

ELECTRIC VEHICLE SERVICE CENTRE (EVSC) FACILITIES OPTIMIZATION IN JAKARTA USING GEOGRAPHIC INFORMATION SYSTEMS (GIS)

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*Corresponding Author, Received: 18 June 2025, Revised: 26 Dec. 2025, Accepted: 29 Dec. 2025

ABSTRACT: Cities that continue to rely on fossil fuel-powered cars, contributing to greenhouse gas emissions and climate change, face significant challenges regarding green transportation. In addition to the growing dependence on fossil fuels, the fluctuating prices of these fuels and air pollution from traditional transportation severely impact public health. These issues can be addressed by adopting electric vehicle (EV) technology to replace fossil fuel-powered cars. Adequate service center facilities are essential for promoting EV adoption and fostering a sustainable transportation ecosystem. The characteristics of a site are vital for constructing EVSCs. This study aims to identify suitable locations and environments for EVSCs in Jakarta Province. Various data sources, including the Detailed Spatial Plan (RDSP) of the Special Region of Jakarta Province, existing condition maps, and population density, are utilized to optimize the development of EVSCs using overlapping map techniques (Geographic Information Systems). Furthermore, this study compares the characteristics of current EVSC locations in Jakarta with those in Hefei, China. Hefei City is well-established in achieving high EV adoption, indicating it has sufficient EVSC facilities to meet users' charging needs. The findings suggest that the placement of EVSC facilities must consider major highways, commercial buildings, retail businesses, and development and conservation areas. Adequate EVSC facilities in appropriate locations within the Jakarta area are crucial for meeting users' demands for green mobility.

Keywords: Electric Vehicle, Service Centre, Green Transportation, Facilities, Geography Information System (GIS)

1. INTRODUCTION

Climate change and rising greenhouse gas emissions have become critical global challenges, particularly in urban centers where transportation remains heavily reliant on fossil fuel-powered vehicles [1]. The transport sector alone contributes a substantial share of urban air pollution and CO₂ emissions, making it one of the priority targets for mitigation strategies worldwide [23]. In response, many major cities—including Jakarta—are pursuing sustainable transportation transitions by promoting the adoption of electric vehicles (EVs), which offer the potential to substantially reduce tailpipe emissions and improve air quality when coupled with clean energy sources. However, despite increasing EV uptake, research has increasingly shown that vehicle availability alone does not guarantee successful EV implementation; the presence of robust supporting infrastructure plays a crucial role in realizing the environmental and social benefits of electrification [22].

One key component of this infrastructure ecosystem is the Electric Vehicle Service Center (EVSC), which provides essential after-sales support including testing, repair, maintenance, and battery lifecycle services [2]. EVSCs also can serve as hubs for battery recycling and end-of-life management—a

critical consideration as EV fleets scale up. Without strategically located service centers, EV users may experience barriers to ownership due to concerns about maintenance accessibility and long-term reliability, which in turn can hinder broader adoption [22]. Furthermore, the equitable distribution of service infrastructure has emerged as an important determinant of user confidence and social acceptance, reducing disparities in access across different urban neighborhoods [3].

In Jakarta, the current EVSC network remains both limited in number and unevenly distributed, complicating efforts to build a comprehensive support ecosystem. The absence of a detailed spatial database identifying optimal locations for additional EVSCs further exacerbates planning challenges. Without such data-driven insights, infrastructure investments risk being reactive rather than strategic, potentially perpetuating service gaps and inequities that undermine long-term sustainability goals.

Consequently, a spatially informed and data-driven strategy is essential to identify where EVSC facilities should be developed to align with population demand, land use patterns, transportation networks, and equity considerations. Geographic Information Systems (GIS)-based spatial overlay analysis offers a powerful methodological framework for this purpose, allowing planners to integrate

diverse spatial data layers into composite suitability assessments [22]. To situate Jakarta's experience within a broader context of successful EV ecosystem development, this study also examines Hefei City, China, recognized for its high EV adoption rates and robust supportive infrastructure network. The comparative analysis helps identify transferable best practices while highlighting contextual constraints unique to Jakarta's urban form and governance landscape.

This GIS approach enables the development of a more strategic, adaptive, and long-term planning model for EVSC deployment, grounded in empirical spatial evidence rather than ad hoc decision-making. Findings from this study are expected to contribute significantly to policy discourse on sustainable transportation, informing actionable recommendations that can improve infrastructure readiness and support inclusive electrification of urban mobility systems.

2. RESEARCH SIGNIFICANCE

This study offers a novel contribution by shifting the focus of electric vehicle infrastructure planning from charging facilities to Electric Vehicle Service Centers (EVSCs), an area that remains underexplored in urban sustainability research. Unlike previous studies that primarily emphasize charging station optimization, this research integrates EV service facilities into a GIS-based spatial overlay framework,

incorporating population density, land use regulations, and environmental constraints. The originality of this study also lies in its comparative approach, benchmarking Jakarta against Hefei—one of China's most successful EV cities—to derive transferable spatial planning strategies. The findings provide a data-driven and context-sensitive model for equitable EVSC deployment in rapidly urbanizing megacities.

3. RESULTS

Jakarta, the country's capital and commercial hub, presents a significant challenge in developing an environmentally friendly transportation infrastructure. With a land area of 661.52 km² and 159,083 electric vehicle (EV) users as of April 2024, the city has significant potential to shift to a sustainable mobility system. However, supporting infrastructure in the form of Electric Vehicle Service Centers (EVSC) is still limited, with only ten (10) service locations accessible, all from the Wuling brand. For instance, Hefei City in China, with an area of 11,434 km², has erected at least eight EVSCs for the Wuling brand, each having an average service range of 1.43 km. Hefei is not only geographically larger, but it is also actively developing a national EV ecosystem through progressive laws and full backing from the municipal administration. The goal of producing 1 million electric vehicles by 2025 solidifies Hefei's status as a role model for the creation of a green metropolis based on transportation electrification [4].

