ROUTE PLANNING FOR A NEW GRESIK–MOJOKERTO COMMUTER RAIL CORRIDOR USING DEMAND, LAND USE, AND ACCESSIBILITY ANALYSIS

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ABSTRACT

Rapid suburban growth in the Gerbangkertosusila metropolitan area has intensified daily interregional mobility, particularly along the Gresik–Mojokerto corridor, where direct commuter rail service is not yet available. Therefore, this study aims to identify and justify a proposed new commuter rail corridor by integrating travel demand concentration, land use suitability, accessibility structure, and simulated modal-shift potential. The analysis combines spatial concentration of mapped trip origins, corridor-based spatial screening, land-use evaluation, and a scenario-based passenger-demand framework, using 385 analytical trip observations, comprising 254 motorcycle-based trips and 131 car-based trips. The results show that 322 of 385 mapped trips, or 83.64%, are concentrated in Gresik and Mojokerto, confirming the corridor's strategic importance. The proposed alignment follows major transport, industrial, residential, educational, and socio-religious nodes and forms a direct corridor of approximately 44.14 km, with a projected end-to-end travel time of less than one hour. The existing modal structure remains dominated by private vehicles, particularly motorcycles, while the stated-preference simulation indicates a prospective passenger-capture potential of 72.47% under the tested time–fare scenarios. Spatially, the strongest passenger-capture potential occurs in areas with high travel concentration and better corridor accessibility. These findings indicate that the proposed line has planning-stage potential to improve corridor accessibility, strengthen interdistrict connectivity, and support a more efficient regional mobility structure. This study contributes an integrated corridor-planning framework for early-stage commuter rail development.

Keywords: *Commuter rail; Travel demand; Land use; Accessibility; Modal shift. Gresik–Mojokerto.*

1. INTRODUCTION

Rapid suburban expansion in the Gerbangkertosusila (GKS) metropolitan area has intensified daily interregional mobility, particularly along corridors that connect residential, industrial, and service-based activity centers. One of the corridors most affected by this dynamic is the Gresik–Mojokerto corridor, where the absence of direct rail connectivity has reinforced a strong dependence on private vehicles for commuting and other routine trips. As road-based travel remains dominant, increasing traffic volumes have contributed to congestion, longer travel times, lower reliability, and broader mobility inefficiency in metropolitan regions where transport supply does not keep pace with demand (Musolino et al., 2023; Yang et al., 2022; Chen et al., 2022). Recent studies have highlighted that rapidly expanding metropolitan regions require integrated transport systems capable of accommodating increasing commuter demand while reducing dependence on private vehicles.

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In this context, commuter rail has emerged as a strategic transport mode because it provides high-capacity services, improves regional accessibility, and supports sustainable metropolitan development. Consequently, identifying suitable commuter rail corridors through integrated analyses of travel demand, land use, and accessibility has become an increasingly important research topic in rapidly developing metropolitan regions.

The Gresik–Mojokerto corridor is regionally important because it connects areas with strong economic, industrial, residential, and service interactions within the broader GKS metropolitan structure. Gresik plays a strategic role as an industrial and logistics hub, while Mojokerto serves as an important residential and regional activity center, generating substantial cross-district travel demand. In addition, continued demographic growth and increasing mobility intensity in the corridor indicate that travel demand is likely to remain strong in the future. Under these circumstances, improving corridor connectivity extends beyond transportation planning and constitutes an important regional development strategy, as efficient mobility enhances labor accessibility, economic integration, and territorial cohesion across the metropolitan area (Badan Pusat Statistik Provinsi Jawa Timur, 2020; Badan Pusat Statistik Provinsi Jawa Timur, 2025; Ewing & Cervero, 2010). Furthermore, the corridor contains a continuous concentration of industrial estates, residential neighborhoods, educational institutions, commercial areas, and public service facilities that collectively generate substantial daily commuting flows. Such a spatial configuration provides favorable conditions for commuter rail development because major trip origins and destinations are distributed along a relatively direct metropolitan corridor. Consequently, the corridor represents a promising candidate for commuter rail development, warranting further evaluation through an integrated framework that considers travel demand, land-use characteristics, accessibility, route planning, and operational feasibility.

However, despite its favorable spatial characteristics and important regional role, the Gresik–Mojokerto corridor is still not served by a direct commuter rail line. Existing railway services in the GKS area connect several surrounding corridors, yet direct rail movement between Gresik and Mojokerto remains unavailable, forcing travelers to rely on indirect rail connections or road-based transport. This network gap reduces the competitiveness of public transportation and limits the role of rail as a high-capacity alternative for regional commuting. At the same time, the corridor's spatial structure, characterized by expanding residential areas, industrial zones, public facilities, educational institutions, and activity centers, suggests strong potential for a more direct and efficient commuter rail connection. Within the broader Gerbangkertosusila context, similar road-based mobility pressure has also been observed in nearby metropolitan corridors where commercial and industrial expansion has contributed to longer intercity travel times, particularly in the Surabaya–Sidoarjo corridor (Waloejo et al., 2020). Therefore, the main issue is no longer whether rail is beneficial in general, but rather where and how a new commuter rail alignment should be planned to respond effectively to actual travel demand, spatial structure, and regional mobility needs (Japan International Cooperation Agency, 2011; Zaiachuk & Zolotunets, 2024).

Previous studies have consistently shown that planning a new rail corridor should be supported by an integrated assessment of passenger demand, accessibility, land-use characteristics, and route feasibility. Demand-oriented studies indicate that travel time, travel cost, and service competitiveness strongly influence users' willingness to shift from private vehicles to rail (Helmmie & Joewono, 2022; Thaithatkul et al., 2023; Abbasi et al., 2023). Accessibility studies further demonstrate that the effectiveness of rail investment depends on how well the proposed service connects origins, destinations, and activity nodes within the urban–suburban structure (Chen et al., 2022; Dianin et al., 2024; Otsuka et al., 2022). GIS-based accessibility analysis has also been widely used to evaluate public transport performance in metropolitan areas by identifying spatial service gaps, population coverage, and accessibility differences across urban regions (Biswas et al., 2023). From a spatial planning perspective, land-use patterns and the distribution of settlements, industrial areas, and public facilities are also essential for identifying corridors with strong and sustainable passenger potential, while route planning studies emphasize that alignment selection should reflect both demand concentration and operational relevance (Öztürk & Bozkurtoğlu, 2023; Giuliano, 2004; Rahmadani et al., 2025). Recent studies increasingly emphasize that effective commuter rail planning should integrate travel demand, accessibility, land-use characteristics, and spatial analysis within a unified planning framework. Such an approach enables planners to evaluate not only potential passenger demand but also the spatial suitability and operational feasibility of proposed rail corridors, particularly during the early planning stage when detailed operational data remain limited. Therefore, integrating these complementary perspectives provides a more comprehensive basis for identifying strategically viable commuter rail corridors.

However, existing literature is still dominated by studies that focus on travel demand and modal shift without proposing a clear alignment, or by broader rail development discussions that do not sufficiently integrate corridor-specific spatial analysis. In the case of the Gresik–Mojokerto corridor, this gap is particularly important because the challenge is not merely to estimate whether commuter rail could attract passengers, but to identify a plausible new alignment based on the corridor's actual spatial structure. In other words, demand forecasting alone is insufficient if it is not linked to the physical logic of route planning, while spatial corridor analysis alone is incomplete if it is not supported by evidence of potential passenger demand. A more integrated approach is therefore needed to bridge mobility demand, land-use conditions, and route selection in planning a new commuter rail corridor (Qian et al., 2023; Hou et al., 2021; Ergin, 2024).

This study addresses that gap by combining user-response-based passenger capture, land use and accessibility analysis, and corridor-based spatial screening within a single route-planning framework for early-stage commuter rail development. In this way, the study contributes not only a proposed alignment for the Gresik–Mojokerto corridor, but also an integrated methodological approach for linking demand evidence, spatial structure, and route selection in suburban rail planning (Otsuka et al., 2022; Öztürk & Bozkurtoğlu, 2023; Qian et al., 2023; Dianin et al., 2024; Ergin, 2024).

