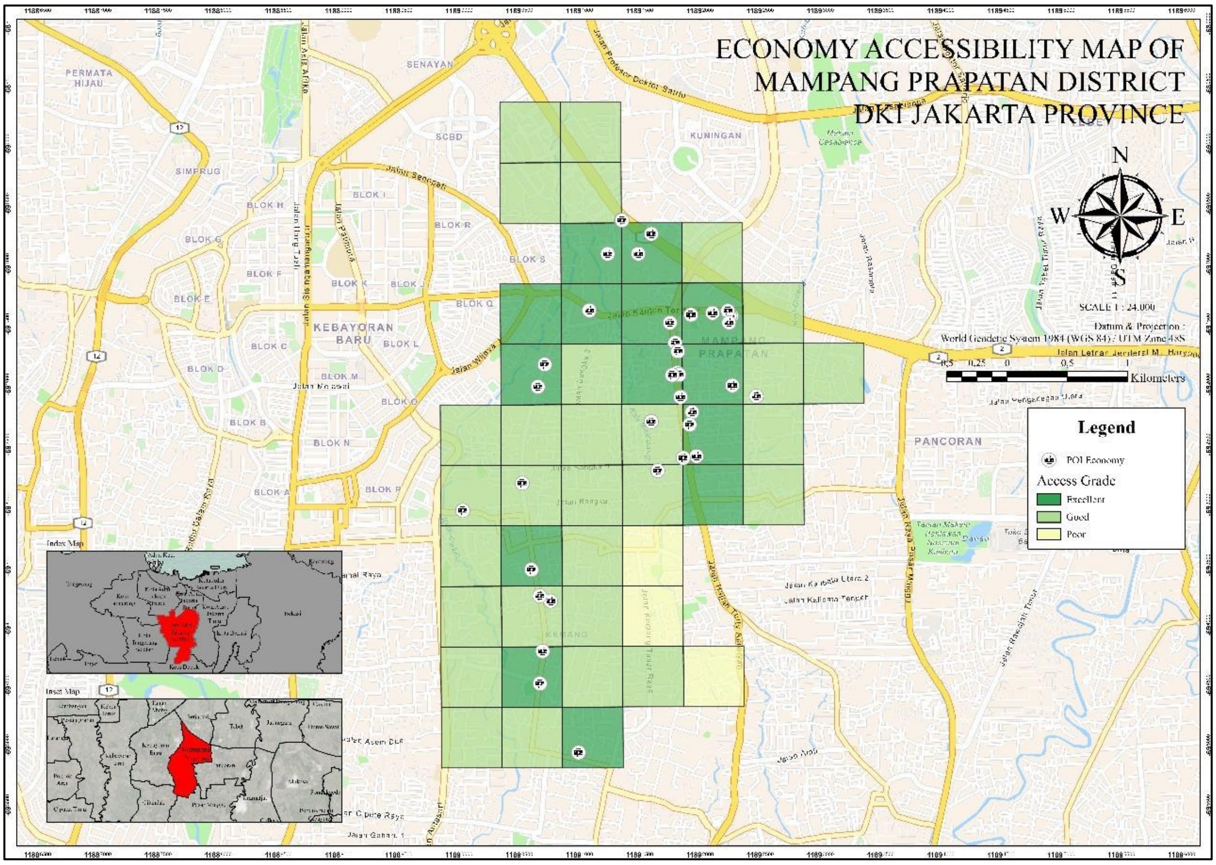

Figure 5. Economy Accessibility of Mampang Prapatan District

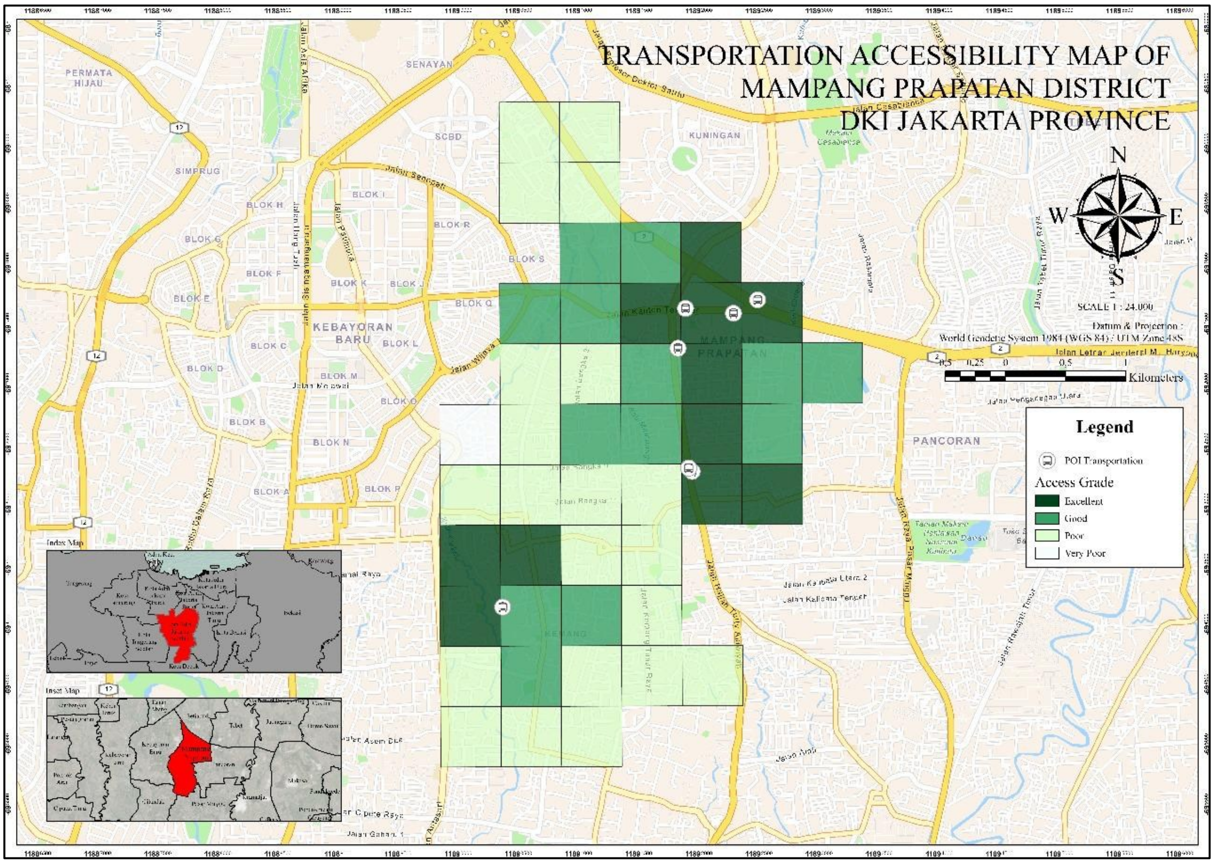

Figure 6. Transportation Accessibility of Mampang Prapatan District

span from 0.00 to 1.00 and are classified into five ordinal performance tiers adapted from Alamanos & Papaioannou (2020).

Grid cell distribution across accessibility tiers indicates that moderate accessibility covers 27% of the district, followed by High (26%), Very High (16%), Low (17%), and Very Low (14%). The upper three tiers collectively represent 69% of the spatial grid, demonstrating that most of Mampang Prapatan benefits from moderate to high walking accessibility to core urban services (Figure 8). However, approximately 31% of grid cells fall below the moderate threshold. The spatial coexistence of well-served and underserved cells within a 7.73 km^2 administrative area highlights pronounced intra-district disparities that aggregated subdistrict-level metrics fail to capture.

Spatial Regimes of Accessibility

A contiguous cluster of Very High CAI values occupies grid units D4, D5, E4, E5, and F5. Grid E4 records the maximum index score (1.00), while the four adjacent cells range between 0.80 and 0.90. This high-accessibility cluster aligns with the Mampang commercial core, where healthcare facilities, commercial banking, retail centers, and TransJakarta transit nodes co-locate along a major arterial corridor. This spatial convergence reinforces the role of primary arterial roads as multi-service attractors within high-density Asian metropolitan contexts (Ewing & Cervero, 2010; Moreno et al., 2021).

