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Implementation of Bicycle Lanes on Soekarno Hatta Street, Malang City: An Environmentally Friendly Transportation Approach

Martini Candy Angela, Rifky Aldila Primasworo, Pamela Dinar Rahma
Civil Engineering Study Program, Tribhuwana Tunggadewi University, Malang, 65144, Indonesia

e-mail: rifky.aldila@unitri.ac.id

ABSTRACT
Soekarno Hatta Street is one of the main thoroughfares in the city of Malang, characterized by high levels of activity and heavy traffic, which contribute to congestion, reduced safety, and environmental degradation. The implementation of dedicated bike lanes is seen as a way to promote eco-friendly transportation while improving safety and comfort for non-motorized road users. The methods employed in this study include field observations, interviews, and questionnaires administered to the public and road users. Public perception analysis was conducted using the Importance Performance Analysis (IPA) method, which was used to understand the perceptions of the community and road users regarding the planned implementation of bicycle lanes on Soekarno-Hatta Road, while the technical assessment referred to the Guidelines for Designing Bicycle Facilities (05/SE/Db/2021). The results indicate that the road corridor has considerable potential for implementation as a bicycle lane; however, it still faces several obstacles, such as illegal parking and a lack of supporting facilities. Recommended strategies for implementing bicycle lanes include road space planning, the provision of markings and physical separators, improvements to lane surface quality, and integration with activity centers. The implementation of these strategies is expected to enhance safety, comfort, and public interest in using bicycles as a daily mode of transportation.

Keywords: *Bicycle Lanes; Sustainable Transportation; Public Perception; IPA Analysis.*

1. Introduction

Sustainable transportation is a concept for developing transportation systems that aims to reduce environmental impacts, increase energy efficiency, and enhance the quality of life in urban communities. This concept emphasizes a balance between environmental, social, and economic aspects in transportation planning and management. One form of sustainable transportation implementation is the development of non-motorized modes, particularly bicycles, which are considered environmentally friendly, energy-efficient, and effective for short- to medium-distance travel [1]. Globally, the use of bicycles as an urban mode of transportation has been proven to reduce carbon emissions by up to 11% per trip compared to private motorized vehicles and to significantly alleviate congestion in densely populated urban areas [2].

Malang City is one of the largest cities in East Java, Indonesia, with a population of more than 843,000 people, according to data from the Malang City Central Statistics Agency (BPS) in 2023. The development of Malang City as a center of education, business, and tourism has significantly increased residents' mobility. This condition is reflected in the growth of motorized vehicles in Malang City, which has averaged 8–10% per year over the last five years, far exceeding the growth of road capacity, which is only around 1–2% per year [3]. This disparity between vehicle growth and road infrastructure capacity has become the root cause of increasingly chronic congestion, particularly on the city's main corridors. One of the most affected corridors is Jalan Soekarno Hatta,

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one of the busiest roads in Malang City, connecting residential areas with strategic activity centers, including the campuses of Brawijaya University and Malang State Polytechnic, which accommodate more than 60,000 active students. Consequently, problems such as traffic congestion, air pollution, and increasing greenhouse gas emissions have become increasingly serious issues requiring immediate attention [4].

The growing population in urban areas has led to a high reliance on motorized vehicles. Data from the Indonesian National Police (Polri) recorded more than 20,000 traffic accident cases per year in East Java, with the majority occurring on urban road segments with high traffic intensity [5]. On the other hand, the transportation sector accounts for approximately 23% of total national greenhouse gas emissions, making it one of the largest contributors to Indonesia's emissions [6]. The problems currently faced, particularly in land transportation, include traffic congestion, traffic accidents, and air pollution [7][8]. Therefore, there is an urgent need for environmentally friendly energy sources that can reduce the effects of global warming and carbon dioxide emissions [9]. Addressing these problems through various means requires both behavioral and structural changes, including the adoption of environmentally friendly transportation [1]. However, the low level of safety and comfort for cyclists on public roads is often a major obstacle to making cycling a daily mode of transportation. A survey conducted by the Ministry of Transportation of the Republic of Indonesia found that more than 67% of respondents expressed reluctance to use bicycles as a daily mode of transportation due to the unavailability of safe, separated bicycle lanes from motorized traffic [10]. Therefore, bicycle-based transportation systems need to be actively promoted to reduce public dependence on motorized vehicles [4].

Providing safe and comfortable bicycle lanes is a key factor in encouraging public interest in cycling [11][12]. Various international studies have shown that the availability of adequate bicycle lane infrastructure can increase the number of cyclists by up to 200–300% within three to five years after implementation [13]. In Indonesia, several cities, such as Surabaya, Bandung, and Jakarta, have made efforts to develop bicycle lanes, with varying results. A study in Surabaya showed a 35% increase in cyclists after the construction of bicycle lanes in the Gubeng–Wonokromo area. At the same time, an evaluation in Bandung identified that inconsistent design and the lack of supporting facilities were the main inhibiting factors for the success of similar programs [14]. These facts confirm that the success of bicycle lane implementation is not solely determined by the availability of physical space, but also by the quality of design, alignment with local conditions, and public acceptance. Well-designed bicycle lanes not only improve cyclist safety but can also reduce conflicts with motorized vehicles. Therefore, bicycle lane planning needs to consider road geometric conditions, traffic characteristics, and user perceptions and needs.