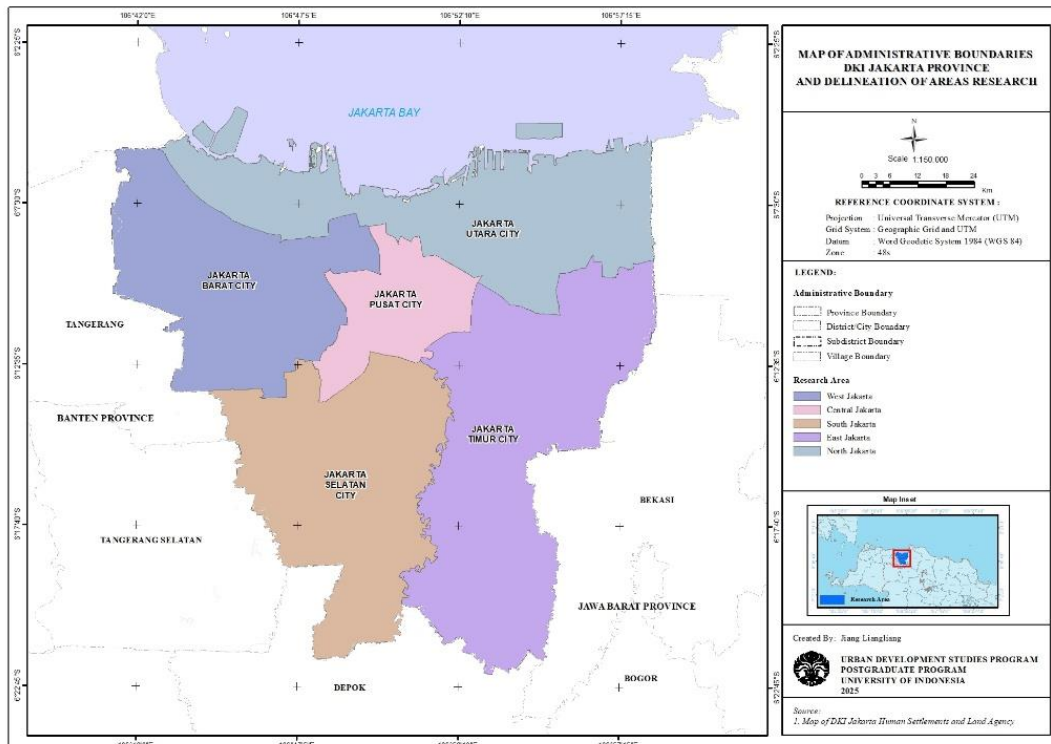


Fig.1 Map of Jakarta's Administrative Boundaries

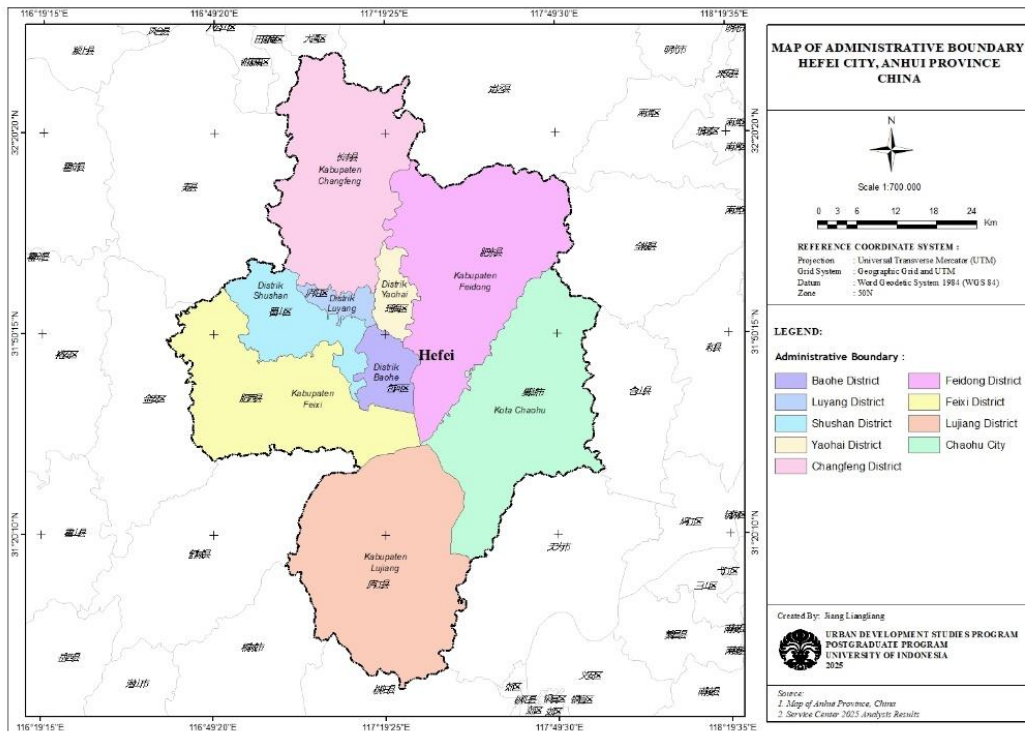


Fig.2 Map of Hefei's Administrative Boundaries

A comparative overview of the spatial characteristics and Electric Vehicle Service Center (EVSC) provision between Jakarta and Hefei. Jakarta, with a total area of 661.52 km², is currently served by only ten Wuling EVSCs. This indicates a relatively low density of service centers and suggests potential accessibility challenges for EV users across the city. In contrast, Hefei covers a much larger area of 11,434 km² yet is supported by at least eight Wuling EVSCs, with an average service area of only 1.43 km² per facility. Despite its greater geographic size, Hefei demonstrates a significantly higher EVSC density, reflecting a more compact, clustered, and strategically planned service network that better supports high levels of electric vehicle adoption.

This number reflects a relatively low EVSC density of only one EVSC serving over 31,800 EV customers and covers a huge area that is disproportionate to everyday mobility needs and supporting infrastructure. Hefei, on the other hand, is not only physically larger, but it has also established a progressive EV ecosystem with higher EVSC density and aggressive national production targets.