Based on this background, this study aims to propose a new commuter rail alignment for the Gresik–Mojokerto corridor by integrating potential passenger demand analysis with land-use, accessibility, and corridor-spatial evaluation. Specifically, the study identifies the corridor's strategic importance, examines potential travel demand and modal shifts, analyzes the spatial distribution of activity and land use, and proposes a more direct commuter rail route responsive to regional mobility patterns. By doing so, the study provides policy-relevant evidence for early-stage commuter rail planning and regional connectivity improvement in the GKS metropolitan area. This case also represents a broader planning problem in emerging metropolitan regions, where proposed rail corridors must be justified before operation using limited demand data, spatial evidence, and preliminary service assumptions. The novelty of this study lies in integrating stated-preference-based passenger capture, spatial concentration of mapped trip origins, land-use suitability, accessibility structure, operational directness, and corridor suitability scoring into a single planning-stage corridor appraisal framework.

2. STUDY AREA

2.1. Corridor Setting and Strategic Importance

The study area is the Gresik–Mojokerto corridor in the Gerbangkertosusila (GKS) metropolitan region, East Java, Indonesia. The corridor links industrial, logistics, residential, employment, and public-service areas within the wider Surabaya metropolitan system. However, Gresik and Mojokerto are not yet connected by direct commuter rail, so interdistrict mobility still depends heavily on private road-based transport or indirect rail movement through other urban nodes. This condition reduces the competitiveness of public transport and limits the availability of a high-capacity alternative for suburban commuting. **Fig. 1** shows the study area and the existing transport setting within the GKS region.

The corridor is relevant for rail-corridor appraisal because it combines unmet rail connectivity, interdistrict movement, mixed land-use structure, and transitional land that may support alignment feasibility. Improved mass transportation accessibility has also been recognized as a strategic priority in the GKS area to support labor mobility, economic interaction, and interdistrict transport integration

(Japan International Cooperation Agency, 2011). Evidence from the broader Surabaya metropolitan road network further indicates that industrial and commercial expansion can reduce road performance along major intercity corridors, including the Surabaya–Mojokerto, Surabaya–Sidoarjo, and Surabaya–Gresik corridors (Waloejo et al., 2020). Therefore, the Gresik–Mojokerto corridor provides a relevant case for examining a new commuter rail alignment that responds to regional mobility needs and spatial development patterns.

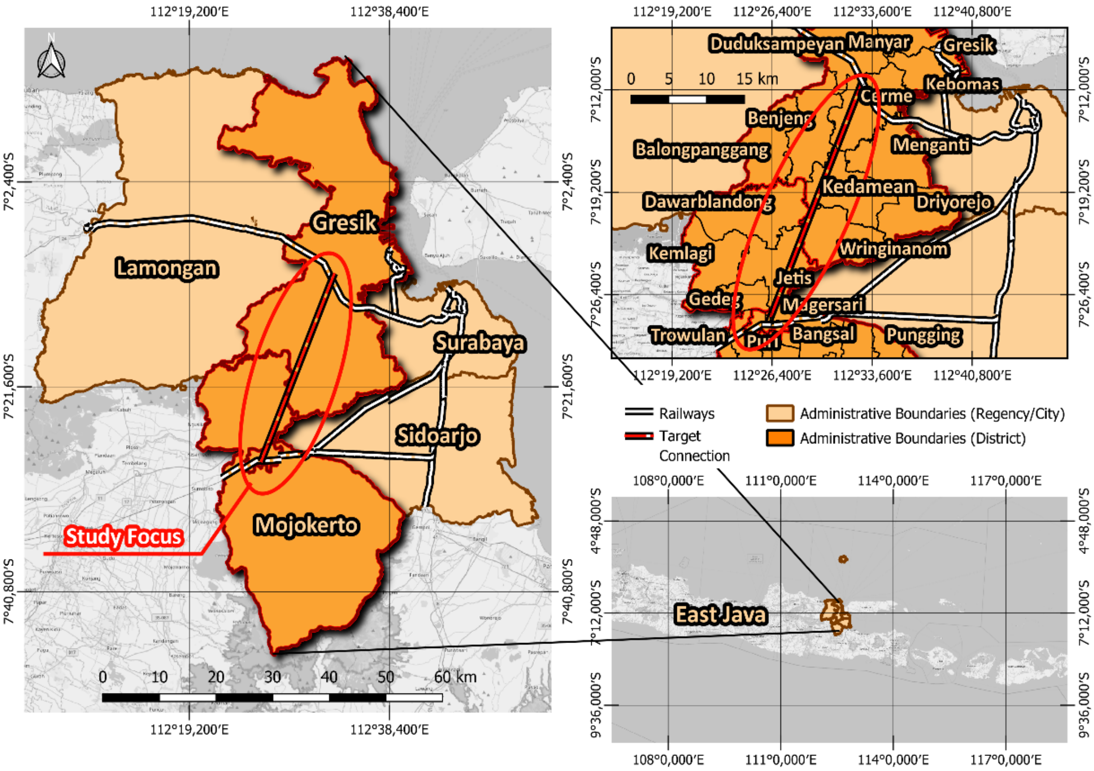

Fig. 1. Gerbangkertosusila (GKS) metropolitan region.

2.2. Population Density, Land Use and Corridor Characteristics

Population growth and density patterns reinforce the strategic importance of the corridor. As shown in **Fig. 2**, the Gerbangkertosusila region has persistent high-density concentrations around the Surabaya–Sidoarjo–Gresik urban core, while the Gresik–Mojokerto corridor links these dense metropolitan areas with developing peri-urban and transitional zones. In 2025, Gresik Regency had approximately 1.38 million inhabitants, while Mojokerto Regency had approximately 1.16 million inhabitants, indicating substantial mobility pressure and the need for efficient interdistrict transport (Badan Pusat Statistik Provinsi Jawa Timur, 2020; Badan Pusat Statistik Provinsi Jawa Timur, 2025).

Spatially, the Gresik–Mojokerto corridor contains mixed land uses, including industrial areas, settlements, agricultural land, and local activity centers. These conditions indicate both trip-generation potential and alignment constraints. While built-up expansion increases interdistrict travel pressure, remaining agricultural and semi-open areas provide opportunities for lower-conflict rail alignment. **Fig. 3** presents the corridor land-use pattern, while **Table 1** summarizes the dominant characteristics of each route section (Rahmadani et al., 2025; Giuliano, 2004; Ewing & Cervero, 2010).

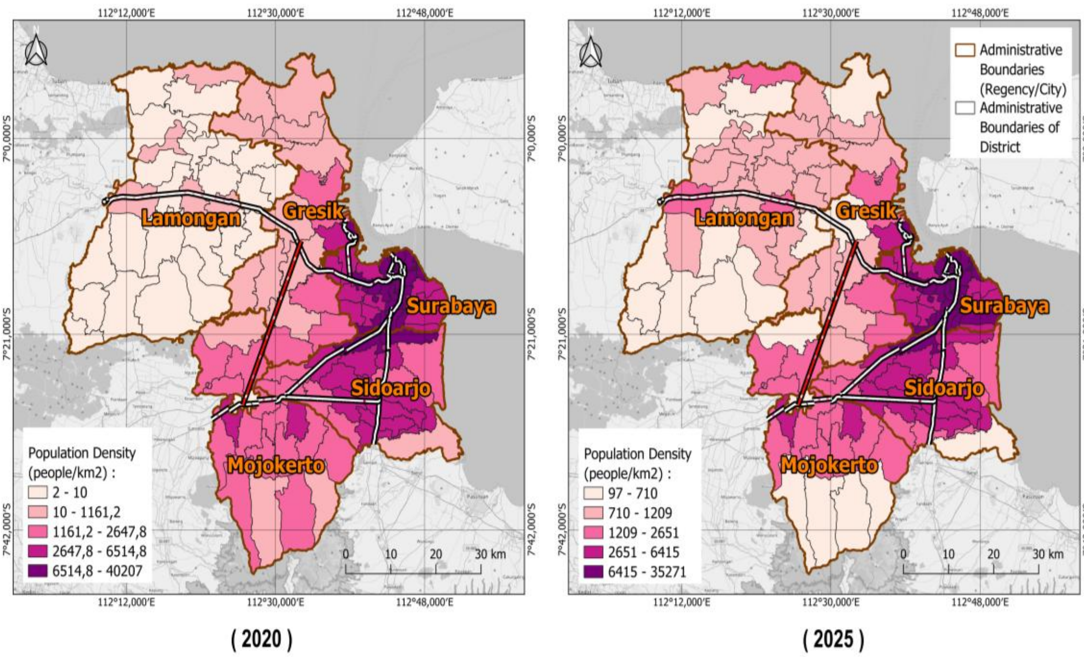

Fig. 2. Population density distribution of the Gerbangkertosusila region in 2020 and 2025.

