ISSN: 1858-4837; E-ISSN: 2598-019X
Volume 20, Nomor 2 (2025),
https://jurnal.uns.ac.id/region
DOI: 10.20961/region.v20i2.97726

Identification of spatial and temporal land cover alterations in the Jakarta TOD areas utilizing Google Earth data

Tanuda Pedro Rusdiono[1*] and Adi Wibowo[1]

[1]Departement of Geography, Faculty of Mathematics and Natural Sciences, University of Indonesia, Depok, Indonesia

*Corresponding author's email: tanuda.pedro@ui.ac.id

Abstract. The Provincial Government of Special Capital Region of DKI Jakarta has designated Transit Oriented Development (TOD) areas at several Mass Rapid Transit (MRT) station locations through Regional Regulation Number 31 of 2022 concerning the Detailed Spatial Planning (RDTR) of DKI Jakarta. This designation aims to enhance spatial utilization within these areas. However, there are concerns that the intensified spatial use may not fully adhere to the minimum planning criteria stipulated in the regulation. This study aimed to identify land-cover changes in Jakarta's TOD areas between 2012 and 2024. Although the official TOD implementation commenced in 2022, the selection of 2012 as a baseline provides insight into historical land cover conditions before significant TOD influence, thereby allowing an assessment of long-term trends. Satellite imagery from Google Earth for the years 2012 and 2024 were analysed using GIS tools and manually digitized classifications, with a Sankey diagram used to visually represent land cover transitions, particularly in the Lebak Bulus area. The findings revealed that while most TOD areas show limited changes, Lebak Bulus experienced significant conversion of vegetation and open spaces into built-up areas.

Keywords: Jakarta; Land Cover Change; MRT; TOD

1. Introduction

Jakarta's rapid urbanization has necessitated innovative approaches to urban planning, one of which is Transit Oriented Development (TOD). TOD is intended to improve public transportation efficiency, reduce reliance on private vehicles, and optimize urban land use [1][2][3][4]. However, the intensification of urban development often leads to significant changes in land cover, potentially conflicting with environmental and planning standards as set out in the Detailed Spatial Plan (RDTR) of DKI Jakarta [5][6]. In the RDTR, the planning of

Received: January 05, 2025; Accepted: April 17, 2025; Available online: July 31, 2025

TOD areas includes critical criteria such as providing green open spaces and water bodies to ensure a balance between development and environmental sustainability [6]. Despite this, there are apprehensions that the dynamics of this development may disregard the provisions outlined in these regulations, which could potentially alter the land cover.

Previous research shows Jakarta has undergone significant changes in urban land cover. For instance, Jakarta's built-up area increased by 19% over the past two decades, with a 31% reduction in green areas during the same period [7]. The increase in built-up volume correlates with declining air quality and rising surface temperatures, posing serious challenges to urban sustainability [7]. One of the contributing factors is the massive urbanization that has resulted in converting green land to built-up land [8]. Meanwhile, land conversion for built-up area development affects surface temperatures and potentially reduces water resources due to vegetation loss [9]. Jakarta's accelerated urbanization, which is characterized by a decrease in green spaces and an increase in built-up areas, has resulted in a decrease in water resources, a decline in air quality, and an increase in surface temperatures. This underscores the significance of sustainable urban planning.

Analysing land cover changes is crucial in urbanization and urban sustainability [8]. Previous journals provide a broad overview of urbanization's impacts on the urban environment, such as increased surface temperatures [10], reduced air quality [11], and the loss of green spaces [12][13]. The studies emphasize the need for monitoring and planning to promote sustainable urban development [8][10][11][12][13]. Comprehending and tracking alterations in land cover are crucial for mitigating the effects of urbanization, such as increasing surface temperatures, deteriorating air quality, and the depletion of green spaces, underscoring the necessity for sustainable urban development planning.