Surrounding the central core, a contiguous band of Moderate to High accessibility cells (CAI 0.40–0.60) encompasses grid units C4, C5, F6, G5, and G6. These cells are characterized by mixed residential-commercial land uses located within a 5 to 15-minute walk of the primary cluster. This transitional zone functions as a continuous spatial gradient rather than a discrete boundary: economic and transportation scores remain high, whereas healthcare accessibility declines with increasing distance, consistent with spatial distance-decay effects observed in other dense urban environments (Zhang et al., 2025).

Low and Very Low CAI values are concentrated along the northern and southern peripheries of the district. In the north, grid units A1, B1, C1, and C2 consistently record CAI values near 0.20, driven by reduced healthcare and transportation sub-scores. A similar spatial deficit occurs in the south across grids D10, E10, and E11 (CAI 0.20–0.30). Field verification and land-use data indicate that these underserved cells are dominated by narrow local streets, dead-end alleys inside dense kampung blocks, and gated residential compounds spatial

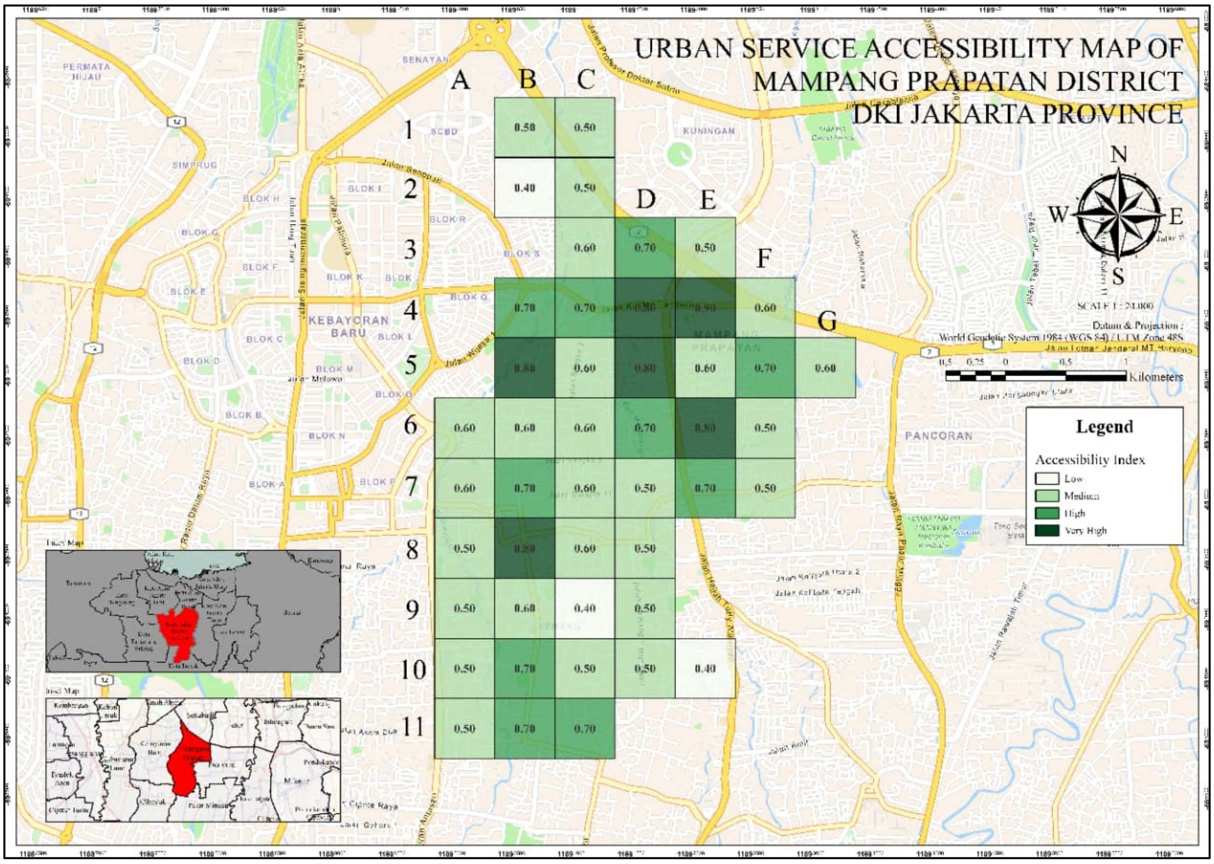

Figure 7. Urban Services of Mampang Prapatan District

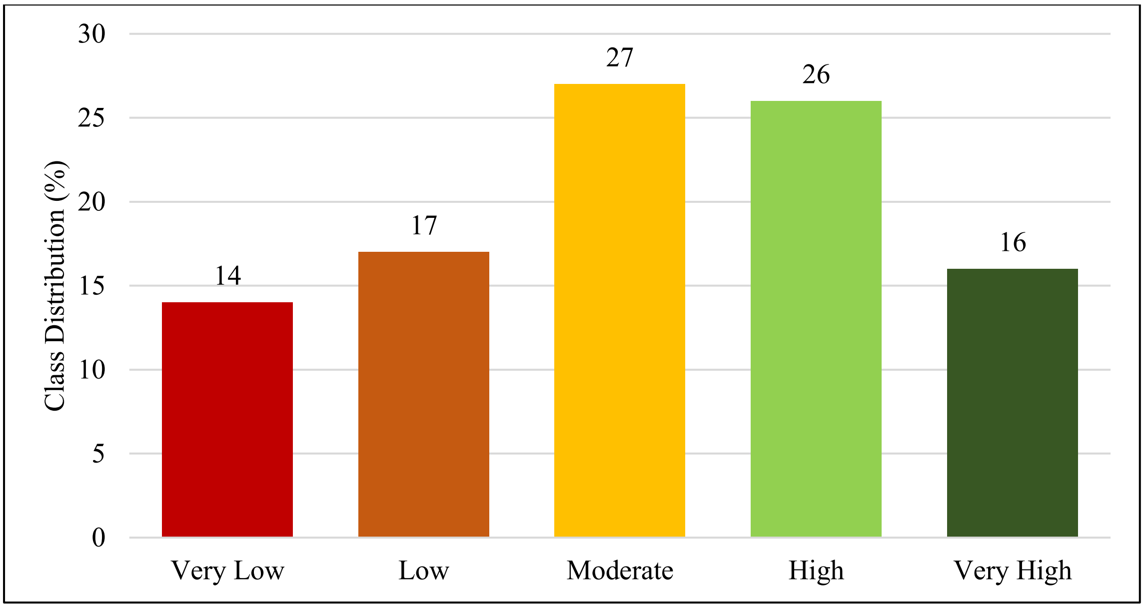

Figure 8. Class Distribution of the Composite Accessibility Index

configurations that increase effective network walking distances to arterial services.

Cross-tabulating the population density index with the CAI reveals a non-trivial spatial equity pattern. Approximately 18% of grid cells classified under High or Very High population density fall simultaneously into Low or Very Low CAI classes. Concentrating within interior northern and southern kampung blocks, these mismatch areas represent high-priority intervention zones combining heavy localized service demand with constrained pedestrian access. Conversely, roughly 6% of grids exhibit Low population density alongside Very High accessibility, reflecting commercial corridor nodes characterized by limited residential populations but abundant service provision.

This spatial divergence underscores the structural limitations of relying on aggregated subdistrict-level metrics. Evaluated strictly at the kecamatan scale, Mampang Prapatan appears well-served with a mean CAI of 0.53 and a median of 0.55. However, fine-scale grid mapping uncovers localized service deficits that administrative averages obscure, corroborating findings by Wang et al. (2026) and Zhang et al. (2025) on the necessity of high-resolution spatial units for exposing concealed accessibility depressions.

