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READINESS ASSESSMENT OF TRANSIT-ORIENTED DEVELOPMENT (TOD) CORRIDORS IN MALANG CITY, INDONESIA: A GIS-BASED EVALUATION OF ACCESSIBILITY AND LAND-USE INTEGRATION

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Abstract

The increasing mobility demand in Indonesian secondary cities highlights the need for spatial integration between transport infrastructure and land-use planning. This study aims to assess the readiness of Transit-Oriented Development (TOD) corridors in Malang City, Indonesia, using a GIS-based multi-criteria evaluation of accessibility and land-use integration. The study adopts the 5D+I framework: Density, Diversity, Design, Destination Accessibility, Distance to Transit, and Intermodality, to measure the spatial relationship between urban form and transport connectivity. Spatial data were obtained from the Laporan Umum Tim PKL Kota Malang 2024, complemented by field surveys, land-use maps, and transport network datasets. Each indicator was analyzed and normalized using GIS-based overlay and buffer analysis to generate a composite TOD Readiness Index (TRI). The results reveal that the Kota Baru–Soekarno Hatta–Tlogomas corridor exhibits the highest readiness level ($TRI = 0.81$), supported by high density, mixed land use, and multimodal accessibility. The Blimbing–Arjosari corridor shows moderate readiness, while peripheral areas remain less prepared due to low density and limited transit coverage. Findings indicate that accessibility and land-use diversity are strongly correlated ($r = 0.72$), suggesting that integrated planning enhances urban connectivity and supports sustainable mobility. Policy implications include the need for institutional coordination, pedestrian network improvements, and zoning adjustments to encourage compact mixed-use development around transit nodes. This study contributes a replicable GIS-based framework for evaluating TOD readiness in medium-sized Indonesian cities, bridging the gap between spatial analysis and practical urban planning.

Keywords: Transit-Oriented Development (TOD), GIS, Land-use Integration, Accessibility, Urban Corridors, Medium-Sized Cities, TOD Readiness Index

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INTRODUCTION

Rapid urban growth in Indonesian secondary cities has increasingly reshaped travel patterns, land-use intensity, and the spatial distribution of daily activities. Unlike metropolitan regions, medium-sized cities often experience a transitional phase where rising mobility demand is not yet matched by integrated transport infrastructure and coordinated spatial planning. As a result, traffic congestion, inefficient travel routes, and fragmented land-use patterns emerge along primary urban corridors, indicating structural challenges in managing urban accessibility.

Malang City, located in East Java Province, represents a typical medium-sized Indonesian city undergoing such transformation. Its role as an education and tourism hub has generated concentrated development along major arterial corridors, particularly Soekarno-Hatta, Basuki Rahmat, and Tlogomas. These corridors accommodate a mix of universities, commercial activities, and residential areas, leading to high trip generation and increasing pressure on the existing transport system. Despite the presence of railway stations and urban bus services, accessibility remains uneven, reflecting limited coordination between transport provision and surrounding land-use development.

In response to similar urban challenges, Transit-Oriented Development (TOD) has been widely adopted as a planning approach that aligns transport infrastructure with compact and mixed-use urban form. Previous studies have demonstrated that effective TOD implementation can enhance accessibility, support public transport usage, and reduce excessive reliance on private vehicles. However, in Indonesia, TOD initiatives have predominantly focused on large metropolitan areas such as Jakarta, Bandung, and Surabaya, where mass transit systems and institutional capacity are relatively well established. Consequently, empirical evidence on TOD readiness in secondary cities remains limited.

Malang City offers a strategic case for examining TOD readiness beyond metropolitan contexts. The city contains several key transport nodes, including Malang Kota Baru Station, Blimbing Station, Arjosari Terminal, and Landungsari Terminal, each surrounded by diverse urban functions and educational districts. Field observations and planning documents indicate that these nodes exhibit varying degrees of accessibility, land-use mix, and intermodal connectivity, suggesting unequal readiness for TOD-oriented development across corridors.