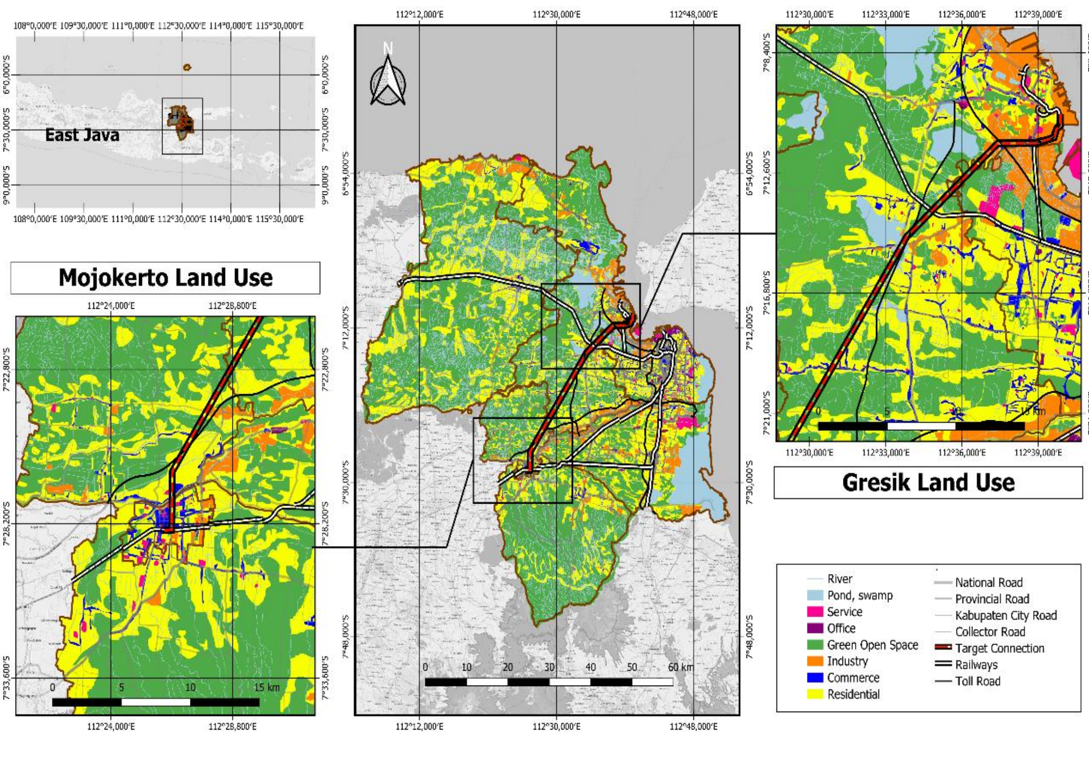

Fig. 3. Land use conditions along the Gresik–Mojokerto corridor.

Table 1.
Dominant land use and corridor characteristics along the proposed Gresik–Mojokerto commuter rail alignment.

No.	Regency/ City	District	Main road segment (s)	Dominant land use characteristics	Planning implications for rail alignment
1	Gresik Regency	Kebomas	Jl. Kapten Darmo Sugondo; Jl. Mayjen Sungkono; Manyar–Mojokerto Toll Road	Industrial area, urban settlement, and regional transport corridor	Strategic demand segment with potential land-acquisition constraints.
2	Gresik Regency	Cerme	Jl. Raya Morowudi	Rice fields, aquaculture, and low-density settlement	Semi-open segment with flexible alignment potential.
3	Gresik Regency	Menganti	Jl. Plampang; Jl. Desa Beton; Jl. Bibis; Jl. Raya Pranti	Rice fields, plantations, and settlements	Growing peri-urban area with feasible alignment potential.
4	Gresik Regency	Kedamean–Wringinanom	Jl. Ki Ageng Lukojoyo; Jl. Kesamben corridor	Rice fields, settlement, plantation, and a small industrial area	Transitional segment supporting route continuity.
5	Gresik Regency	Wringinanom	Jl. Medang Kamulan; Jl. Kepuhklagen	Rice fields, plantations, settlements, and minor land uses	Open-land segment with lower land-conflict potential.
6	Mojokerto Regency	Jetis	Jl. Raya Sidorejo; Jl. Raya Jetis; Mojokerto–Krian Toll Road	Rice fields, settlement, plantation, and industrial area	The mixed-use segment is strengthening access toward Mojokerto.
7	Mojokerto Regency	Gedeg	Jl. Losari Timur	Rice fields, settlement, plantation, and forest area	Low-density segment supporting corridor continuity.
8	Mojokerto City	Magersari	Jl. Gajah Mada; Jl. Bhayangkara	Trade, office, and urban built-up area	Urban activity segment with strong passenger attraction.

Source: Author's compilation based on corridor segment data used in this study.

As shown in **Table 1**, the proposed corridor combines urban-industrial, peri-urban agricultural, transitional, and urban commercial segments. Kebomas and Magersari function as major trip-generating areas, while Cerme, Menganti, Wringinanom, Jetis, and Gedeg provide more flexible alignment conditions through agricultural, plantation, and lower-density settlement land. This spatial structure allows the proposed route to balance passenger-demand capture, land-use feasibility, and corridor continuity.

2.3. Road Network and Corridor Characteristics

The road network in the study area remains the dominant infrastructure for interregional mobility. The GKS road system comprises national, provincial, and district/city roads that serve major economic and settlement areas, but road dependency has also intensified congestion and reduced travel efficiency in several important corridors. More than 80% of the network consists of district/city roads with limited capacity, while arterial and toll road sections increasingly operate under growing pressure from transport demand. Previous evidence from the broader Surabaya metropolitan road network shows that industrial and commercial expansion can reduce road performance along major intercity corridors, including the Surabaya–Mojokerto, Surabaya–Sidoarjo, and Surabaya–Gresik corridors (Waloejo et al., 2020). In the present study, this evidence is used as a regional context, while the justification for the Gresik–Mojokerto commuter rail proposal is based on the corridor's own demand concentration, land-use pattern, accessibility structure, and simulated modal-shift potential. **Fig. 4** presents the road network characteristics of the GKS area relevant to the study corridor.