The center–periphery accessibility gradient in Mampang Prapatan mirrors spatial patterns documented across dense metropolitan contexts in Asia. Alam et al. (2025) observed a similar concentration of high pedestrian reachability along major arterial roads in Dhaka, accompanied by sharp declines within interior residential blocks. Parallel spatial structures have been documented in Beijing (Zhang et al., 2025) and Hangzhou (Wang et al., 2026), where primary transport nodes generate high-accessibility clusters within heterogenous residential environments. The 69% proportion of grid cells achieving at least moderate accessibility in Mampang Prapatan aligns with the 55–80% coverage range reported in comparable inner-city studies, depending on selected service categories and travel-time thresholds.

These empirical insights highlight three main spatial planning directions. First, service-deficit zones in northern (A1–C2) and southern (D10–E11) boundary grids warrant targeted interventions, including micro-transit feeder loops, mobile health clinics, and multi-use community nodes. Second, high-density, low-accessibility mismatch grids should be prioritized within the upcoming Detailed Spatial Planning revision to align service allocation with localized population demand. Third, infrastructure investments should target internal non-motorized network connectivity inside kampung blocks, where modest footpath improvements of 100–200 meters can substantially shorten effective walking distances to arterial services.

Methodological constraints are consolidated into three explicit considerations. First, population estimates derived via the uniform building allocation rule do not distinguish residential from non-commercial structures, meaning densities along the Mampang–Kuningan commercial spine reflect upper-bound estimates rather than precise nighttime counts. Second, the analysis relies on a static POI dataset from 2024, omitting temporal fluctuations in facility operation. Third, standard walking-time thresholds assume uniform terrain and unhindered movement, potentially underestimating actual pedestrian effort in areas marked by heavy vehicular congestion or degraded sidewalk infrastructure.

CONCLUSION

This study evaluated walking-based accessibility to essential urban services in relation to building configuration and population density in Mampang Prapatan District, South Jakarta. Utilizing a 500 × 500 meters spatial grid, Google Open Buildings footprints, OpenStreetMap network distance calculations, and a multi-criteria weighting scheme, the analysis integrated health, transportation, and small-scale economic service layers into a composite urban service accessibility index.

Spatial patterns across the grid reveal a distinct core–periphery structure. Grid units across central and northeastern sections of the district, where population density remains high, predominantly occupy Moderate, High, and Very High accessibility tiers. These upper tiers collectively encompass 69% of the study area, reflecting favorable baseline pedestrian access to essential services. Conversely, 31% of spatial grid units fall into Low or Very Low accessibility categories, forming contiguous clusters along southern, southeastern, and southwestern boundaries. Several underserved peripheral cells support moderate to high population densities, highlighting a spatial mismatch between localized residential demand and service concentration. The service availability pattern confirms that only a central cluster maintains balanced proximity across all three service domains, whereas peripheral zones encounter persistent service deficits. High built density in Mampang Prapatan does not inherently produce equitable pedestrian access to essential urban functions. The open-data, grid-based analytical framework demonstrated here provides a reproducible method for identifying high-demand, underserved urban neighborhoods across comparable metropolitan contexts.

AUTHOR CONTRIBUTIONS

Dian Nugraheni: conceptualization, methodology, and writing—original draft preparation; **Muhammad Rafi Devrian**: data curation, formal analysis, and software; **Tasya Nabila**: investigation, visualization, and writing—review and editing; **Anisa Nabila Rizki Ramadhani**: formal analysis; **Vella Ahalla Hulaifah Somantri**: supervisor. All authors have read and agreed to the published version of the manuscript.

FUNDING

This research received no external funding.

DATA AVAILABILITY STATEMENT

The data used in this study are publicly available from their respective sources. Data generated or processed during this study are available from the corresponding author upon reasonable request.

CONFLICT OF INTEREST

The authors declare there is no conflict.