This study employed a GIS-based spatial overlay analysis to identify optimal locations for the development of EVSCs in DKI Jakarta. The analysis integrated multiple spatial layers, including the distribution of existing EVSCs, population density, the detailed land use plan, and the road network. Data were validated to comply with Jakarta Satu geospatial standards, followed by data cleaning, clipping, simplification, and conversion to spatial formats. The spatial analysis followed a three-stage GIS approach:

1. Intersection: Identified overlapping areas between existing EVSC locations and urban infrastructure layers.
2. Buffer (5 km): Created service radii around existing EVSCs based on urban mobility standards, representing optimal user accessibility.
3. Clip & Merge: Integrated multiple geospatial datasets to generate a composite priority map, highlighting underserved regions for future development.

This approach ensures a data-driven foundation for identifying EVSC development zones that are both technically feasible and socially impactful. A composite suitability score was generated for each spatial unit to evaluate the level of demand and accessibility for EVSC deployment. The results were then validated against secondary data sources and mobility patterns, and the outcomes were presented as thematic maps and analytical tables to inform strategic, data-driven EVSC planning across Jakarta.

3.1 Spatial Distribution and Coverage Analysis of Existing EVSC Facilities in Jakarta

To support the spatial analysis and service coverage mapping, a comprehensive inventory of existing Electric Vehicle Service Centers (EVSCs) in DKI Jakarta was compiled. The dataset includes 15 service centers operating under various operators, with Wuling identified as the dominant brand currently providing dedicated EV servicing infrastructure.

Table 1. Existing Wuling EVSC Facilities in Jakarta

No	Area	Location	Latitude	Longitude
1	Arista Cengkareng	Jl. Kapuk Cengkareng No. 7, RT 7/RW 14, Cengkareng, Kota Jakarta Barat 11730	-6.1301	106.728
2	Prima Kebon Jeruk	Jl. Panjang No. 46, RT 006/RW 001, Kedoya Selatan, Kec. Kebon Jeruk, Jakarta Barat, DKI Jakarta 11520	-6.1892	106.7705
3	Arista P. Jayakarta	Jl. Pangeran Jayakarta No. 33, Pinangsia, Taman Sari, Jakarta Barat 10730	-6.1361	106.8293
4	Arista Garuda	Jl. Garuda No. 74, Kemayoran, Jakarta Pusat 10620	-6.1426	106.8469
5	Prima Harmoni	Jl. Balikpapan No.11, RT 08/RW 06, Petojo Selatan, Gambir, Jakarta Pusat, DKI Jakarta 10160	-6.1604	106.8196
6	Maju Motor Senayan	Jl. Asia Afrika No. 17 RT.001 RW.003 Kel. Gelora, Kec. Tanah Abang, Jakarta Pusat 10270	-6.2166	106.8007
7	Prima Fatmawati	Jl. RS. Fatmawati No. 45 A E RT.002/RW.005, Cipete Selatan, Cilandak, Kota Jakarta Selatan 12411	-6.285	106.792
8	Pegasus Agung	Jl. Raya Lenteng Agung No. 8 RT 3/RW 1, Lenteng Agung, Jagakarsa, Jakarta Selatan, DKI Jakarta 12610	-6.3099	106.8206
9	BZHC Indah	Jl. Sultan Iskandar Muda No.Kavling 9, RT.9/RW.1, Kby. Lama Sel., Kec. Kby. Lama, Kota Jakarta Selatan, Daerah Khusus Ibukota Jakarta 12310	-6.2543	106.7793
10	Arista Kalimalang	Jl. Raya Kalimalang No. 20A, Duren Sawit, Jakarta Timur 13440	-6.2455	106.9093