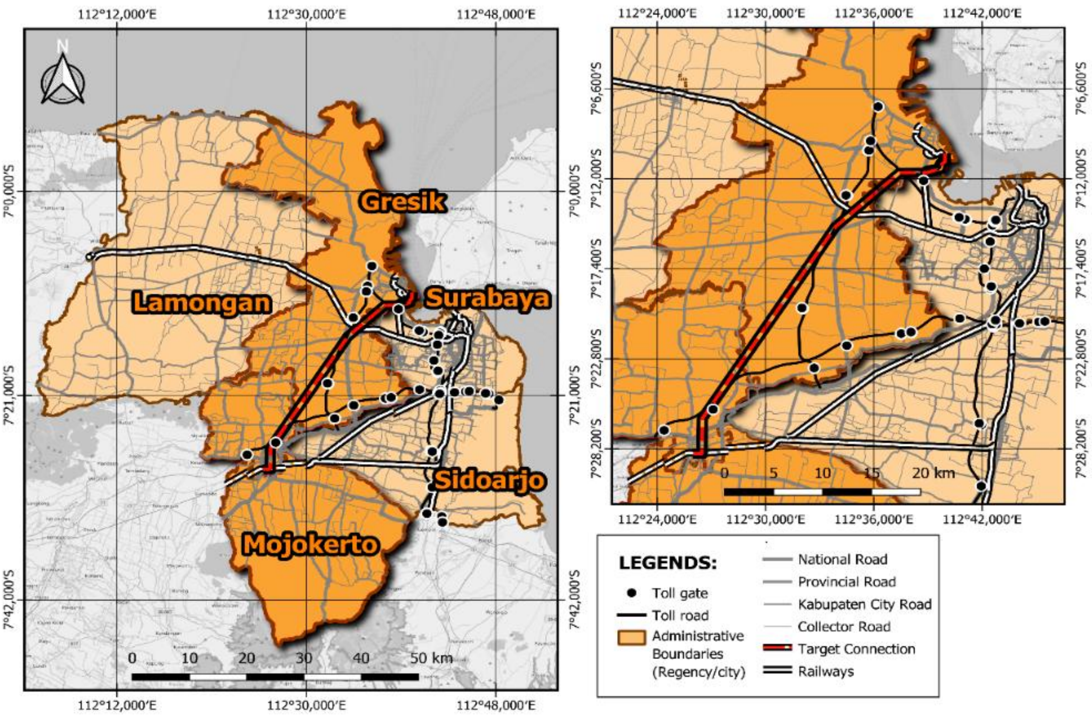

Fig. 4. Road network characteristics of the Gerbangkertosusila area.

From a corridor-planning perspective, these road and spatial characteristics indicate that the Gresik–Mojokerto corridor has both strong transport-demand potential and a clear need for a high-capacity public transport alternative. The combination of a growing population, mixed land use, strategic regional function, incomplete rail connectivity, and road network pressure makes this corridor a suitable candidate for a new commuter rail alignment. Therefore, the study area is not only relevant as a location with unmet transport demand, but also as a spatial corridor where the integration of accessibility, land use, and regional mobility considerations is essential for route planning.

Existing public transport services between Gresik and Mojokerto remain limited in terms of direct connectivity. Although road-based public transport services are available through regional bus routes and the Trans Jatim network, most public transport journeys require transfers and indirect routing. Likewise, no direct commuter rail service currently connects the two areas. Based on the stated-preference survey, current journeys between Gresik and Mojokerto are predominantly completed within the 30–60-minute category, although longer travel times are experienced by respondents travelling from more distant origins. Consequently, private motorcycles and cars remain the dominant modes for interdistrict travel, reinforcing the need for a more direct and integrated high-capacity public transport corridor.

3. METHODOLOGY

3.1. Research Design and Analytical Dataset

This study adopted an integrated planning-oriented framework to estimate prospective passenger demand and evaluate the spatial suitability of the proposed Gresik–Mojokerto commuter rail corridor. The analytical framework combines stated-preference-based passenger demand estimation with GIS-based spatial corridor screening to support early-stage commuter rail planning.

The stated-preference survey was conducted from October to December 2025 and involved existing motorcycle and private-car users with travel experience or potential travel relevance to the proposed corridor. Eight hypothetical service scenarios were evaluated by combining travel times ranging from 43 to 92 minutes and fares ranging from IDR 3,000 to 10,000. Travel time and fare were treated as explanatory variables, whereas the binary mode choice—remaining with the existing private mode or shifting to commuter rail—served as the response variable. Because the proposed commuter rail service has not yet been implemented, the stated-preference responses were interpreted as prospective behavioural intentions rather than observed travel behaviour.

The datasets used in this study comprised both primary survey data and supporting secondary datasets (**Table 2**). The stated-preference survey generated 3,080 raw choice records, which were aggregated into 385 analytical trip observations for corridor-level analysis. The analytical trip observations were subsequently classified into motorcycle- and car-based trips to estimate passenger capture separately before integrating both travel markets into the corridor-level demand model.

Following data preparation, motorcycles and private cars were analysed as separate travel markets because they represent different mobility characteristics in the Indonesian metropolitan context and may respond differently to changes in travel time and fare (Helmmie & Joewono, 2022; Isler et al., 2023; Otsuka et al., 2022). Passenger capture was therefore estimated independently for each mode before both estimates were integrated into the corridor-level demand analysis.

3.2. Passenger demand estimation

The first stage of the analysis estimated the probability that existing private-mode trips would shift to the proposed commuter rail service. The mode-choice model was estimated using the 3,080 raw stated-preference choice records to capture behavioural responses under hypothetical service scenarios, whereas the 385 aggregated analytical trip observations were used to estimate corridor-level passenger capture for planning purposes.

Let $P_{MC\to CR}$ denote the probability that a motorcycle-based trip shifts to commuter rail, and let $P_{CAR\to CR}$ denote the probability that a car-based trip shifts to commuter rail. These probabilities were calculated as:

$$P_{MC\to CR} = \frac{N_{MC\to CR}}{N_{MC}} \tag{1}$$

$$P_{CAR\to CR} = \frac{N_{CAR\to CR}}{N_{CAR}} \tag{2}$$

where $N_{MC\to CR}$ is the number of motorcycle-based trips shifting to commuter rail, N_{MC} is the total number of motorcycle-based trips, $N_{CAR\to CR}$ is the number of car-based trips shifting to commuter rail, and N_{CAR} is the total number of car-based trips:

$$P_{MC\to CR} = \frac{184}{254} = 0.7244 \tag{3}$$

$$P_{CAR\to CR} = \frac{95}{131} = 0.7252 \tag{4}$$

The overall stated-preference-based passenger-capture potential was then estimated as:

$$P_{CR} = \frac{N_{CR}}{N_{Total}} \tag{5}$$

where N_{CR} is the total number of analytical observations classified as simulated shift-to-rail cases and N_{Total} is the total number of analytical observations. Accordingly,

$$P_{CR} = \frac{279}{385} = 0.7247 \tag{6}$$

Table 2.

Data sources, analytical coverage, and processing methods used in the study.

Data/ variable	Source	Spatial coverage / analytical unit	Temporal coverage	Analytical role	Processing method
Stated-preference survey responses	Field survey conducted by the authors	385 respondents; 3,080 raw choice records	October–December 2025	Estimate potential user response to commuter rail	Responses were coded as binary mode-choice outcomes under eight time–fare scenarios.
Aggregated analytical trip observations	Processed from stated-preference survey dataset	385 trips: 254 motorcycle-based and 131 car-based	October–December 2025	Estimate passenger capture and corridor demand	Raw responses were aggregated into trip observations and classified into stay/shift outcomes.
Mapped trip-origin dataset	Survey-based trip-origin dataset compiled by the authors	385 mapped trip origins	October–December 2025	Identify mapped origin concentration and corridor dominance	Trip-origin locations were geocoded and aggregated by administrative area for subsequent spatial concentration analysis.
Travel time and fare scenarios	Hypothetical service scenarios	Eight scenarios were applied to all respondents	October–December 2025	To model behavioral sensitivity to service competitivene ss	Scenario values were used in the binary choice model to estimate the modal-shift probability.
Population data	BPS East Java	Gresik and Mojokerto in the GKS context	2020–2025	Describe demographic growth and mobility pressure	Population trends were compared descriptively to support corridor importance.
Land-use conditions	Secondary spatial datasets and author-based land-use interpretation/ digitization in QGIS	Proposed Gresik–Mojokerto alignment and its main route sections	2025–2026	Evaluate land-use suitability and spatial feasibility	Dominant land uses were interpreted in relation to route continuity and land-conflict potential.
Road network characteristi cs	Secondary GKS transport-network data	GKS metropolitan area and study corridor	2025–2026	Examine road dependence and need for rail alternative	Road structure was interpreted to assess corridor pressure and the strategic relevance of rail.
Strategic activity nodes	Corridor observation and route screening	Stations, roads, housing areas, industry, schools, mosques, and bridges	2025–2026	Support route formulation and corridor screening	Activity nodes were linked to land use, accessibility, and corridor continuity.