While the official TOD implementation commenced in 2022, this study deliberately examines the period from 2012 to 2024. The selected time frame is based on the construction process of Jakarta’s MRT stations, which serve as the core of Jakarta's TOD areas, beginning in 2013. The land use sample from 2012 is intended to capture the conditions before the MRT station construction commenced, while the 2024 sample aims to assess land use changes after the implementation of TOD policies. This extended timeframe allows us to assess not only the immediate effects but also the longer-term dynamics of urban land cover change. Moreover, the application of high-resolution Google Earth imagery combined with the innovative use of a Sankey diagram to visualize land cover flows introduces a novel methodological approach in the context of TOD studies. This integrated method provides a more nuanced understanding of how infrastructure developments, such as the MRT, drive urban transformation.

2. Methods

2.1. Study area

Based on DKI Jakarta Governor Regulation No. 31 of 2022, TOD areas have been designated around key MRT stations including Lebak Bulus, Fatmawati, Blok M, Sisingamangaraja, Istora-

Received: January 05, 2025; Accepted: April 17, 2025; Available online: July 31, 2025

Senayan, and Dukuh Atas – Bundaran HI. For this study, the area within an 800-meter radius from each transit node was delineated as the TOD zone.

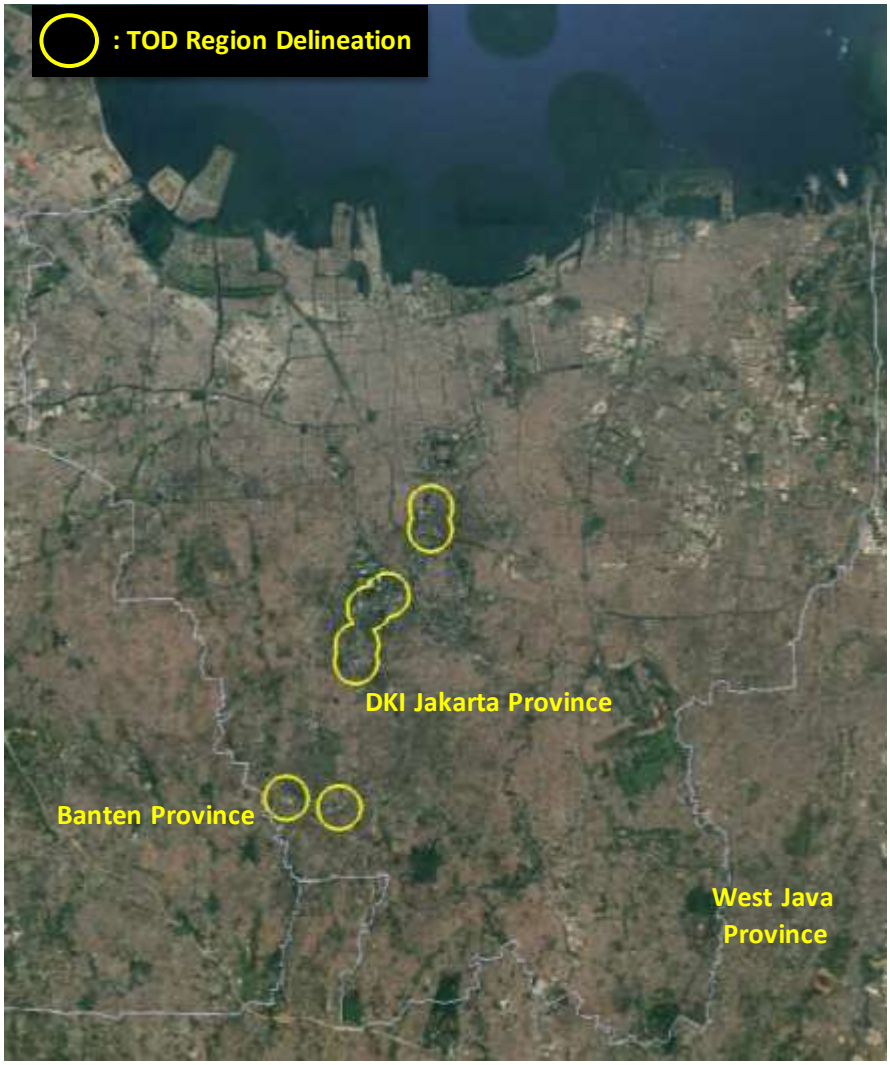


Figure 1. Study location.