Assessing TOD readiness requires an analytical framework capable of capturing the spatial relationship between land-use characteristics and transport accessibility. Geographic Information Systems (GIS) provide a suitable platform for integrating these dimensions through spatial indicators such as density, land-use diversity, network design, proximity to activity centres, walking distance to transit, and intermodal connectivity. By operationalising these indicators into

measurable spatial variables, GIS-based analysis enables the identification of corridors with the highest potential for TOD implementation.

LITERATURE REVIEW

Transit-Oriented Development and Urban Accessibility

Transit-Oriented Development (TOD) has been widely discussed as an approach to improve urban accessibility by aligning transport infrastructure with land-use development. Early studies highlighted the importance of concentrating activities around transit facilities to support efficient travel patterns and reduce excessive dependence on private vehicles (Cervero & Kockelman, 1997). Subsequent research expanded this perspective by emphasising the role of urban design and network connectivity in shaping travel behaviour (Ewing & Handy, 2009; Ewing & Cervero, 2010).

Empirical evidence suggests that TOD outcomes vary significantly depending on urban context. Cities with established transit systems and coordinated land-use control tend to demonstrate stronger accessibility gains, whereas cities with fragmented planning frameworks experience uneven results (Zhao et al., 2020). In Southeast Asia, TOD studies have predominantly focused on large metropolitan regions, while medium-sized cities remain less examined despite experiencing rapid urban transformation (Wibowo et al., 2022).

Multidimensional Indicators for TOD Assessment

To translate TOD principles into measurable variables, researchers have developed indicator-based frameworks capturing the interaction between land use and transport systems. The initial focus on density, diversity, and design (Cervero & Kockelman, 1997) later evolved to incorporate destination accessibility and distance to transit, reflecting the functional performance of transport networks (Ewing & Handy, 2009; Ewing & Cervero, 2010).

Recent studies further extended this framework by including intermodality, particularly in urban contexts where accessibility depends on the integration of multiple transport modes (Curtis et al., 2016). This multidimensional approach enables a more comprehensive assessment of TOD readiness by accounting for both physical urban form and transport connectivity. However, the application of such frameworks has largely been concentrated in cities with mature public transport systems, limiting their generalisability to secondary cities with different mobility structures.

GIS-based Approaches in TOD Studies

Geographic Information Systems (GIS) have become a key analytical tool in TOD research due to their capacity to integrate spatial, demographic, and transport-related datasets. GIS-based methods allow researchers to examine

spatial variations in land-use intensity, accessibility, and proximity to transit facilities using techniques such as buffer analysis, spatial overlay, and network modelling (Vale, 2015; Curtis et al., 2021).

Several GIS-based studies conducted in Asian cities demonstrate how spatial analysis can reveal mismatches between land-use concentration and transit service coverage (Kumar et al., 2020; Irfan et al., 2021; Kamal & Osman, 2022). These mismatches often indicate areas where TOD potential exists but has not been fully realised due to planning or infrastructural constraints. Nevertheless, most existing studies emphasise station-based analysis in metropolitan contexts, providing limited insight into corridor-based TOD readiness in medium-sized cities (Yoon et al., 2019).

Research Gap and Conceptual Positioning

Despite the growing literature on TOD and GIS-based evaluation, two key gaps remain. First, there is limited empirical research addressing TOD readiness in medium-sized cities, particularly in Indonesia, where transport systems are dominated by corridor-based movement patterns rather than extensive rail networks (Wibowo et al., 2022). Second, many studies focus on post-implementation impacts of TOD, while fewer examine pre-implementation readiness based on existing land-use and accessibility conditions.

To address these gaps, this study operationalises the 5D+I framework into measurable GIS-based spatial indicators. Each indicator is selected to directly reflect the identified limitations in previous studies, particularly in capturing corridor-based accessibility patterns and intermodal connectivity in medium-sized cities.

This study addresses these gaps by applying a GIS-based, corridor-oriented evaluation of TOD readiness in Malang City. By integrating multidimensional indicators of land-use characteristics and transport accessibility into a composite readiness index, the study aligns with recent methodological developments (Curtis et al., 2016; Curtis et al., 2021) while responding to the contextual needs of secondary Indonesian cities. This positioning contributes to the literature by offering an empirically grounded framework that supports evidence-based spatial planning prior to TOD implementation.