The estimated binary logistic regression model confirmed that travel time and fare significantly influenced commuter rail choice ($p < 0.05$). The estimated regression coefficients are presented in **Table 3**.

Table 3.

Binary choice model results for commuter rail choice.

Variable	Coefficient	Standard error	Wald statistic	Significance	Interpretation
Travel time	-0.486	0.018	703.538	$p < 0.05$	Longer travel times reduce the probability of choosing commuter rail.
Fare	-0.003	0.00004	723.310	$p < 0.05$	Higher fares reduce the probability of choosing commuter rail.

Note: *The dependent variable was coded as **1** for choosing commuter rail and **0** for remaining with the existing private mode. Travel time was measured in minutes and fare in IDR. The model was estimated using 3,080 stated-preference choice records generated from 385 respondents across eight hypothetical service scenarios. The model achieved a Nagelkerke R^2 of 0.454*

The estimated utility function for commuter rail choice is expressed as:

$$Y_{CR} = 50.977 - 0.486\text{TT} - 0.003\text{F} \tag{7}$$

where Y_{CR} is the utility of choosing commuter rail, TT is travel time (minutes), and F is the proposed commuter rail fare (IDR).

$$Pr(CR) = \frac{1}{1 + e^{-Y_{CR}}} \tag{8}$$

where $Pr(CR)$ is the probability of choosing commuter rail and Y_{CR} is the estimated utility of commuter rail choice.

The estimated capture probabilities were subsequently incorporated into the corridor-level passenger-demand function:

$$Q_{CR} = (P_{MC \to CR} \times Q_{MC}) + (P_{CAR \to CR} \times Q_{CAR}) \tag{9}$$

where Q_{MC} is the volume of existing motorcycle-based corridor trips and Q_{CAR} is the volume of existing car-based corridor trips. Substituting the estimated capture probabilities into Equation (9) gives:

$$Q_{CR} = (0.7244 \times Q_{MC}) + (0.7252 \times Q_{CAR}) \tag{10}$$

3.3. Spatial Corridor Screening

Geospatial processing was conducted using a GIS-based corridor appraisal approach in QGIS. Land-use, road-network, administrative-boundary, and activity-node layers were compiled from secondary spatial datasets, author-based map interpretation, and corridor digitization. These layers were harmonized and overlaid with mapped trip-origin points and the proposed alignment to evaluate the spatial consistency of the Gresik–Mojokerto commuter rail corridor.

To formalize this screening logic, each candidate corridor segment was evaluated using the following corridor suitability function:

$$CSI_j = (w_1 \times D_j) + (w_2 \times A_j) + (w_3 \times L_j) + (w_4 \times C_j) \tag{11}$$

where CSI_j is the corridor suitability index of the segment j, D_j is demand relevance, A_j is accessibility to daily activity nodes, L_j is land-use feasibility, and C_j is continuity with the overall corridor structure.

Because the purpose of the study is early-stage corridor appraisal rather than final engineering optimization, all components were treated as equally important:

$$w_1 = w_2 = w_3 = w_4 = 0.25 \tag{12}$$

Each criterion was scored using a three-point ordinal scale, where 1 indicates low suitability, 2 indicates moderate suitability, and 3 indicates high suitability. CSI scores of 2.50–3.00 indicate high suitability, 1.50–2.49 indicate moderate suitability, and below 1.50 indicate low suitability.

A corridor segment was considered demand-relevant when it passed through major trip-generating environments such as industrial zones, residential areas, trade and service corridors, educational facilities, or social activity nodes. Accessibility was assessed by the segment's ability to connect settlements and routine destination points that shape daily travel. Land-use feasibility referred to the extent to which the segment could be developed with relatively lower spatial conflict, especially by utilizing open land, agricultural land, transition land, or corridor edges. Continuity referred to the segment's ability to maintain a coherent corridor structure from the western to the eastern part of the study area. The screening criteria were adapted from previous studies emphasizing that suburban rail alignment should not be determined solely by demand or land use, but by the interaction of accessibility, corridor structure, and spatial feasibility (Otsuka et al., 2022; Dianin et al., 2024; Öztürk & Bozkurtoğlu, 2023).

4. RESULTS AND DISCUSSION

4.1. Spatial Concentration of Mapped Trip Origins in the Gresik–Mojokerto Corridor

The mapped trip-origin concentration pattern indicates a spatially focused travel market along the Gresik–Mojokerto corridor. Such a concentration supports corridor-based rail planning because fixed-route services operate most effectively where travel demand is spatially clustered. Accordingly, this analysis focuses on the spatial distribution of trip origins and their relationship with the proposed corridor structure, rather than on a complete origin–destination matrix. As shown in **Fig. 5**, travel origins are concentrated predominantly in Gresik and Mojokerto.

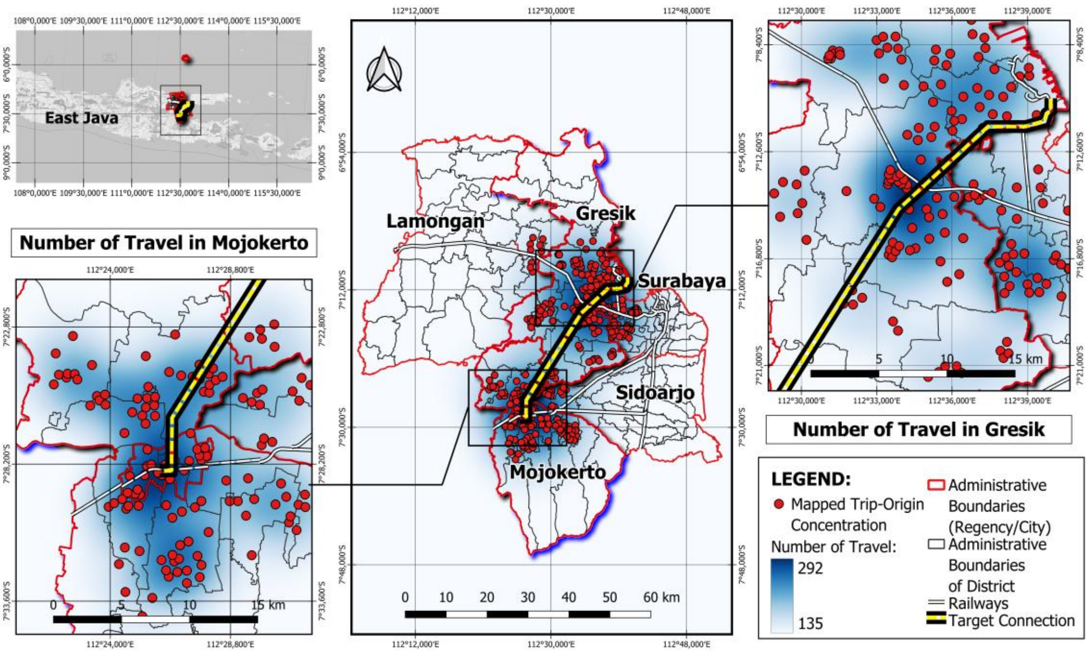

Fig. 5. Spatial concentration of travel origins in the Gresik–Mojokerto corridor

Gresik contributes 171 mapped trips (44.42%), while Mojokerto contributes 151 trips (39.22%). Together, these two areas account for 322 of the 385 mapped trips (83.64% of all observed travel origins). In contrast, Surabaya, Sidoarjo, and Lamongan contribute only 42 trips (10.91%), 12 trips (3.12%), and 9 trips (2.34%), respectively. This pattern indicates that daily mobility is strongly concentrated along the Gresik–Mojokerto axis, supporting its suitability as a commuter rail corridor candidate. Spatial clustering along the main corridor and adjacent activity areas indicates that mobility is shaped by settlement concentration, economic activity, and transport accessibility. This pattern is consistent with previous studies showing that mobility hotspots emerge from the interaction of land use, spatial organization, and daily travel intensity (Du et al., 2024; Xie et al., 2021; Shafiq et al., 2024). Therefore, the observed movement concentration provides empirical support for the proposed rail alignment and establishes a spatial basis for the subsequent route-suitability assessment.