2.2. Data collection and change detection process

Google Earth imagery for the years 2012 and 2024 was obtained for all designated TOD areas. Although TOD policies officially began in 2022, the 2012 imagery was chosen to serve as a pre-development baseline, allowing for the assessment of long-term urban trends. The 2024 data were used to capture the changes following the commencement of TOD-related infrastructure projects. Figure 2 shows the process done to identified land use change.

Received: January 05, 2025; Accepted: April 17, 2025; Available online: July 31, 2025

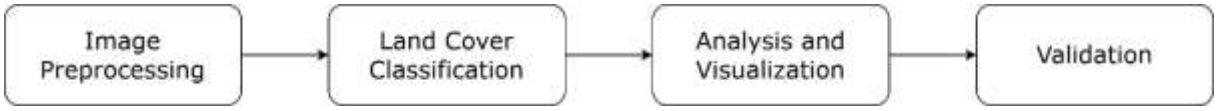


Figure 2. Land use change detection process.

In details, the process as seen Figure 2 is described as follows:

a. Image preprocessing:
- Georeferencing and correction of satellite images using QGIS.
- Delineation of TOD boundaries (800-meter radius) based on MRT station locations.

b. Land cover classification:
- Manual digitization and visual interpretation were performed to classify land cover into key categories: vegetation, built-up areas, barren land, and specific features (e.g., stadium, MRT depot).
- The classification relied on the spectral characteristics visible in high-resolution imagery.

c. Analysis and visualization:
- A change detection analysis was carried out by overlaying classified images from 2012 and 2024 to quantify area changes for each land cover type.
- A Sankey diagram was generated to represent the flow of land cover changes. Notably, significant changes were observed in the Lebak Bulus area, which is why the Sankey diagram focuses on this location. The other TOD areas exhibited either minimal or pre-planned changes and thus did not warrant a similar detailed flow analysis.

d. Validation:
- Ground control points and cross-references with local planning documents were used to validate the results correction of satellite images using QGIS.

2.4. Sankey diagram

Sankey diagrams are a highly effective visualization tool for mapping the flow of resources such as energy, water, and materials in complex systems. Studies show how Sankey diagrams can be used to model the water-energy nexus and the aspects of circularity in the circular economy [14]. This diagram helps identify inefficiencies, potential savings, and loss rates at various supply chain stages, such as distribution, consumption, and waste processing [14]. With the development of a new framework, the Sankey diagram is capable of mapping water recycling flows and facilitating energy intensity analysis in water systems, providing essential insights for stakeholders to manage resources sustainably [14].

In the energy field, Sankey diagrams are used to identify energy-saving opportunities through the simultaneous representation of energy and exergy flows [15]. This approach enables a more detailed assessment of thermodynamic losses in industrial processes while also providing a rational basis for benchmarking and improving energy management. This diagram is highly relevant for national-level analysis, helping policymakers understand inefficiencies in the energy system and formulate more effective strategies.

Received: January 05, 2025; Accepted: April 17, 2025; Available online: July 31, 2025

Furthermore, Sankey diagrams can be employed to map the flow of energy from primary sources to end consumption across various sectors [16]. This diagram visualizes the efficiency and energy losses in industries such as residential, commercial, and transportation and provides essential insights for improving energy efficiency and reducing greenhouse gas emissions. This diagram also facilitates cross-sector analysis by matching energy input and output data, making it a handy tool for data-driven energy planning.

In previous studies, Sankey diagrams were more focused on identifying the flow of energy from its source to its destination. However, in general, when identifying land cover changes in an area, Sankey diagrams have several main advantages. With their intuitive visual format, these diagrams can display the proportions of resource flows and the relationships between elements, making it easier to identify the dominance of specific processes or resources [17]. This diagram also simplifies the interpretation of complex data, making it very useful for non-technical decision-makers [14]. Sankey diagrams have wide applications in various fields, such as energy management, supply chain, and environmental studies [18]. In more modern implementations, interactive features have even been introduced, allowing for dynamic exploration and real-time visualization of the impact of variable changes [19]. Thus, Sankey diagrams not only help identify inefficiencies in the system but also serve as practical visual communication tools to support collaboration and data-driven decision-making.