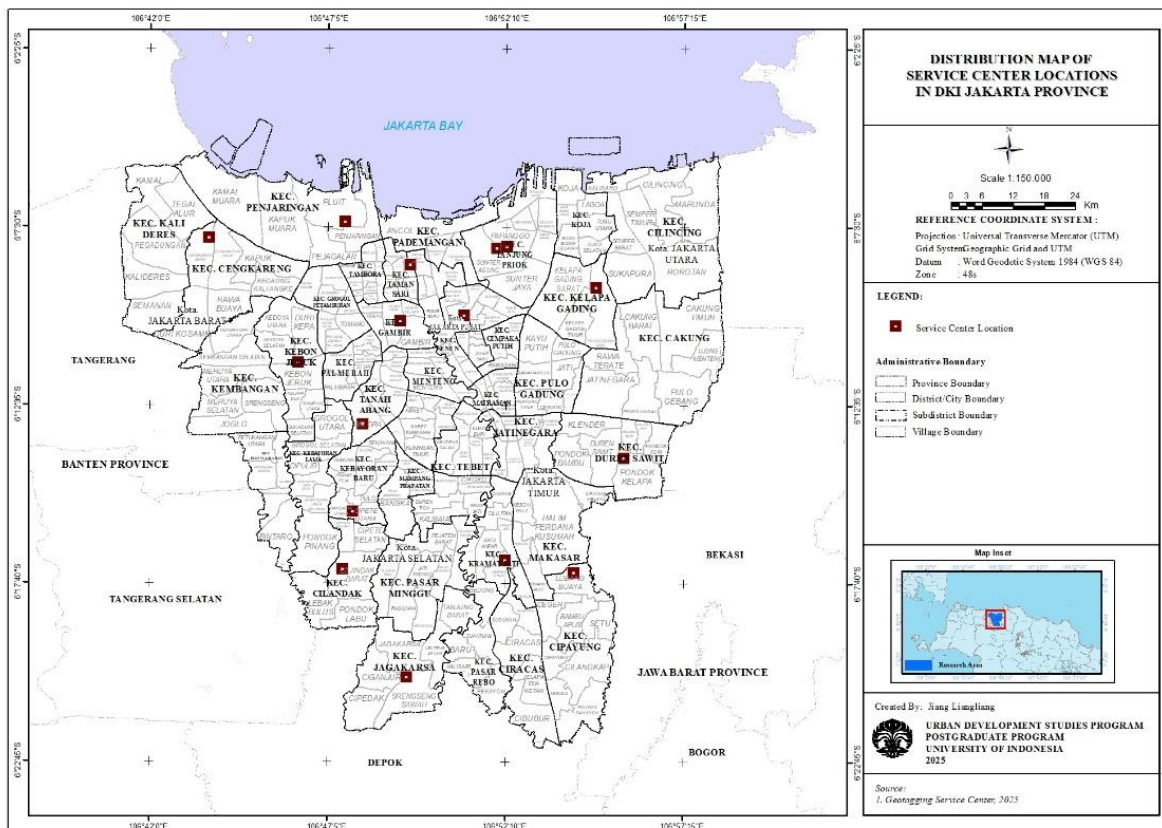


Fig.3 Intersection Process of EVSC in Jakarta

Each entry in the table presents the name of the location, full address, and corresponding geospatial coordinates (latitude and longitude) for spatial integration within GIS-based analysis. These facilities are dispersed across multiple municipalities, including West Jakarta, Central Jakarta, East Jakarta, South Jakarta, and North Jakarta, though the distribution remains relatively uneven.

The spatial analysis assessed the service coverage and unmet demand for Electric Vehicle Service Centers (EVSC) in Jakarta. The study was performed using a three-step Geographic Information System

(GIS)- based approach: Intersection, Buffer, and Clip and merge. The first stage, Intersection, maps the current distribution of EVSCs across Jakarta's subdistricts, represented by red squares. This initial visualization highlights the existing service network's spatial concentration and potential gaps. The second stage involves applying a 5-kilometer buffer around each service center to estimate its effective service range (Fig.4). Based on commonly accepted standards in urban transport studies [11, 12], a 5 km service radius is considered optimal to ensure convenient access to EV service centers.