RESEARCH METHODOLOGY

Study Area and Data Sources

This study was conducted in Malang City, East Java Province, Indonesia, covering an administrative area of approximately 110.06 km². As a medium-sized urban centre, Malang functions as a regional hub for education, tourism, trade, and services, generating intensive daily travel demand across its primary road corridors. The spatial focus of this study includes three main urban corridors that

concentrate transport infrastructure and urban activities: Basuki Rahmat–Soekarno Hatta–Tlogomas, LA Sucipto–Blimbing–Arjosari, and S. Parman–Borobudur–Mayjen Sungkono.

Spatial and transport data were obtained from multiple sources to ensure analytical robustness. Primary data were derived from field surveys conducted in 2024 by the Indonesian Land Transportation Polytechnic (PTDI–STTD), including pedestrian infrastructure observations, transit stop locations, and intermodal facilities. Secondary data consisted of land-use maps, population statistics, urban transport network data, and official planning documents such as the Malang City Spatial Plan (RTRW 2021–2041) and the Transport Master Plan. OpenStreetMap (OSM) data were used to complement road network and intersection information.

TOD Readiness Indicators and Analytical Framework

The TOD readiness assessment was based on six spatial indicators representing the 5D + I framework (Density, Diversity, Design, Destination Accessibility, Distance to Transit, and Intermodality). Each indicator was quantified and spatially analyzed using GIS tools, as described below:

Table 1. Spatial Indicators Representing the 5D+I Framework

Indicator	Description	GIS-Based Measurement	Data Source
Density	Residential and employment intensity around transport nodes	Population density and building floor area within 400 m and 800 m buffers	PKL 2024; RTRW Malang 2021–2041
Diversity	Land-use mix (residential, commercial, institutional, green)	Entropy index calculated from land-use polygons	PKL 2024; Land-use map
Design	Street connectivity and pedestrian environment	Intersection density, sidewalk coverage ratio	Field survey 2024; OSM
Destination Accessibility	Proximity to key activity centres	Cumulative accessibility index (based on travel time)	Transport Master Plan 2023; PKL 2024
Distance to Transit	Walking distance to nearest transit stop	Euclidean and network buffer analysis (≤ 800 m)	OSM; Field observation
Intermodality	Connectivity between different modes	Number of transport services intersecting per node	PKL 2024; BPTD Jabar data

Source: PKL Malang 2024 Data and Author's Calculation

The 5D+I framework was selected due to its ability to comprehensively capture both physical urban form and multimodal transport integration, making it particularly suitable for corridor-based analysis in medium-sized cities.

Each indicator was normalized into a 0–1 scale using min–max standardization, ensuring comparability across variables. To ensure analytical robustness, the spatial results were validated through expert interviews with planners from the Malang City Transport Agency and academics from PTDI–STTD. The final interpretation integrates quantitative spatial analysis with qualitative insights to provide comprehensive policy recommendations for TOD development in Malang City.

Destination accessibility was evaluated by estimating cumulative access to key urban activity centres based on travel time along the road network. Distance to transit measured the effective walking distance from surrounding land parcels to the nearest public transport stop using both Euclidean and network-based approaches. Intermodality reflected the level of connectivity between different transport modes, assessed by identifying the number and type of transport services intersecting at each node.

GIS-based Spatial Analysis

The selection of buffer distances (400 m and 800 m) is based on commonly accepted walking thresholds in TOD studies, representing approximately 5–10 minutes walking distance under typical urban conditions (Cervero & Kockelman, 1997; Ewing & Cervero, 2010).

Intermodality was quantified by counting the number of distinct transport modes (e.g., angkot routes, bus services, and railway access) intersecting within each node buffer zone. Each mode was assigned equal weight.

All spatial analyses were performed using Geographic Information Systems (GIS) to integrate land-use, transport, and accessibility datasets. Buffer zones of 400 m and 800 m were applied around major transit nodes to represent practical walking distances in the local context. Spatial overlay techniques were used to combine land-use patterns with transport infrastructure, while network analysis supported the calculation of accessibility and distance-related indicators.

To enable comparison across indicators with different measurement units, each variable was normalised to a standardised scale ranging from 0 to 1 using min–max transformation. The normalised indicators were subsequently aggregated to generate a composite Transit-Oriented Development Readiness Index (TRI) for each corridor. The index reflects the relative readiness of urban corridors rather than absolute TOD performance, allowing comparative interpretation across spatial segments.