3. Result and discussion

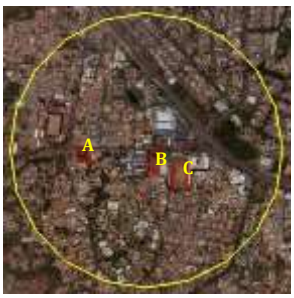
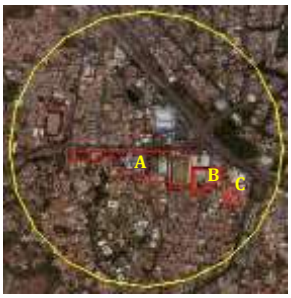
3.1. Result

3.1.1. Land cover change overview. The data presented by Google Earth can be used to identify land cover changes over a certain period. The availability of Google Earth data that can be obtained free of charge can make it easier for researchers and urban policymakers to identify and analyze land cover changes in an area. With the dynamic development of cities, this method will further facilitate supervising and monitoring space utilization in urban areas.

The development of the TOD Area in Jakarta raises the potential for the development of urban utilization. This is because one of the criteria of TOD Area is mixed land use (1). The identification of land cover changes in the TOD Area in more detail can be explained in the following Table 2.

Received: January 05, 2025; Accepted: April 17, 2025; Available online: July 31, 2025

Table 2. Identification of land cover change in Jakarta's TOD area.

TOD Area	Land Cover 2012	Land Cover 2024	Land Cover Change Identification
Lebak Bulus			A: Vegetation Area (7,893 m^2) B: Vegetation Area (5,711 m^2) C: Lebak Bulus Stadium (9,984 m^2) There were three land covers in 2012, which then changed into Lebak Bulus MRT Depot in 2024. The three plots are the vegetation area and Lebak Bulus Stadium. Totally the development of the Lebak Bulus TOD area has converted the vegetation and open space area as large as 23,588 m2 into a built-up area.
			A: MRT Lebak Bulus Depot (85,006 m^2) B: Vegetation Area (16,932 m^2) C: Vegetation Area (7,622 m^2) The construction of MRT Lebak Bulus Depot also resulted in the displacement of 35 buildings. Assuming that the building is a house building with the number of family members per house of four people [20], are 140 people affected by the Development of the Lebak Bulus TOD Area. In addition, through the interpretation of Google Earth image data, it can be identified that in 2024, there are vegetation areas that did not exist in 2012. In 2012, this vegetation area was a dense residential area. The existence of this vegetation area resulted in 121 buildings being displaced. Using the same assumptions, the number of people affected by this land cover conversion is 484 people. A total of 156 residential buildings comprising 624 people were

Received: January 05, 2025; Accepted: April 17, 2025; Available online: July 31, 2025

TOD Area	Land Cover 2012	Land Cover 2024	Land Cover Change Identification
			displaced due to land cover changes in the Lebak Bulus TOD Area.
Fatmawati			A: Vegetation Area (17,596 m^2) B: Vegetation Area (5,732 m^2) C: Barren Land (3,636 m^2) Based on the interpretation of Google Earth image data, in 2012, there was land cover in the form of vegetation around Fatmawati TOD Area. But in 2024, this land cover changed into a residential area and a multi-story building. From the land cover change process, there are at least five buildings that must be evicted, and there are an estimated 20 people affected by the land cover change.
Blok M, Sisingamangaraja, and Istora - Senayan			A: Barren Land (36,536 m^2) In general, there is no significant land cover change in the Blok M, Sisingamangaraja, and Istora-Senayan TOD areas. Existing changes occur in the Senayan TOD area, in 2012 there was a barren land which turned into a multi-storey building in 2024. However, in 2012, the barren land had already seen the process of land leveling. So, it can be concluded that this land cover change was planned in 2012.