REFERENCE

Alam, I., Nur, S. M. S., & Mitra, C. (2025). Accessibility to Public Open Space of a Densely Populated City: A Case Study of Dhaka, Bangladesh. *Computational Urban Science, 5*(1), 25. https://doi.org/10.1007/s43762-025-00187-9

Alamanos, A., & Papaioannou, G. (2020). A GIS Multi-Criteria Analysis Tool for a Low-Cost, Preliminary Evaluation of Wetland Effectiveness for Nutrient Buffering at Watershed Scale: The Case Study of Grand River, Ontario, Canada. *Water, 12*(11), 3134. https://doi.org/10.3390/w12113134

Alamri, A. (2023). A Smart Spatial Routing and Accessibility Analysis System for EMS Using Catchment Areas of Voronoi Spatial Model and Time-Based Dijkstra's Routing Algorithm. *International Journal of Environmental Research and Public Health, 20*(3), 1808. https://doi.org/10.3390/ijerph20031808

Arliani, V., Sjafruddin, A., Santoso, I., & Winarso, H. (2024). Impact of Internal Accessibility on Value Creation in Transit Oriented Development (TOD) Area. *Transportation Research Interdisciplinary Perspectives, 25*, 101106. https://doi.org/10.1016/j.trip.2024.101106

Badan Pusat Statistik [BPS]. (2019). *Market and Trade Center Distribution by Classifications, 2019*. Retrieved January 15, 2026, from https://www.bps.go.id/en/statistics-table/2/MTg3NSMy/market-and-trade-center-distribution-by- classifications.html

Badan Pusat Statistik [BPS]. (2020). *Statistik Pendidikan 2020*. Badan Pusat Statistik.

Badan Pusat Statistik Kota Jakarta Selatan. (2024). *Kecamatan Mampang Prapatan Dalam Angka 2024*. Badan Pusat Statistik Kota Jakarta Selatan.

Badan Pusat Statistik Provinsi DKI Jakarta. (2021). *Rumah Tangga dan Rata-Rata Banyaknya Anggota Rumah Tangga Menurut Kabupaten/Kota di Provinsi DKI Jakarta, 2020* [Table Statistic]. Badan Pusat Statistik Provinsi DKI Jakarta.

Badan Pusat Statistik Provinsi DKI Jakarta. (2023). *Provinsi DKI Jakarta Dalam Angka 2023*. Badan Pusat Statistik Provinsi DKI Jakarta.

Badan Pusat Statistik Provinsi DKI Jakarta. (2025). *Penduduk, Laju Pertumbuhan Penduduk, Distribusi Persentase Penduduk, Kepadatan Penduduk, Rasio Jenis Kelamin Penduduk Menurut Kabupaten/Kota di Provinsi DKI Jakarta,* *2025* [Table Statistic]. Badan Pusat Statistik Provinsi DKI Jakarta.

Bajracharya, N., & Paudyal, D. (2025). Assessing Spatial Accessibility to Health Services in Rural Nepal: A GIS-based Study of Rohini Rural Municipality. *Discover Health Systems, 4*(1), 126. https://doi.org/10.1007/s44250-025-00310-x

Ewing, R., & Cervero, R. (2010). Travel and the Built Environment: A Meta-Analysis. *Journal of the American Planning Association, 76*(3), 265–294. https://doi.org/10.1080/01944363.2010.481147

Fan, P. Y., Chun, K. P., Mijic, A., Tan, M. L., Zhai, W., & Yetemen, O. (2024). Identifying the Impacts of Land-Use Spatial Patterns on Street-Network Accessibility Using Geospatial Methods. *Geographical Analysis, 56*(2), 284-302. https://doi.org/10.1111/gean.12374

Koomen, E., Bank, A., van der Wielen, T., & van Vliet, J. (2023). *Explaining Urban Density Change: Review and Global Analysis of Driving Forces* (SPINlab Research Memorandum No. 21). Vrije Universiteit Amsterdam. https://spinlab.vu.nl/

Maghfira, Z. W., Sutriadi, R., & Perdana, A. B. (2025). Assessing Urban Functional Area Delineation: POI data and KDE Analysis in Pekanbaru. *Computational Urban Science, 5*(1), 33. https://doi.org/10.1007/s43762-025-00194-w