ANALYSIS AND DISCUSSION

Spatial Characteristics of Malang's Urban Corridors

The GIS-based analysis revealed that Malang's spatial structure is dominated by three major arterial corridors with strong urban activity concentration: Stasiun

Malang Kota Baru–Soekarno Hatta–Tlogomas Corridor, Blimbing–LA Sucipto–Arjosari Corridor, and S. Parman–Borobudur–Mayjen Sungkono Corridor. The Laporan Umum Tim PKL Kota Malang 2024 indicates that these corridors exhibit the highest population density and mixed land-use intensity, with educational, commercial, and residential functions clustered along main roads and near transit facilities. The proximity of major campuses (Universitas Brawijaya, Universitas Negeri Malang, and UIN Malang) also contributes to high trip generation and public transport demand.

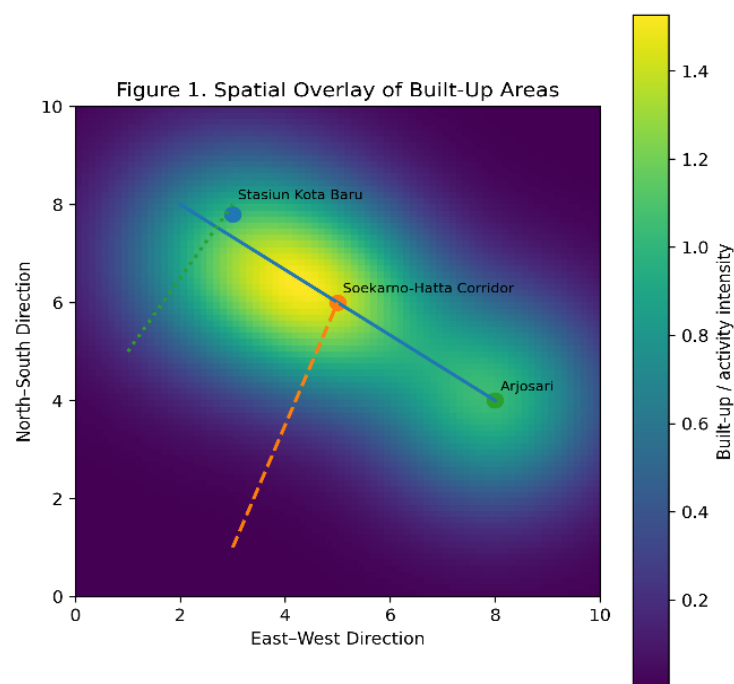


Figure 1. Spatial Overlay of Built-Up Areas and Public Transport Routes showing a Polycentric Urban Pattern in Malang City
 Source: PKL Malang 2024 Data and Author's Calculation

Spatial overlay mapping (Figure 1) demonstrates that built-up areas and public transport routes form a polycentric urban pattern, with high-density clusters around Stasiun Kota Baru, Soekarno-Hatta, and Arjosari. This pattern suggests that the city's land-use configuration already supports the fundamental characteristics of a TOD-based structure.

TOD Readiness Index (TRI) Result

The computed Transit-Oriented Development Readiness Index (TRI) integrates six weighted indicators (Density, Diversity, Design, Destination Accessibility, Distance to Transit, and Intermodality). Table 2 summarises the composite scores and readiness classification for each corridor.

Table 2. TOD Readiness Index by Corridor in Malang City

Corridor	TRI Score	Readiness Category	Dominant Strength	Primary Constraint
Kota Baru – Soekarno Hatta – Tlogomas	0.81	Highly Ready	High density, diverse land use, and good pedestrian access	Limited intermodal linkage with feeder services
Blimbing – LA Sucipto – Arjosari	0.68	Moderately Ready	High accessibility and multimodal nodes	Weak pedestrian network and land-use fragmentation
S. Parman – Borobudur – Mayjen Sungkono	0.54	Moderately Ready	Balanced land-use and proximity to bus corridors	Limited activity mix and poor sidewalk condition
Peripheral Suburban Corridors	0.37	Less Ready	Availability of land for TOD expansion	Low density and weak transit service coverage

Source: PKL Malang 2024 Data and Author's Calculation

The Kota Baru–Soekarno Hatta–Tlogomas corridor achieved the highest readiness score (TRI = 0.81), indicating strong alignment between transport accessibility and land-use integration. This corridor demonstrates compact development, continuous sidewalk infrastructure, and high public transport ridership potential due to the presence of multiple trip attractors. Conversely, suburban corridors recorded low TRI values (<0.40), primarily due to sparse population density and inadequate public transport coverage.