Received: January 05, 2025; Accepted: April 17, 2025; Available online: July 31, 2025

TOD Area	Land Cover 2012	Land Cover 2024	Land Cover Change Identification
Dukuh Atas – Bundaran HI			In general, there is no change in land cover in the Dukuh Atas - Bundaran HI TOD Area. This may be because the Dukuh Atas and Bundaran HI MRT stations are located below ground level, so they do not require space above ground. In addition, the existing land use in the area is already dominated by built-up areas. This is by the land designation of the area in the Detailed Spatial Planning of DKI Jakarta as City Scale Trade and Services.

The comparative analysis between 2012 and 2024 shows that most TOD areas in Jakarta have experienced limited changes in land cover. However, the Lebak Bulus TOD area stands out with significant transformations, notably the conversion of large vegetation and open spaces into built-up areas, including the establishment of the MRT depot.

3.1.2. Sankey diagram. The Sankey diagram (Figure 3) illustrates the quantitative flow of land cover changes in TOD area. It visualizes how substantial portions of vegetation and barren land were reallocated into built-up areas. The diagram's design emphasizes the intensity and volume of these changes, offering a clear depiction of urban densification processes.

Received: January 05, 2025; Accepted: April 17, 2025; Available online: July 31, 2025

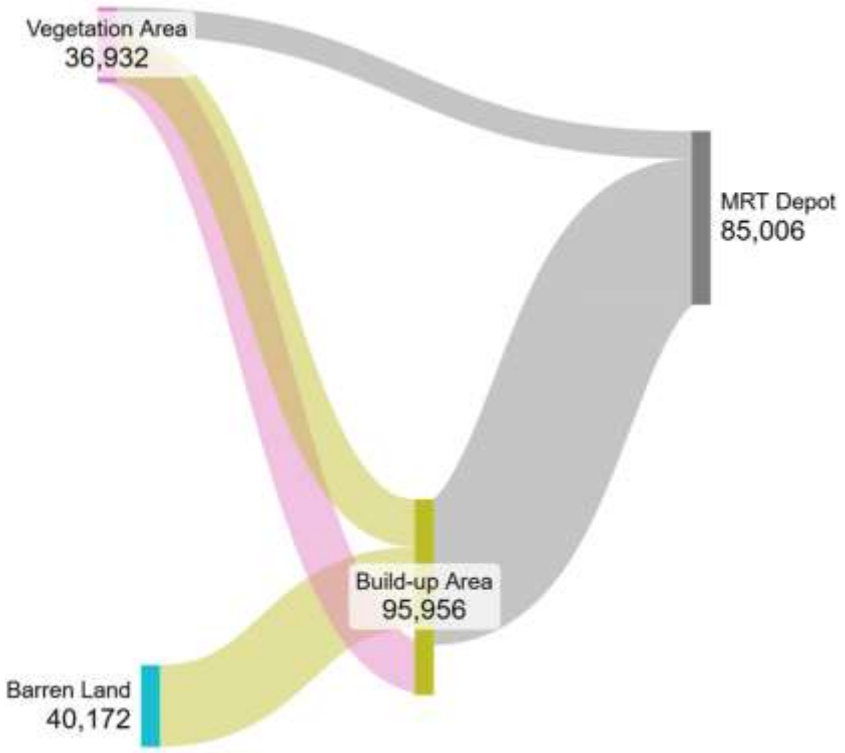


Figure 3. Sankey diagram of land cover change in Jakarta TOD area.

Each initial land cover (in 2012) is represented by a block on the left side of the diagram, with the total number of units of each listed: vegetation area (36,932 m2) and barren land (40,172 m2). The thickness of the line flowing from this 2012 land cover shows the proportion of unit distribution towards the 2024 land cover change.