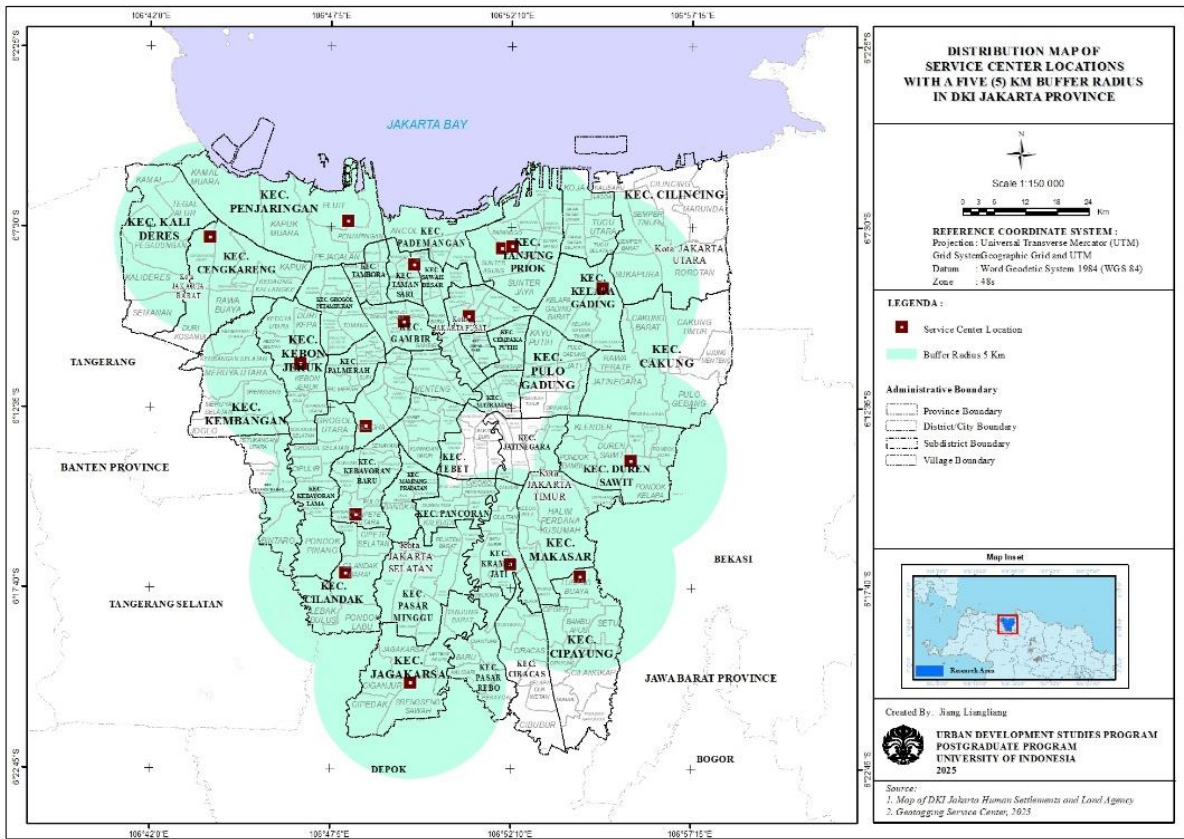


Fig.4 Buffer Process of EVSC in Jakarta

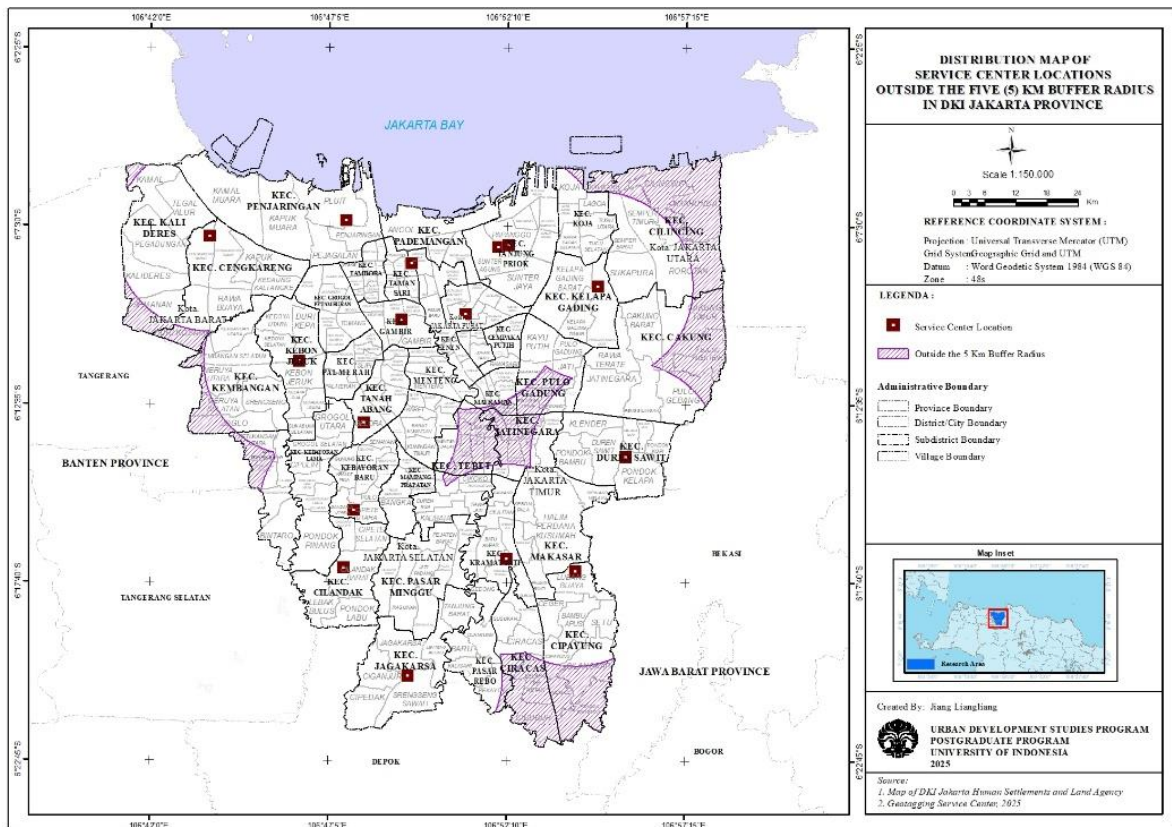


Fig.5 Clip and Merge Process of EVSC in Jakarta

The spatial analysis followed established GIS-based methodologies [13, 14] that utilize intersection, buffering, and clip-and-merge techniques to map current service coverage and identify underserved areas. The resulting buffer zones, shown in light green, represent areas within optimal proximity to EVSC facilities, based on general accessibility standards for urban transportation services [11]. This step helps to visualize the spatial reach of the current infrastructure.

In the final stage, Clip & Merge (Fig.5), a spatial overlay analysis is performed to delineate areas that fall outside the 5-kilometer buffer zones. These regions, highlighted in purple hatching, indicate underserved zones where current EVSC facilities do not provide adequate coverage. Identifying these gaps is crucial for planning future EVSC development to ensure equitable access and support the adoption of electric vehicles.

The analysis reveals that several districts in North Jakarta, East Jakarta, parts of West Jakarta, and Southern Jakarta remain outside the optimal service radius. This finding suggests a clear need for targeted infrastructure investments in these areas to address geographic disparities and promote a more inclusive and resilient EV ecosystem in Jakarta.

There are some notable contrasts when compared to the EVSC distribution model in Hefei, which is known for its cluster and corridor strategy. In Hefei, EVSCs are concentrated in the city center and commercial districts, with significant EVSC corridors along important transit routes (for example, metro lines or arterial highways). The service radius in Hefei is often smaller (about 1-3 km in the city center) to encourage high adoption of electric vehicles in urban mobility. However, suburban areas have a greater radius. In comparison, the layout in Jakarta, as seen on this map, uses a more spread node method with a 5km radius coverage. This technique is consistent with the more dispersed character of Jakarta's road network and the necessity to serve a diverse range of residential areas.

3.2 Spatial Overlay Analysis for Identification of Potential EVSC Locations

The priority locations for EVSC development were identified through a comprehensive spatial overlay analysis integrating multiple geospatial datasets, including Jakarta's 2021 population density map (Fig.6), land use and cultural activity zones (Fig.7), and protected area boundaries (Fig.8).