Spatial Distribution of TOD Readiness

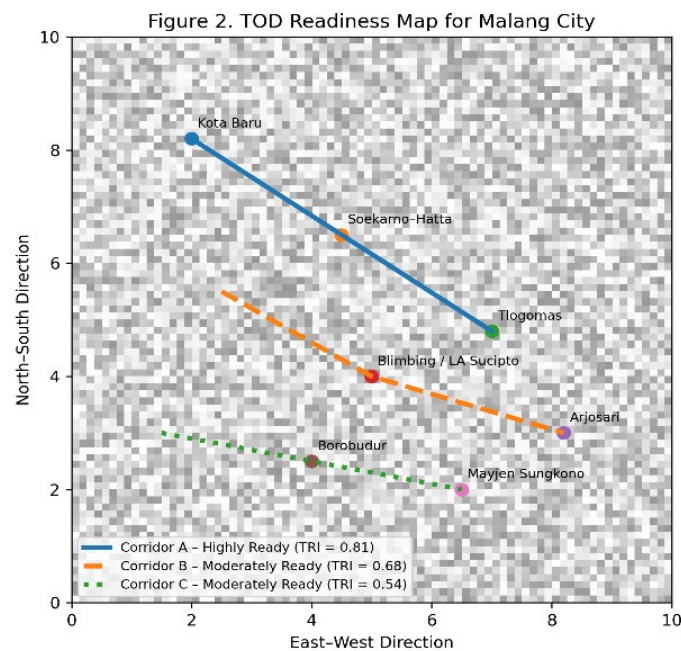


Figure 2. TOD Readiness Map Showing TRI Values Along the Main Corridors of Malang City

Source: PKL Malang 2024 Data and Author's Calculation

The GIS-based thematic map (Figure 2) illustrates the spatial variation of TOD readiness across Malang City.

1. High-readiness zones ($TRI > 0.75$) are concentrated around Stasiun Malang Kota Baru and the Soekarno Hatta corridor, where land-use intensity and multimodal connectivity are strongest.
2. Moderate-readiness zones ($0.50\text{--}0.74$) extend towards Blimbing and Tlogomas, which serve as secondary urban nodes with active transport services and educational activities.
3. Low-readiness zones (<0.50) are primarily found in peripheral areas, including western and southern Malang, characterized by single-use residential zoning and limited transit options.

This spatial pattern confirms the presence of a hierarchical TOD potential, suggesting that urban development policies should prioritize the

enhancement of accessibility and public transport service integration within the first two corridors.

Accessibility and Land-Use Integration Analysis

Spatial correlation analysis between the land-use entropy index and accessibility index shows a significant positive relationship ($r = 0.72$), indicating that mixed-use areas are generally well connected to transit services. This implies that land-use diversity directly supports accessibility improvement in urban corridors, a condition favourable for TOD planning.

However, field verification reveals gaps in last-mile connectivity and pedestrian comfort. Sidewalk discontinuity and limited shading infrastructure reduce the attractiveness of walking to transit stops, especially in the Arjosari and Borobudur segments. Such micro-scale barriers diminish effective accessibility despite favourable macro-scale land-use configurations.

The study also identifies weak integration between urban bus services (angkot) and railway nodes, where feeder routes often terminate more than 200 metres from station entrances. Improving these intermodal transfer points would significantly raise intermodality scores and overall corridor readiness.