The vegetation area underwent a substantial transformation, with most units converted into built-up areas. This implies that the vegetation in the TOD area was transformed into a built-up area to accommodate the urbanization requirements that may be linked to the development of the TOD Area. Additionally, a small portion of the vegetation area is designated as the MRT Depot. This indicates the endeavour to allocate land to advance the TOD Area. Moreover, barren land substantially contributed to the expansion of the built-up area. This transition indicates that once barren land is being used for urban development. Furthermore, several parcels of vacant land were allocated to the Lebak Bulus MRT Depot, demonstrating the use of vacant property to facilitate the advancement of transportation infrastructure. However, there have been instances where built-up area was later transformed into vegetated areas and the MRT Depot. The conversion of built-up area into vegetated area, as well as the MRT Depot, may have an impact on the relocation of residents who formerly lived there. According to satellite analysis, the construction of the MRT station harmed a total of 160 buildings.

Received: January 05, 2025; Accepted: April 17, 2025; Available online: July 31, 2025

3.2. Discussion

The analysis of land cover changes in Jakarta's Transit-Oriented Development (TOD) areas from 2012 to 2024 reveals critical insights into aligning these changes with the goals of TOD development as outlined in the city's Detailed Spatial Plan (RDTR). This study addresses the primary research objective of evaluating land use transformations and their adherence to TOD principles, with findings discussed below.

Firstly, the results indicate significant land cover changes were concentrated in the Lebak Bulus TOD area, where substantial portions of vegetation were replaced by built-up areas, including the MRT depot. This transformation reflects a clear prioritization of urban densification and infrastructure development. Conversely, other TOD areas, such as Dukuh Atas and Fatmawati, exhibited minimal or planned changes, suggesting preexisting urban density or challenges in redeveloping established zones. These observations highlight partial adherence to TOD principles, particularly the mixed use of urban spaces and integration of green and public areas.

Secondly, the findings provide scientifically grounded interpretations of these transformations. For instance, while converting vegetation and barren land to transit infrastructure aligns with urban development objectives, it underscores a lack of balance between growth and environmental preservation. The precise analysis of satellite imagery validates this land cover transitions, demonstrating the credibility of the results. Specific cases, such as the conversion of 35 buildings into vegetation in the Lebak Bulus TOD, reveal efforts to introduce green zones. However, these efforts are offset by more extensive vegetation losses elsewhere.

Thirdly, a comparison with previous studies confirms the broader trends of urbanization in Jakarta, including the reduction of green spaces and expansion of built-up areas. This study uniquely emphasizes the variations in land use changes across different TOD areas, revealing disparities in applying TOD principles. While the conversion of barren land into transit infrastructure aligns with common urbanization patterns, the findings underscore the need for more comprehensive policy enforcement to ensure TOD developments meet sustainable urbanization goals.

Finally, the implications for policy and planning are evident. The study stresses the importance of stricter adherence to RDTR criteria, particularly in maintaining green spaces and providing public areas within TOD zones. Enhanced monitoring mechanisms and regulatory enforcement are critical to balancing urban growth and environmental sustainability. Such measures can address challenges like the urban heat island effect, declining air quality, and reduced ecological resilience, ensuring that TOD areas fully contribute to the broader objectives of sustainable urban development.

This study underscores that while TOD development in Jakarta has achieved progress in urban densification, further efforts are needed to integrate ecological sustainability. Addressing

Received: January 05, 2025; Accepted: April 17, 2025; Available online: July 31, 2025

these gaps will ensure TOD areas fulfill their potential as key drivers of sustainable and resilient urban environments.

To build on this study, future research could address the following aspects, so here are the recommendations for future studies:

a. Broader Spatial and Temporal Scope: Expanding the analysis to include additional TOD areas and extending the observation period could provide a more comprehensive understanding of land cover dynamics and long-term trends in TOD implementation.
b. Integration of Climate and Social Impacts: Investigating the effects of TOD-related land cover changes on urban heat islands, air quality, and community displacement would offer insights into the environmental and social sustainability of TOD developments.
c. Evaluation of Additional TOD Criteria: Future studies should explore other TOD planning elements, such as pedestrian pathways, bicycle lanes, and public spaces, to evaluate how well these factors align with RDTR guidelines.
d. Incorporating Advanced Methodologies: Utilizing high-resolution remote sensing data, machine learning, or multi-temporal satellite imagery could improve the precision and depth of land cover analysis.
e. Policy Implementation Analysis: Assessing the effectiveness of existing policies in regulating TOD development and identifying barriers to policy enforcement could provide actionable recommendations for urban planners and policymakers.