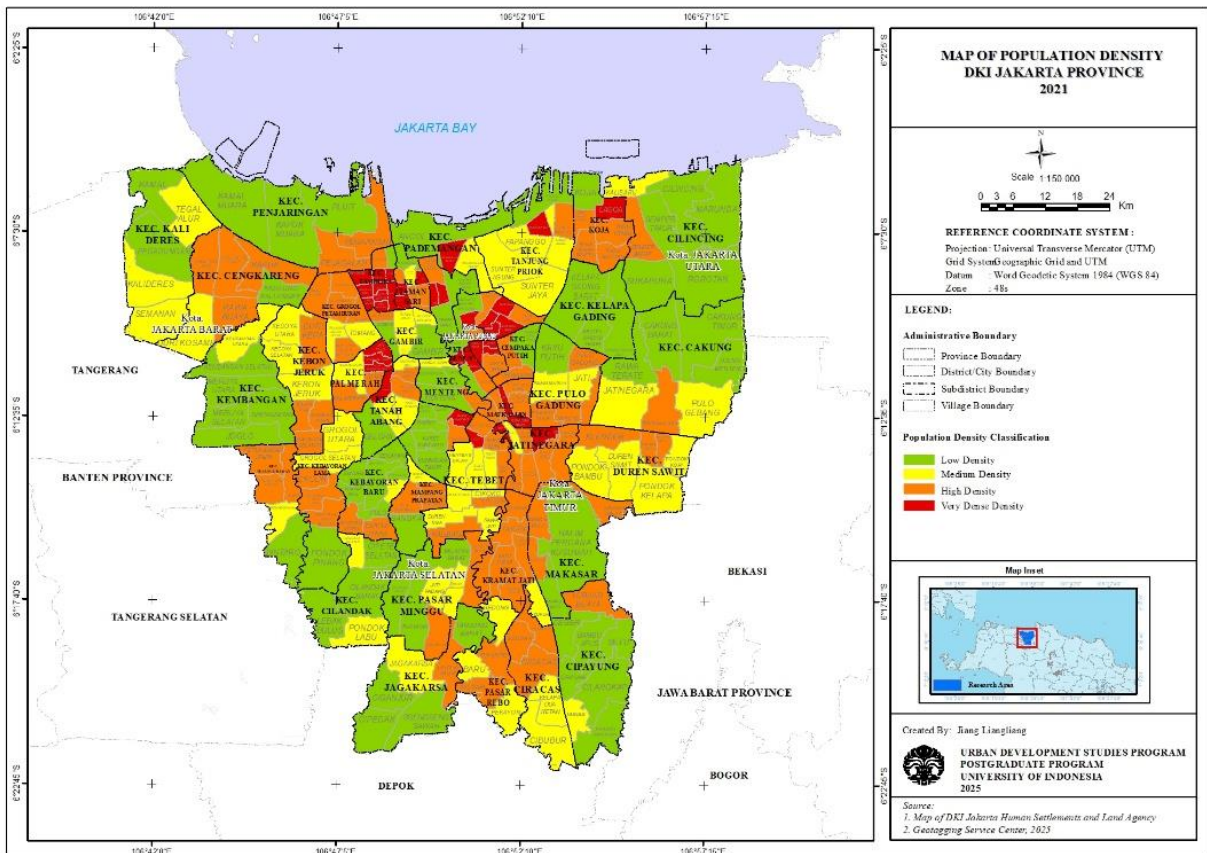


Fig.6 Jakarta Population Density Map 2021

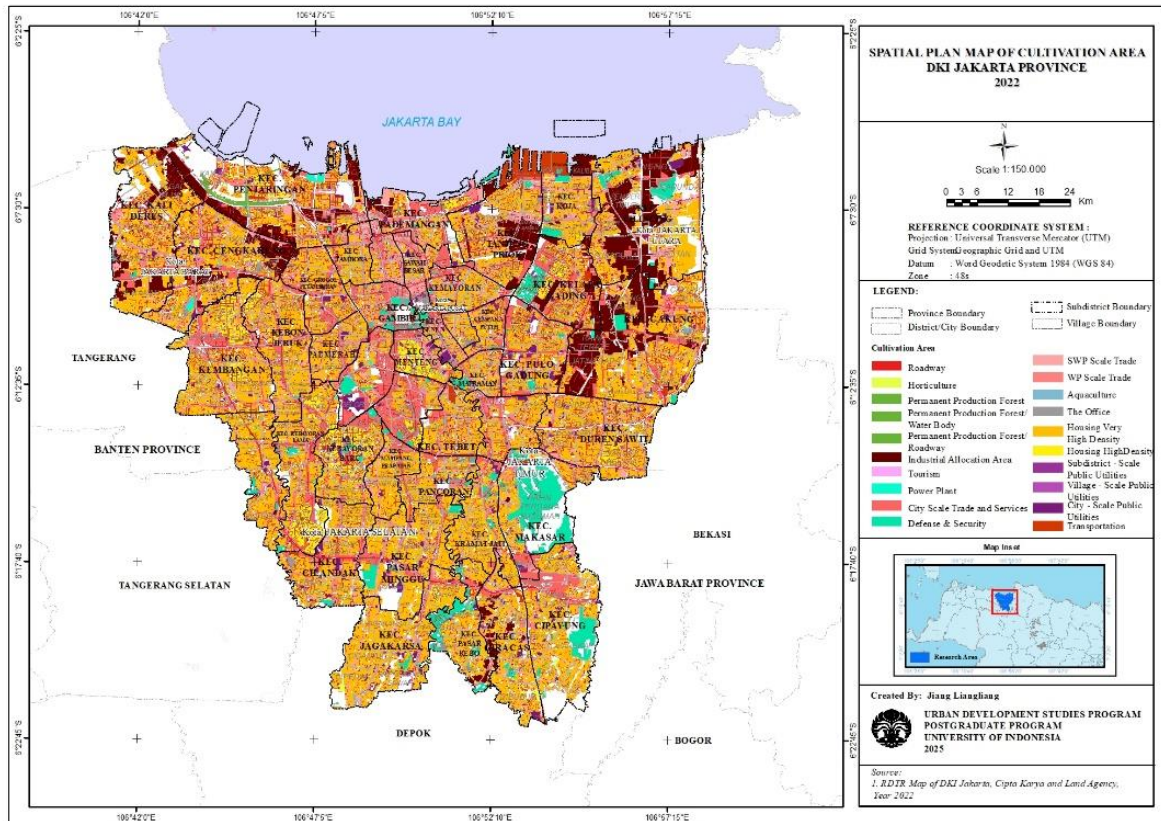


Fig.7 Land Use of Jakarta Cultural Map

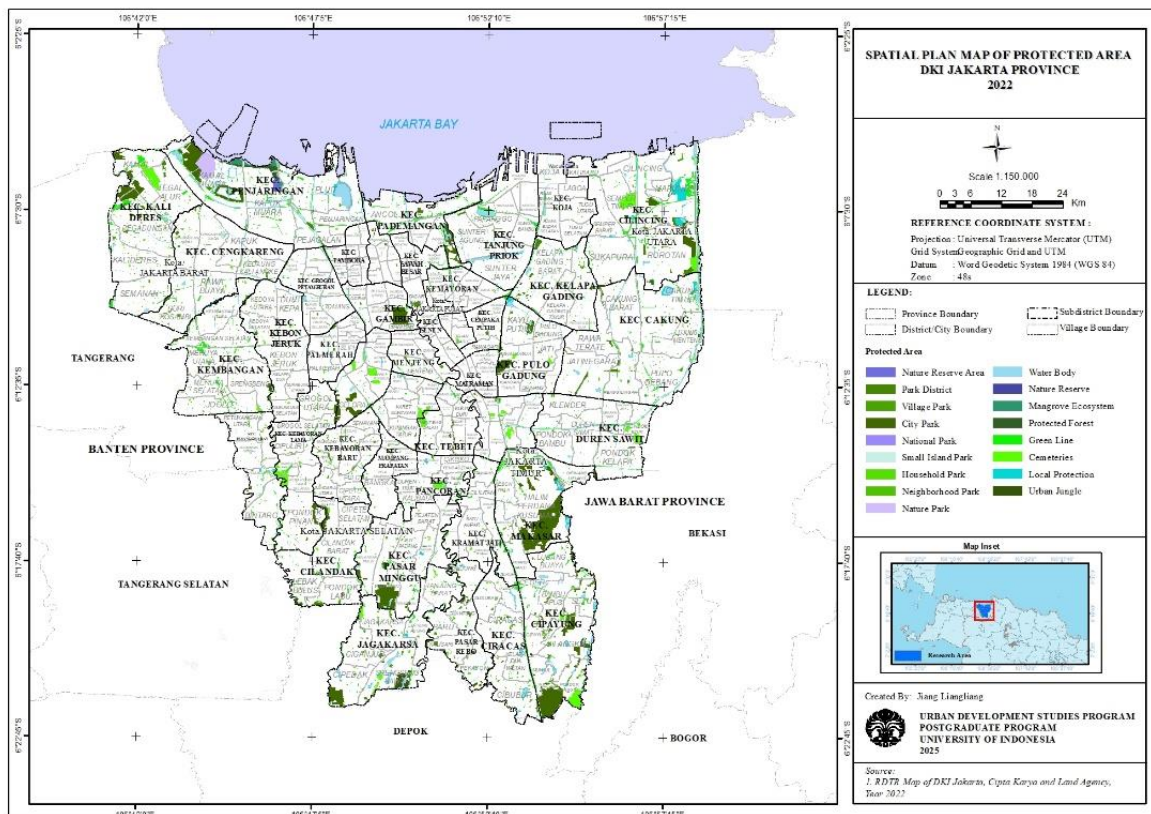


Fig.8 Jakarta Protected Area Map

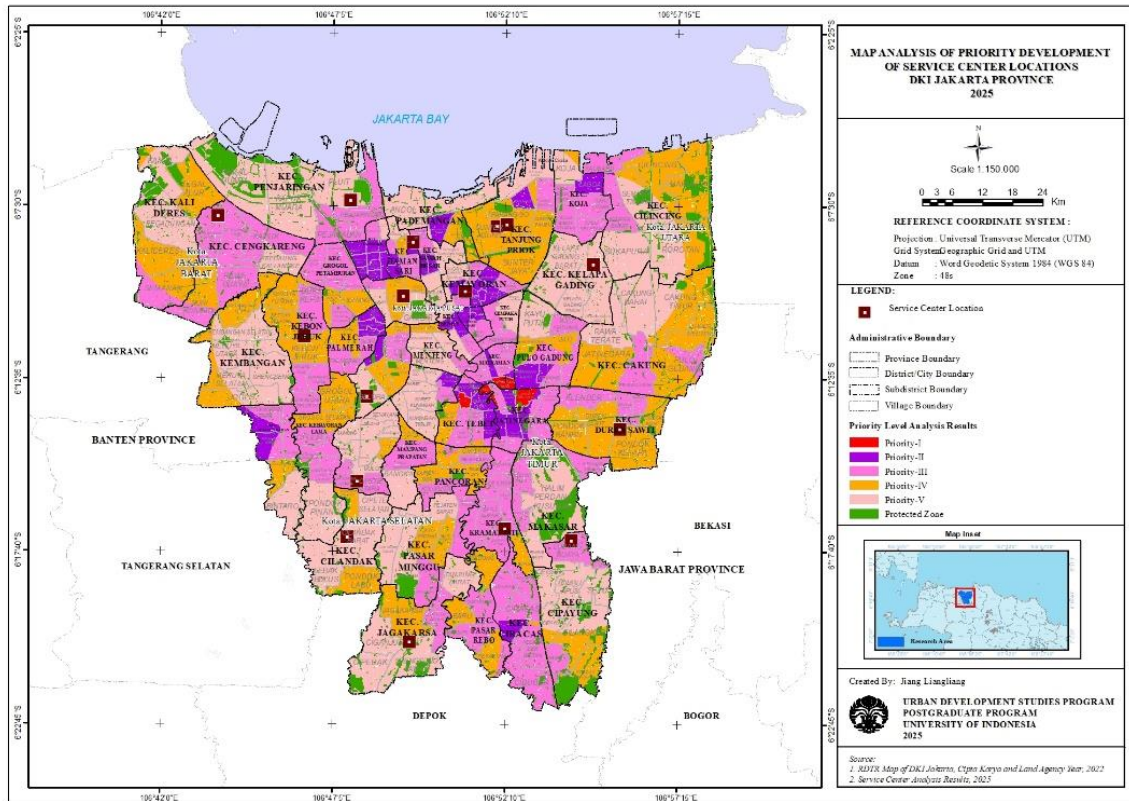


Fig.9 The Spatial Overlay Analysis

The analysis aimed to optimize service coverage while balancing environmental and urban planning considerations. Each map layer was assigned a score reflecting its relative influence on EVSC demand, with higher population density and urban cultural zones contributing positively, and protected areas constraining development options.