4.2. Route Suitability Based on Land Use and Strategic Activity Nodes

After confirming that the Gresik–Mojokerto axis represents the dominant movement structure within the study area, the next question is whether the proposed commuter rail route is spatially appropriate. The results indicate that the proposed alignment is not merely the shortest geometric connection between Gresik and Mojokerto, but also follows a sequence of land-use environments and strategic activity nodes that are highly relevant to daily commuter mobility. As summarized in **Table 4**, the route begins at Indro Station, passes through transport, industrial, commercial, residential, educational, and socio-religious environments, and terminates at Mojokerto Station. This sequence indicates that the corridor connects not only the two intercity anchors but also intermediate activity nodes with substantial daily trip-generation potential.

In this study, accessibility was interpreted using a planning-stage node-based corridor appraisal approach rather than a station-level population catchment forecast. The proposed alignment was assessed according to its ability to connect transport nodes, industrial areas, residential clusters, schools, religious facilities, bridge connections, and urban commercial areas. This approach is appropriate for early-stage corridor appraisal because the objective was to identify whether the route links daily activity nodes and supports first-mile and last-mile access potential, rather than to produce a final station-level catchment analysis.

The proposed alignment consists of three functional sections. The western section, covering Indro Station, Mayjend Sungkono Street, and Kapten Darmo Sugondo Street, represents a strong origin-side market because it connects transport, industrial, commercial, and dense settlement areas. The middle section, including Hidayatul Mujahiddin Grand Mosque, Muhammadiyah 7th Junior High School Cerme, Golden East Menganti Housing, Grand Kedamean Regency Housing, and Al Mubaroq Mosque, supports intermediate mobility through residential, educational, village, and transitional land-use environments. The eastern section, including Paringan 1 Elementary School, Hidmu Junior High School, Gajah Mada Bridge, and Mojokerto Station, strengthens route continuity and links the corridor to Mojokerto’s urban destination structure.

Overall, the route balances passenger-generation potential with spatial feasibility by combining high-activity areas with transitional and semi-open segments. This interpretation is consistent with previous studies showing that suburban rail route planning should consider the interaction between demand concentration, land-use suitability, accessibility, and corridor continuity (Dianin et al., 2024; Öztürk & Bozkurtoğlu, 2023; Otsuka et al., 2022). The CSI assessment further supports this interpretation by providing a systematic comparison of corridor segments**.** To quantify route suitability, the equal-weighted CSI function described in Section 3.3 was applied to each main segment. Each criterion was scored using a three-point ordinal scale, where 1 indicates low suitability, 2 indicates moderate suitability, and 3 indicates high suitability. The CSI assessment further supports these findings by providing a systematic comparison of corridor segments. As shown in **Table 5**, most segments achieved high suitability, with CSI scores ranging from 2.50 to 2.75. Kebomas, Menganti, and Magersari recorded the highest scores because they combine strong demand relevance, accessibility, and corridor continuity, whereas Cerme and Gedeg were classified as moderately suitable due to lower demand relevance despite their more flexible land-use conditions.

Table 4.
Land-use characteristics and justification of the proposed commuter rail alignment.

Route point	Dominant Land Use	Justification
Indro Station	Transport node, industrial area, and urban settlement	Serves as the western transport anchor of the corridor, where dense settlement and industrial activity support intermodal integration and strong trip-generation potential.
Mayjend Sungkono Street	Commercial, service, and residential corridor	Represents a high-activity corridor with strong daily movement intensity, while still offering peripheral space that may support route development with lower pressure on dense built-up areas.
Kapten Darmo Sugondo Street	Light industry, residential area, and open land	Captures worker-related travel demand and provides relatively flexible corridor space with lower land-use conflict compared with fully dense urban sections.
Hidayatul Mujahiddin Grand Mosque	Residential area and socio-religious facility	Functions as a significant community activity node, supporting the integration of daily local travel into the proposed transport corridor.
Muhammadiyah 7th Junior High School Cerme	Developing a residential area and transitional land	Acts as a generator of scheduled daily trips by students and staff, while the surrounding transitional land improves corridor feasibility.
Golden East Menganti Housing	Residential area and rice fields	Represents a growing housing area that still retains open land, allowing route development with relatively low social and spatial conflict.
Grand Kedamean Regency Housing	Residential area and green open land	The surrounding agricultural and open land reduces the need for intervention in existing built-up housing, supporting corridor continuity with lower development constraints.
Al Mubaroq Mosque	Village settlement and rice fields	Located within a village-based residential environment dominated by surrounding rice fields, offering relatively low land-use conflict while maintaining local accessibility value.
Paringan 1 Elementary School	Village settlement, green open land, educational facility, and medium-scale industry	Combines educational and settlement functions with surrounding open land and moderate industrial activity, making the corridor relevant for daily trips while remaining spatially feasible.
Hidmu Junior High School	Residential area, educational facility, and green open land	Serves an area where educational activity and residential demand are supported by adjacent open land, improving route feasibility near built-up settlements.
Gajah Mada Bridge	Open space, riverside area, and transport infrastructure	Functions as a continuity node that supports efficient connection between route sections and strengthens the structural coherence of the corridor.
Mojokerto Station	Transport node and commercial area	Serves as the eastern terminal of the corridor and connects the proposed line to the existing rail network, enabling onward passenger distribution and stronger regional integration.

Table 5.
Corridor suitability index of the proposed Gresik–Mojokerto commuter rail segments.

Segment	Demand relevance	Accessibility	Land-use feasibility	Continuity	CSI score	Interpretation
Kebomas	3	3	2	3	2.75	High suitability
Cerme	2	2	3	2	2.25	Moderate suitability
Menganti	3	2	3	3	2.75	High suitability
Kedamean–Wringinanom	2	2	3	3	2.50	High suitability
Wringinanom	2	2	3	3	2.50	High suitability
Jetis	2	2	3	3	2.50	High suitability
Gedeg	2	2	3	2	2.25	Moderate suitability
Magersari	3	3	2	3	2.75	High suitability

The ordinal score was defined as follows: score 1 indicates low suitability, score 2 indicates moderate suitability, and score 3 indicates high suitability. For demand relevance, high suitability refers to segments with strong trip-generating activity. For accessibility, high suitability refers to direct connection with multiple daily activity nodes. For land-use feasibility, high suitability refers to open, agricultural, transitional, or relatively low-conflict land. For continuity, high suitability refers to strong connection with the overall Gresik–Mojokerto corridor structure. The CSI was used as a planning-stage screening tool rather than a final engineering feasibility index.

4.3. Operational Relevance of the Proposed Commuter Rail Corridor

The proposed corridor also demonstrates a meaningful operational advantage. As illustrated in **Fig. 6**, the alignment extends approximately 44.14 km and provides a more direct connection between Gresik and Mojokerto than the current travel pattern, which still depends on indirect movement through Surabaya. Under the proposed configuration, the end-to-end journey is projected to take less than 1 hour. This is a significant result because travel-time competitiveness is one of the most important factors in attracting users away from private vehicles, particularly in commuter settings where schedule reliability and predictable travel times strongly influence travelers' decisions.

An end-to-end travel time of less than one hour corresponds to an average commercial speed of approximately 44.14 km/h, indicating that the proposed corridor is operationally competitive for daily commuter services. Although this estimate is based on a planning-stage operating assumption, it suggests that the proposed alignment has the potential to provide a direct and time-efficient connection between Gresik and Mojokerto.