By addressing these aspects, future research can contribute to a deeper and more holistic understanding of TOD dynamics, ensuring that these developments effectively promote sustainable and inclusive urban environments.

4. Conclusion

This study analyzed the evolution of land cover in Jakarta's TOD areas from 2012 to 2024. Although the official TOD implementation started in 2022, the extended timeframe provides critical insights into long-term trends and the broader impacts of urban development. The study underscores the critical need for stricter adherence to TOD principles, focusing on achieving a balance between urban development and ecological preservation. Key recommendations include:

a) Strengthened regulatory frameworks
- Revise the RDTR to include explicit minimum requirements for green open spaces within TOD zones.
- Mandate periodic compliance audits to ensure that new developments do not excessively diminish these areas.

b) Continuous monitoring
- Establish a dedicated monitoring system using periodic remote sensing analysis (e.g., every 2–3 years) to continuously evaluate land cover changes.
- Integrate data from Google Earth with local data sources for more accurate monitoring.

c) Targeted policy implementation

Received: January 05, 2025; Accepted: April 17, 2025; Available online: July 31, 2025

- Address the unique development pressures by tailoring strategies that consider the specific urban dynamics of each TOD location.
- Encourage stakeholder collaboration to identify and bridge gaps in the implementation of TOD principles.

By adopting these measures, policymakers can ensure that Jakarta's TOD developments contribute to sustainable urban growth while preserving critical environmental resources.

Acknowledgments
The authors express their deepest gratitude to the Department of Geography, Faculty of Mathematics and Natural Sciences, Universitas Indonesia, for providing the facilities that supported this research. Special thanks are also extended to PT. Airmas EMC for granting the opportunity to pursue studies at the Department of Geography, Faculty of Mathematics and Natural Sciences, Universitas Indonesia.

Declaration of generative AI and AI-assisted technologies in the writing process
While preparing this work, the authors used Quillbot, DeepL Translator (https://www.deepl.com/id/translator), and OpenAI for writing review. After using these tools/services, the authors reviewed and edited the content as needed and take full responsibility for the publication's content.

References
[1] Morfosa. Corridor Level Planning Transit Oriented Development : Potensi dan Tantangan 2024.
[2] Yen BTH, Mulley C, Chen MYJ, Chiou Y-C. How Transit-Oriented Development Concepts and Strategies Influenced Green Transport Systems: A Meta-Analysis Approach. Asian Transp Stud 2024;10:100136. https://doi.org/10.1016/j.eastsj.2024.100136.
[3] Kaniewska J, Ewing R, Sabouri S, Ameli H. Is Transit-Oriented Development Affordable for Low- And Moderate-Income Households? Cities 2024;147:104772. https://doi.org/10.1016/j.cities.2023.104772.
[4] Dai Y, Du S, Min H. Comparative Hotspot Analysis of Urban Living Environments and Transit-Oriented Development (TOD) Strategies: A Case Study of Beijing and Xi'an. ISPRS Int J Geo-Information 2023;12:446. https://doi.org/10.3390/ijgi12110446.
[5] Mukhamedjanov A, Kidokoro T, Seta F, Yang Y. Reshaping the Concept of Transit-Oriented Development in Response to Public Space Overheating Near the Transit Nodes of Tokyo. Cities 2021;116:103240. https://doi.org/10.1016/j.cities.2021.103240.
[6] Pemerintah Provinsi DKI Jakarta. Peraturan Gubernur DKI Jakarta No. 31 Tahun 2022 tentang Rencana Detail Tata Ruang Wilayah Perencanaan Provinsi DKI Jakarta. Indonesia: 2022.
[7] Sarker T, Fan P, Messina JP, Mujahid N, Aldrian E, Chen J. Impact of Urban Built-Up Volume on Urban environment: A Case of Jakarta. Sustain Cities Soc 2024;105:105346. https://doi.org/10.1016/j.scs.2024.105346.