Malczewski, J. (2000). On the Use of Weighted Linear Combination Method in GIS: Common and Best Practice Approaches. *Transactions in GIS, 4*(1), 5-22. https://doi.org/10.1111/1467-9671.00035

Malczewski, J. (2011). Local Weighted Linear Combination. *Transactions in GIS, 15*(4), 439-455. https://doi.org/10.1111/j.1467-9671.2011.01275.x

Morales, J., Flacke, J., Morales, J., & Zevenbergen, J. (2019). Mapping Urban Accessibility in Data Scarce Contexts Using Space Syntax and Location-Based Methods. *Applied Spatial Analysis and Policy, 12*(2), 205–228. https://doi.org/10.1007/s12061-017-9239-1

Moreno, C., Allam, Z., Chabaud, D., Gall, C., & Pratlong, F. (2021). Introducing the "15-minute city": Sustainability, Resilience and Place Identity in Future Post-Pandemic Cities. *Smart Cities, 4*(1), 93–111. https://doi.org/10.3390/smartcities4010006

Obregón-Biosca, S., Sánchez-Escobedo, J., & Somohano-Martínez, M. (2016). Planificación de rutas turísticas para autobús a través de indicadores de accesibilidad integral y de dotación de bienes materiales e inmateriales. *Revista Transporte y Territorio, 14*, 144–166.

Ojeda Casares, S., Valverde Martínez, J., Ramírez Torres, A., & Enrique Regueira, I. (2024). The Statistical Grid as a Unit of Observation and Analysis: Andalusia, Spanish Region Case Study. *Investigaciones Regionales, 2024*(59), 149–165. https://doi.org/10.38191/iirr-jorr.24.015

Silalahi, F. E. S., Hidayat, F., Dewi, R. S., Purwono, N., & Oktaviani, N. (2020). GIS-based Approaches on the Accessibility of Referral Hospital Using Network Analysis and the Spatial Distribution Model of the Spreading Case of COVID-19 in Jakarta, Indonesia. *BMC Health Services Research, 20*(1), 1053. https://doi.org/10.1186/s12913-020-05896-x

Tariverdi, M., Nunez-del-Prado, M., Leonova, N., & Rentschler, J. (2023). Measuring Accessibility to Public Services and Infrastructure Criticality for Disaster Risk Management. *Scientific Reports, 13*(1), 1569. https://doi.org/10.1038/s41598-023-28460-z

Wang, J., Dang, Y., & Samsura, D. A. A. (2026). Urban Rail Transit Expansion, Public Housing Provision and Transport Equity: A Case Study in Hangzhou, China. *Urban Rail Transit, 12*(2), 182-192. https://doi.org/10.1007/s40864-025-00263-7

Wang, Z., & Niu, L. (2018). A Data Model for Using OpenStreetMap to Integrate Indoor and Outdoor Route Planning. *Sensors, 18*(7), 2100. https://doi.org/10.3390/s18072100

World Bank. (2019). *Time to ACT: Realizing Indonesia's Urban Potential* (Flagship report). World Bank.

World Bank. (2024). *Urban population (% of Total Population) – Indonesia* [Dataset]. World Bank Open Data. Retrieved from https://data.worldbank.org/indicator/SP.URB.TOTL.IN.ZS?locations=ID

Worldometer. (2024). *Indonesia Demographics 2024 (Population, Age, Sex, Trends)*. Retrieved from https://www.worldometers.info/demographics/indonesia-demographics/

Zhang, M., Jiang, Q., Tao, S., Dai, T., & Ma, S. (2025). The Spatial Structural Patterns of Commuting Trips by Bus and Metro in Beijing, China: Complementary or Competing?. *Travel Behaviour and Society, 40*, 101032. https://doi.org/10.1016/j.tbs.2025.101032

Zhang, Y., Wang, H., Luo, K., Wu, C., & Li, S. (2024). Study on Spatialization and Spatial Pattern of Population Based on Multi-Source Data: A Case Study of the Urban Agglomeration on the North Slope of Tianshan Mountain in Xinjiang, China. *Sustainability, 16*(10), 4106. https://doi.org/10.3390/su16104106.