Although operational studies commonly optimize train timetables, headway, and service frequency after corridor selection, the present study focuses on planning-stage corridor identification and preliminary route appraisal. Therefore, the proposed corridor is evaluated primarily in terms of its spatial and operational feasibility, whereas detailed operating schedules remain beyond the scope of the present study. Previous studies have shown that train headway, service frequency, and timetable design are generally optimized after the corridor alignment and stopping pattern have been established, using projected passenger demand, operational constraints, rolling-stock availability, and safety headway as key planning inputs (Xu et al., 2021). Likewise, transit line planning frameworks recognize that service frequency is determined after route selection because it depends on expected passenger demand, capacity requirements, and operational objectives (Schmidt & Schöbel, 2024). Accordingly, the operational pattern of the proposed Gresik–Mojokerto commuter rail service, including train headway and service frequency, should be established during the subsequent operational planning stage based on detailed demand forecasting, timetable optimisation, rolling-stock allocation, and infrastructure capacity.

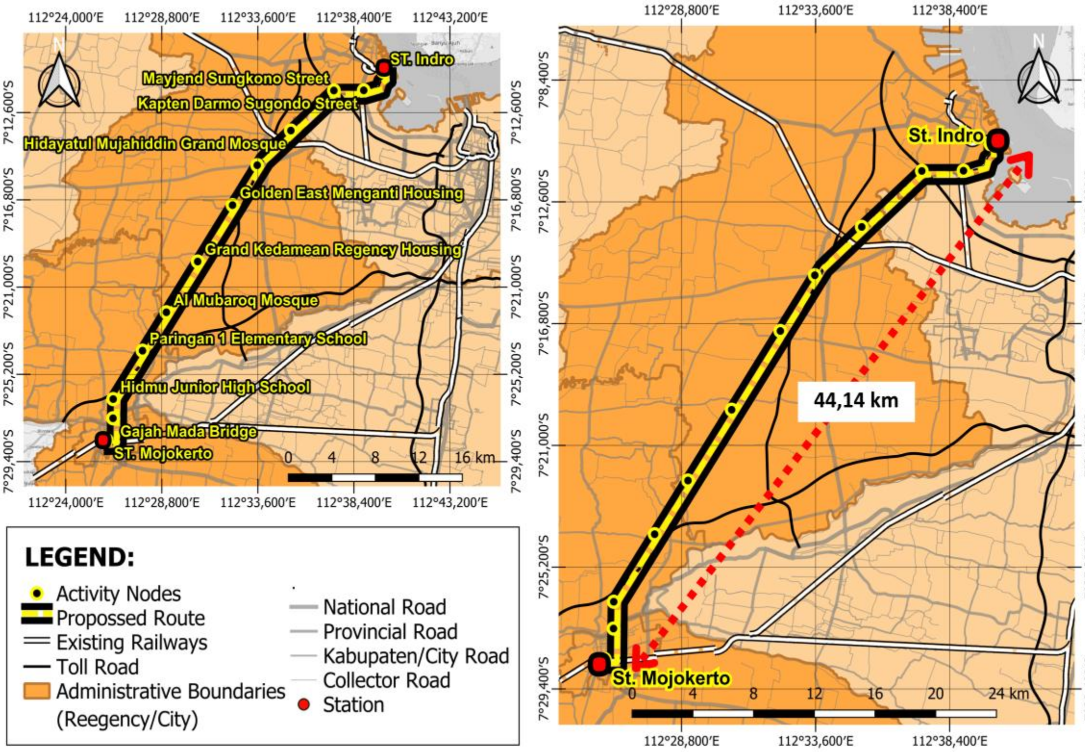

Fig. 6. Land-use-based proposed commuter rail alignment in the Gresik–Mojokerto corridor

The proposed corridor's operational relevance is supported by its directness and travel-time competitiveness. Relative journey time and reliability are key determinants of public transport competitiveness, particularly for recurrent daily trips (Lunke et al., 2021). By providing a direct Gresik–Mojokerto connection, the proposed route can improve route legibility, reduce dependence on indirect travel, and strengthen the attractiveness of commuter rail relative to private vehicles. Thus, the proposed line is both spatially feasible and operationally competitive, reinforcing its potential to reduce dependence on private vehicles and support a modal shift toward commuter rail.

4.4. Existing Modal Structure and Baseline Mobility Dependence

The baseline modal structure prior to the implementation of the proposed commuter rail service is shown in **Fig. 7**. The figure indicates that current travel in the corridor is strongly dominated by private transport, with approximately 66% of trips being motorcycle-based and the remaining 34% being car-based. This distribution highlights the corridor's strong dependence on road-based private transport prior to the introduction of commuter rail.

Spatially, motorcycle trips are more widely distributed across rural and peri-urban sections, where medium-distance travel and limited public transport access make motorcycles the most practical daily mode. Car trips are more concentrated in urbanized and corridor-adjacent areas with stronger road accessibility and higher activity intensity. This pattern shows that both modes reflect road dependence, although motorcycles are associated with more dispersed daily mobility, whereas car travel is concentrated in denser urban and interurban areas. This baseline condition indicates that the corridor remains fragmented, road-dependent, and weakly served by competitive mass transit. Limited access to integrated public transport can reinforce dependence on private modes, whereas improved accessibility and network integration can increase mass-transit use (Kühnel et al., 2025; Fale et al., 2025). Therefore, the predominance of private vehicles provides a clear baseline against which the simulated commuter rail-induced modal shift can be interpreted.

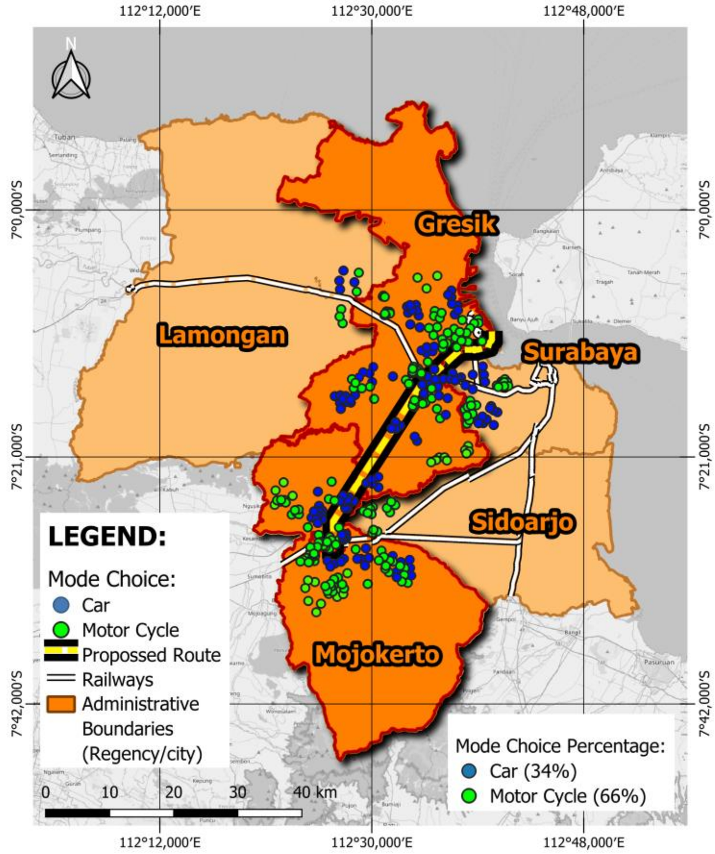

Fig. 7. Existing modal structure in the Gresik–Mojokerto corridor

4.5. Simulated Modal Shift after the Introduction of Commuter Rail

Applying Equation (10) to the aggregated analytical trip observations yielded a commuter rail demand of approximately 279 passenger trips under the analysed planning scenario. Using the analytical dataset totals:

$$Q_{CR} = (0.7244 \times 254) + (0.7252 \times 131) \tag{13}$$

$$Q_{CR} = 184 + 95 = 279 \tag{14}$$

This estimate corresponds to an overall stated-preference-based passenger-capture rate of 72.47%, indicating substantial potential for commuters to shift from private vehicles to the proposed rail service. **Fig. 8** presents the spatial distribution of this simulated modal-shift potential across the study corridor.