Policy and Planning Implications

The analysis demonstrates that Malang City possesses strong potential for TOD development, particularly along the Kota Baru–Soekarno Hatta–Tlogomas corridor, which meets most criteria of the 5D+I framework. Nevertheless, the successful implementation of TOD requires coordinated efforts in several key areas:

1. **Institutional Integration**
Alignment between the Malang City Planning Department and the Transport Agency is essential to ensure consistency between spatial zoning and public transport routes. A unified TOD corridor master plan should be formulated to guide zoning incentives and infrastructure upgrades.
2. **Pedestrian and Non-Motorized Infrastructure**
Pedestrian improvements should prioritise continuous sidewalks with a minimum width of 1.5–2.0 meters, shading elements, and safe crossing facilities within 400 m of major transit nodes. The improvement of walkability and bicycle networks must accompany transit upgrades. Streetscape revitalisation around Soekarno Hatta and Tlogomas can enhance design quality and encourage modal shift.
3. **Intermodal Facility Enhancement**

The creation of Transit Interchange Nodes linking angkot, railway, and bus services is critical. A physical integration policy, such as shared ticketing or unified signage, would further increase accessibility and travel efficiency.

4. Land-Use Regulation and Incentives

Development control policies should allow higher Floor Area Ratios (FAR) and mixed-use zoning within 800 metres of transit stations. Incentives for vertical development and mixed residential–commercial projects can increase corridor density and reduce travel distances.

5. Data and GIS Integration in Planning

Continuous data monitoring through GIS platforms enables dynamic evaluation of TOD progress and helps policymakers visualize the spatial impact of development initiatives.

These interventions can be prioritised through short-term (1–3 years) pedestrian improvements and medium-term (3–5 years) intermodal integration strategies to ensure phased TOD implementation.

DISCUSSION SUMMARY

Overall, the GIS-based readiness evaluation confirms that Malang City is moderately to highly ready for TOD implementation in specific corridors, especially near existing multimodal hubs. The integration of accessibility and land-use data using the 5D+I framework effectively captures both macro- and micro-spatial interactions that determine TOD feasibility.

The study's methodological contribution lies in combining empirical field data with spatial modelling, enabling planners to identify priority areas for policy intervention. Furthermore, it demonstrates how medium-sized cities, often overlooked in TOD research, can leverage spatial analysis to achieve evidence-based and context-specific urban transport planning.

CONCLUSION

This study demonstrates that corridor-based TOD assessment provides a more suitable analytical approach for medium-sized cities compared to station-based evaluation commonly used in metropolitan contexts.

This study contributes both methodologically, by proposing a GIS-based corridor evaluation framework, and practically, by providing spatially explicit guidance for TOD policy implementation in medium-sized cities.

This study assessed the readiness of Transit-Oriented Development (TOD) corridors in Malang City, Indonesia, through a GIS-based integration of accessibility and land-use indicators. The evaluation applied a 5D+I framework: Density, Diversity, Design, Destination Accessibility, Distance to Transit, and Intermodality, to measure the spatial relationship between transport infrastructure

and urban form. The results revealed distinct spatial patterns of readiness across the city's major transport corridors, highlighting both potential and challenges for future TOD implementation.

The analysis identified that the Kota Baru–Soekarno Hatta–Tlogomas corridor achieved the highest readiness index ($TRI = 0.81$), indicating strong land-use integration, high accessibility, and multimodal connectivity. The Blimbing–LA Sucipto–Arjosari corridor and S. Parman–Borobudur–Mayjen Sungkono corridor demonstrated moderate readiness levels, primarily constrained by discontinuous pedestrian infrastructure and limited land-use diversity. Peripheral areas of Malang showed low readiness due to sparse development and insufficient transit coverage.

The spatial correlation between land-use mix and accessibility ($r = 0.72$) confirmed that mixed-use urban areas generate better accessibility performance and higher TOD readiness potential. This implies that enhancing spatial integration and multimodal accessibility could significantly increase TOD feasibility in medium-sized cities like Malang.

In conclusion, Malang City demonstrates moderate to high readiness for TOD development, particularly in its central and educational corridors. Through a GIS-based integration of accessibility and land-use data, this study has shown that evidence-based spatial analysis can effectively guide sustainable transport and urban planning. Strengthening institutional coordination, improving intermodal connectivity, and fostering mixed-use development are key steps toward realising TOD as a catalyst for sustainable urban transformation in Indonesian medium-sized cities.

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