To facilitate interpretation and strategic planning, the composite scores were classified into five priority levels using a constant of 0.8. The scoring results obtained the lowest score of 2 and the highest score of 6. To create a classification into 5 classes, the constant added is 1, which is calculated as Eq (1):

$$(2 - 6 = 4) \rightarrow 4/5 = 0.8 \quad (1)$$

The final classification ranges were defined as:

- **Priority I:** 5.6 – 6.4 (Very High Need)
- **Priority II:** 4.7 – 5.5 (High Need)
- **Priority III:** 3.8 – 4.6 (Moderate Need)
- **Priority IV:** 2.9 – 3.7 (Low Need)
- **Priority V:** 2.0 – 2.8 (Very Low Need)

The spatial overlay analysis produced a comprehensive priority map illustrating potential sites for future EVSC development throughout DKI Jakarta. This map synthesizes layers of population density, existing EVSC distribution, detailed land use plans (RDTR), and transportation networks, resulting in a visual classification of urban areas according to service demand and spatial suitability. The analysis

revealed significant spatial disparities, with central and highly urbanized districts exhibiting higher priority levels, while peripheral and protected zones were identified as lower priority or excluded from development consideration. Key urban subdistricts in South Jakarta, East Jakarta, and West Jakarta emerged as critical areas for EVSC expansion, reflecting both unmet service needs and strategic connectivity potential. This map provides a data-driven foundation for guiding equitable and sustainable EVSC network expansion in Jakarta, ensuring alignment with broader urban planning and green mobility objectives.

The spatial priority map for potential EVSC development in Jakarta (Figure 5) provides an integrated visualization of service needs across the metropolitan area. The analysis combines spatial layers, including existing EVSC locations, service coverage buffers (5 km radius), population density, and urban land use patterns derived from the city's detailed spatial plan. The overlay results highlight significant geographic disparities in EVSC accessibility, particularly in southern, eastern, and parts of western Jakarta, where high-priority zones (Priority I and II) are concentrated but lack sufficient service coverage. Several underserved districts with dense residential areas and strategic transport corridors, such as Jagakarsa, Pasar Minggu, Duren Sawit, and Kalideres, emerge as key candidates for future EVSC deployment to enhance spatial equity

and support growing EV adoption. Conversely, the northern and central districts exhibit relatively better service coverage but still present localized gaps, especially in industrial and port-adjacent zones. The integration of environmental protection areas further informs sustainable site selection by identifying zones where EVSC development should be avoided. Overall, the spatial analysis offers a data-driven basis for prioritizing EVSC infrastructure expansion, ensuring alignment with both mobility demand and green urban development objectives.

3.3 Discussion

The spatial overlay analysis conducted in this study highlights significant geographic disparities in the current Electric Vehicle Service Center (EVSC) network in Jakarta. Compared to the more advanced and strategically clustered EVSC system in Hefei, Jakarta's EVSC deployment remains sparse and uneven, especially in high-density and fast-growing residential areas. GIS-based methods enabled the identification of underserved districts in the southern, eastern, and southwestern parts of the city. This underscores the need for a more targeted, data-driven infrastructure development strategy to support Jakarta's transition toward sustainable transportation [15, 16]. Optimizing EVSC locations based on spatial demand factors—such as population density, land use patterns, and transportation network connectivity—can significantly improve service equity and support broader electric vehicle (EV) adoption [17].

In the context of green cities, EVSCs serve as critical infrastructure for energy transition and sustainable mobility. Well-distributed and strategically planned EVSCs uphold the green city principle, where electric vehicles produce zero exhaust emissions, contributing to cleaner air [18, 19]. Clean technology becomes especially appealing and viable in densely populated areas that strive for better air quality. Site selection should consider proximity to users, EV distribution in the area, and the service capacity of each station [6, 20]. The reliability of charging infrastructure and battery swapping systems is also crucial for sustaining EV operations [21]. Placement decisions must coincide not only with technical and geographical issues but also with broader urban sustainability goals, such as integrating public transportation with green mobility, decreasing congestion, and supporting equitable service distribution [16].

When deciding on the optimum site, consider the distance from the user's location [7], the distribution of electric vehicles in the area [8], and the service capacity that the service center can offer [9]. The dependability of charging infrastructure and battery swapping systems is crucial to facilitate the sustained functioning of electric vehicles [10]. This placement considers not only technical and spatial aspects but

also urban sustainability goals such as integrating public transportation with green mobility, reducing congestion, and ensuring fair and equitable service distribution. EVSC's closeness to toll lanes, terminals, commercial districts, and industrial areas enables it to be part of a comprehensive low-emission mobility ecosystem.

Jakarta could benefit from adopting a hybrid EVSC layout strategy—blending cluster, corridor, and nodal approaches—similar to successful practices in Hefei. This would ensure better service coverage across dense urban cores and peripheral commuter zones, supporting a more inclusive and resilient low-emission mobility ecosystem [17]. As the number of EV users grows, Jakarta must proactively expedite the development of EVSCs to minimize service bottlenecks and maintain user satisfaction. Incentive policies, public-private partnerships, and the integration of technology and service information systems should support investment in EVSCs. Furthermore, incorporating user behavior research through surveys and service quality assessments will ensure that future EVSC infrastructure meets the evolving needs of urban EV users and fosters a more inclusive, accessible, and sustainable mobility system.

4. CONCLUSIONS

This study highlights the essential role of Electric Vehicle Service Centers (EVSCs) as crucial infrastructure for the sustainable transition to electric mobility in urban areas. The spatial analysis conducted using GIS-based overlay techniques reveals that the current distribution of EVSCs in Jakarta is uneven and inadequate, leaving significant regions—particularly in South, East, and parts of West and North Jakarta—beyond the optimal 5-kilometer service radius. This gap poses a substantial obstacle to broader EV adoption and user satisfaction. In contrast, the EVSC deployment model in Hefei illustrates a more advanced and strategic approach, characterized by dense clusters in urban centers and corridor-based coverage along key transport routes. Hefei's smaller service radii and integrated infrastructure offer valuable insights for Jakarta's future planning.

The results reveal critical service gaps and prioritize zones for future EVSC development, providing actionable insights for policymakers and Urban planners should focus on the recommended priority locations to address current geographic disparities and align with urban mobility patterns, promoting equitable access to EV services. Comparisons with the successful EVSC model in Hefei further highlight the importance of adopting a strategic, spatially adaptive infrastructure planning approach. Moving forward, integrating dynamic mobility data, real-time EV adoption trends, and

stakeholder input can enhance the robustness of this planning framework. Ultimately, the study supports Jakarta's goal of building a resilient, sustainable, and inclusive electric mobility ecosystem, contributing to broader climate and urban livability objectives.

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