The modal-shift map illustrates the spatial distribution of simulated shift-to-rail intensity based on respondent trip-origin locations. The percentage ranges shown in the figure represent relative spatial intensity classes rather than station-level ridership forecasts. Accordingly, the map identifies areas where modal-shift potential is relatively stronger or weaker along the proposed corridor**.**

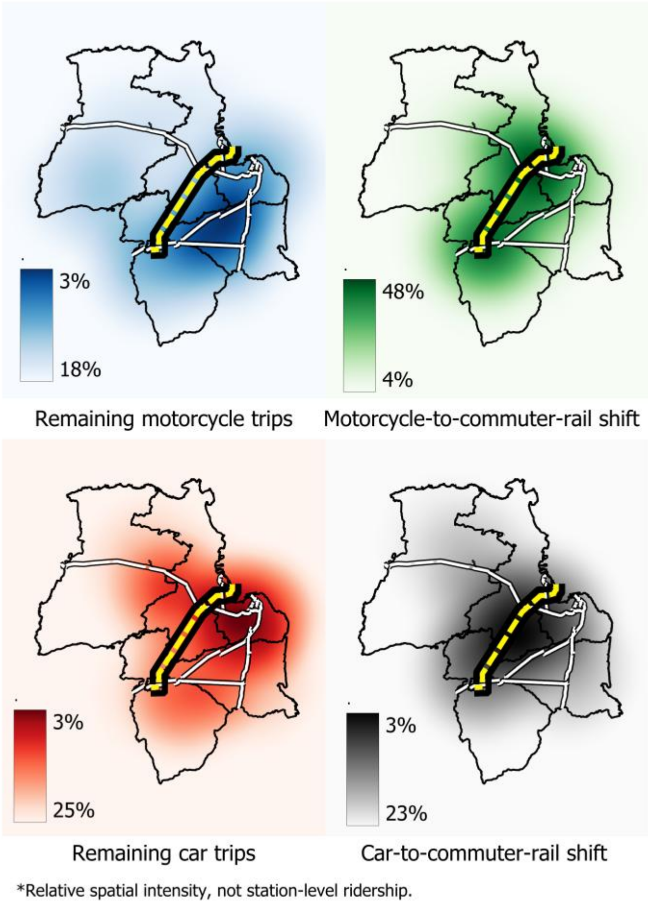

Fig. 8. Spatial intensity of simulated modal-shift potential under the proposed commuter rail scenario.

The strongest modal shifts occur in areas with high travel concentration and strong spatial linkage to the proposed corridor, indicating that rail effectiveness depends on corridor accessibility and network integration. This pattern is consistent with the estimated passenger-capture rate of 72.47% and further confirms that travel time and fare significantly influence commuter rail choice. It also supports previous findings that public transport accessibility, service integration, and proximity to activity centers are key determinants of modal shift from private vehicles to mass transit (Kühnel et al., 2025; Fale et al., 2025).

However, some trips remain attached to private modes, particularly in areas farther from the proposed corridor or less integrated with the network. This reflects spatial impedance, where distance, access quality, and connectivity gaps continue to shape travel behavior even after a rail service is introduced. Such differentiated responses are consistent with studies showing that transport interventions affect users unevenly across accessibility gradients and network conditions (Fathoni & Widyastuti, 2025). Therefore, the simulation provides more than an aggregate modal-shift estimate. It shows where the proposed rail corridor is likely to be most effective and where supporting access or feeder integration may still be required. Taken together, these findings demonstrate that commuter rail effectiveness depends not only on passenger demand but also on accessibility, land-use characteristics, and network integration. This integrated perspective strengthens the study's contribution by linking demand concentration, land-use-based route suitability, operational competitiveness, baseline modal structure, and spatially differentiated modal-shift potential within a single corridor-planning framework.

4.6. Integrated Interpretation and Study Contribution

Overall, the results show that the Gresik–Mojokerto corridor is suitable for commuter rail development because it combines concentrated travel demand, strategic land-use conditions, corridor accessibility, and measurable modal-shift potential. Together, these findings indicate that the proposed corridor satisfies both spatial and behavioural requirements for early-stage commuter rail planning, demonstrating that demand concentration and spatial suitability can be effectively integrated within a single corridor appraisal framework. Similar to studies in other metropolitan regions, the findings show that prospective commuter rail corridors are most viable when concentrated travel demand is supported by station accessibility, compatible land use, and a continuous spatial structure (Otsuka et al., 2022; Dianin et al., 2024; Öztürk & Bozkurtoğlu, 2023).

The main contribution of this study is the integration of demand concentration, land-use suitability, operational competitiveness, and user-response simulation into a single early-stage commuter rail planning framework. This integrated approach provides a stronger basis for corridor selection than analyses that treat demand estimation, route planning, and modal shift separately. Unlike conventional approaches that examine these components independently, the proposed framework evaluates prospective passenger demand alongside corridor suitability, thereby providing a more comprehensive basis for identifying potential commuter rail alignments.

Practically, the proposed Gresik–Mojokerto commuter rail corridor has the potential to improve accessibility, strengthen interdistrict connectivity, reduce dependence on private vehicles, and support a more efficient regional mobility structure. These findings suggest that integrating behavioural demand with spatial planning can assist decision-makers in identifying corridors that are both operationally competitive and spatially feasible before undertaking more detailed engineering and economic evaluations.

From a service-planning perspective, the proposed corridor requires supporting access strategies to convert planning-stage modal-shift potential into actual ridership. Because motorcycles dominate the existing mobility structure, station access should include park-and-ride facilities, feeder services, and safe first-mile/last-mile connections, as feeder accessibility and intermodal transfer facilities are important factors in strengthening mass transit use (Saiyad et al., 2022; Ortega et al., 2021). The high-suitability segments, particularly Kebomas, Menganti, Kedamean–Wringinanom, Jetis, and Magersari, may serve as priority areas for station-area planning and phased corridor development. Accordingly, the long-term effectiveness of the proposed commuter rail service will depend not only on the main corridor alignment but also on its integration with feeder services, station accessibility, and surrounding activity nodes.

5. CONCLUSIONS

This study demonstrates that the Gresik–Mojokerto corridor has planning-stage potential for the development of a new commuter rail service, supported by concentrated travel demand, spatially suitable corridor conditions, and meaningful modal-shift potential. The spatial origin concentration analysis shows that regional movement is concentrated along the Gresik–Mojokerto axis, with Gresik accounting for 171 mapped trips (44.42%) and Mojokerto accounting for 151 mapped trips (39.22%). Together, these two areas represent 322 of 385 mapped trips, or 83.64% of total observed travel origins, providing a strong empirical basis for prioritizing the corridor as a commuter rail candidate.

The spatial analysis shows that the proposed alignment is justified not only by its direct connection between the two main corridor anchors, but also by its ability to link strategic activity nodes and land-use environments along the route. The corridor traverses transport, industrial, residential, educational, and socio-religious areas, indicating its relevance for both intercity movement and intermediate daily travel demand. Operationally, the proposed route extends approximately 44.14 km and offers a projected travel time of less than one hour, strengthening its competitiveness against private road-based transport.

The baseline modal structure confirms that corridor mobility remains dominated by motorcycles and cars, while the simulation results indicate substantial potential for shifting trips from both private-mode groups to commuter rail. These results should therefore be interpreted as planning-stage modal-shift potential rather than final operational ridership. Overall, this study demonstrates that integrating travel-demand analysis, land-use characteristics, accessibility, and corridor suitability provides a robust planning-stage framework for identifying prospective commuter rail corridors. Beyond the Gresik–Mojokerto case, this approach offers a transferable methodology that may assist transport planners in evaluating potential commuter rail corridors in metropolitan regions with similar spatial and mobility characteristics.

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