Received: January 05, 2025; Accepted: April 17, 2025; Available online: July 31, 2025

[8] Wibowo A, Salleh KO, Frans FT. S, Semedi JM. Spatial Temporal Land Use Change Detection Using Google Earth Data. IOP Conf Ser Earth Environ Sci 2016;47:012031. https://doi.org/10.1088/1755-1315/47/1/012031.

[9] Arif N, Toersilowati L. Monitoring and Predicting Development of Built-Up Area in Sub-Urban Areas: A Case Study of Sleman, Yogyakarta, Indonesia. Heliyon 2024;10:e34466. https://doi.org/10.1016/j.heliyon.2024.e34466.

[10] Siswanto S, Nuryanto DE, Ferdiansyah MR, Prastiwi AD, Dewi OC, Gamal A, et al. Spatio-Temporal Characteristics of Urban Heat Island of Jakarta Metropolitan. Remote Sens Appl Soc Environ 2023;32:101062. https://doi.org/10.1016/j.rsase.2023.101062.

[11] Wei Y, Yuanxi L, Yu L, Mingxiang X, Liping Z, Qiuliang D. Impacts of Rainfall Intensity and Urbanization on Water Environment of Urban Lakes. Ecohydrol Hydrobiol 2020;20:513–24. https://doi.org/10.1016/j.ecohyd.2020.06.006.

[12] Peng L, Huang K, Zhang H, Sun W. Exploring the Impacts of Urbanization on Vegetation Growth from The Perspective of Urban Expansion Patterns and Maturity: A Case Study On 40 Large Cities in China. Sustain Cities Soc 2024;115:105841. https://doi.org/10.1016/j.scs.2024.105841.

[13] Reyes-Avila AD, Baxter RA. Assessment of Urbanization Impacts in Tegucigalpa Urban Greenness Via Normalized Difference Vegetation Index. Trees, For People 2024;18:100680. https://doi.org/10.1016/j.tfp.2024.100680.

[14] Rambau LD, Mativenga PT, Marnewick AL. Enhancing Frameworks for Utilising Sankey Diagrams in Modelling the Water-Energy Nexus and Circularity. J Clean Prod 2024;456:142355. https://doi.org/10.1016/j.jclepro.2024.142355.

[15] Soundararajan K, Ho HK, Su B. Sankey Diagram Framework for Energy and Exergy Flows. Appl Energy 2014;136:1035–42. https://doi.org/10.1016/j.apenergy.2014.08.070.

[16] Subramanyam V, Paramshivan D, Kumar A, Mondal MAH. Using Sankey Diagrams to Map Energy Flow from Primary Fuel to End Use. Energy Convers Manag 2015;91:342–52. https://doi.org/10.1016/j.enconman.2014.12.024.

[17] Qiao Y, Zhu L, Cao H, Liu Z, Wang G, Meng F. Sankey Diagram Mapping of Greenhouse Gas Emissions in Road Infrastructure Projects: A Cradle-To-Laid Perspective. Sustain Cities Soc 2025;130:106614. https://doi.org/10.1016/j.scs.2025.106614.

[18] Daniel D, West-Mitchell K. The Sankey Diagram: An Exploratory Application of a Data Visualization Tool. Transfusion 2024;64.

[19] Choudhary VK, Kumar G, Suman S, Kumar A. A Comprehensive Review on Data Visualization Techniques for Real-Time Information. 2024 Int. Conf. Inven. Comput. Technol., IEEE; 2024, p. 866–71. https://doi.org/10.1109/ICICT60155.2024.10544996.

[20] Suryo MS. Analisa Kebutuhan Luas Minimal Pola Rumah Sederhana Tapak Di Indonesia. J Permukim 2017;12:116. https://doi.org/10.31815/jp.2017.12.116-123.

Received: January 05, 2025; Accepted: April 17, 2025; Available online: July 31, 2025