Although studies on bicycle lanes have been conducted in several major Indonesian cities, research specifically analyzing the potential for implementing bicycle lanes in Malang City, particularly along the Jalan Soekarno Hatta corridor, remains very limited. No study has comprehensively integrated a technical assessment based on the Guidelines for Designing Bicycle Facilities (05/SE/Db/2021) with a public perception analysis using the Importance-Performance Analysis (IPA) approach for this corridor. This research gap underscores the urgency of conducting this study. Based on these issues, this study aims to analyze the potential for implementing bicycle lanes on the Jalan Soekarno Hatta corridor, examine the perceptions of the community and road users regarding the development plan, and formulate strategies for implementing bicycle lanes that are effective, safe, and sustainable by referring to applicable technical guidelines [15].

2. Materials and Methods

Sustainable transportation is a framework for developing transportation systems that balance environmental, social, and economic dimensions to minimize negative impacts while supporting urban quality of life [1]. In the context of urban mobility, non-motorized transportation, particularly cycling, has emerged as one of the most viable sustainable alternatives, given its zero direct emissions, low operational costs, and effectiveness for short- to medium-distance travel [2]. The transportation sector currently accounts for approximately 23% of national greenhouse gas emissions in Indonesia [6], reinforcing the urgency of transitioning toward low-carbon mobility solutions.

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Several international studies have demonstrated that cities with well-integrated cycling infrastructure experience measurable reductions in vehicle dependency, congestion levels, and urban air pollution, alongside improvements in public health outcomes [13]. These findings collectively position bicycle lane development not merely as an infrastructure investment but as a strategic policy instrument for achieving sustainable urban transportation goals.

Bicycle lane design constitutes a critical determinant of cycling uptake and safety. According to the Guidelines for Designing Bicycle Facilities (05/SE/Db/2021) issued by the Directorate General of Highways of the Republic of Indonesia, bicycle lanes are classified into several typologies based on their degree of physical separation from motorized traffic, including fully protected lanes, buffered lanes, and shared lanes [15]. Road geometric conditions govern the selection of an appropriate typology, prevailing vehicle speeds, and traffic volume characteristics. Studies conducted in Indonesian cities confirm that the absence of physical separators and inadequate lane markings are among the primary factors discouraging cycling adoption, with more than 67% of potential cyclists citing safety concerns as their principal barrier [10]. Furthermore, supporting facilities such as bicycle parking, directional signage, and surface quality are identified as complementary determinants of lane functionality and user comfort [11][12]. These technical parameters collectively inform the design standards that must be satisfied for a bicycle lane to be both operationally effective and publicly accepted.

The Importance Performance Analysis (IPA) method, originally developed by Martilla and James [16], provides a structured analytical framework for evaluating service or infrastructure attributes based on two dimensions: the level of importance assigned by users and the level of performance perceived in practice. By mapping these dimensions onto a two-axis Cartesian matrix, IPA produces four strategic quadrants — Concentrate Here, Keep Up the Good Work, Low Priority, and Possible Overkill — each carrying distinct implications for resource allocation and improvement priorities [17]. In the context of transportation infrastructure research, IPA has been widely applied to assess user satisfaction with public transit services, pedestrian facilities, and cycling infrastructure across various Indonesian cities, including Surabaya, Denpasar, and Banda Aceh [14]. The method is particularly valuable in bridging the gap between technical planning standards and actual user needs, enabling planners to identify which infrastructure attributes require immediate intervention and which are already performing adequately. The integration of IPA with technical guideline assessment, as adopted in this study, therefore offers a comprehensive and empirically grounded approach to bicycle lane planning that addresses both engineering requirements and community expectations simultaneously.

2.1. Research Location

The research location is Jalan Soekarno Hatta, Malang City. The research was conducted directly in the field for six days (weekends), on Saturday and Sunday mornings and afternoons during peak traffic times. Nevertheless, this study acknowledges that data collection limited to weekend days is one limitation to be considered when interpreting the research findings. Weekday traffic movement patterns generally differ significantly, particularly in terms of commercial vehicle volume, regular commuting movements of workers and students, and higher intensity of roadside friction. These conditions have the potential to produce more complex traffic conflict characteristics compared to weekend conditions. Therefore, the inclusion of weekday data collection in future research is strongly recommended to provide a more comprehensive picture of the existing conditions of the Jalan Soekarno Hatta corridor.

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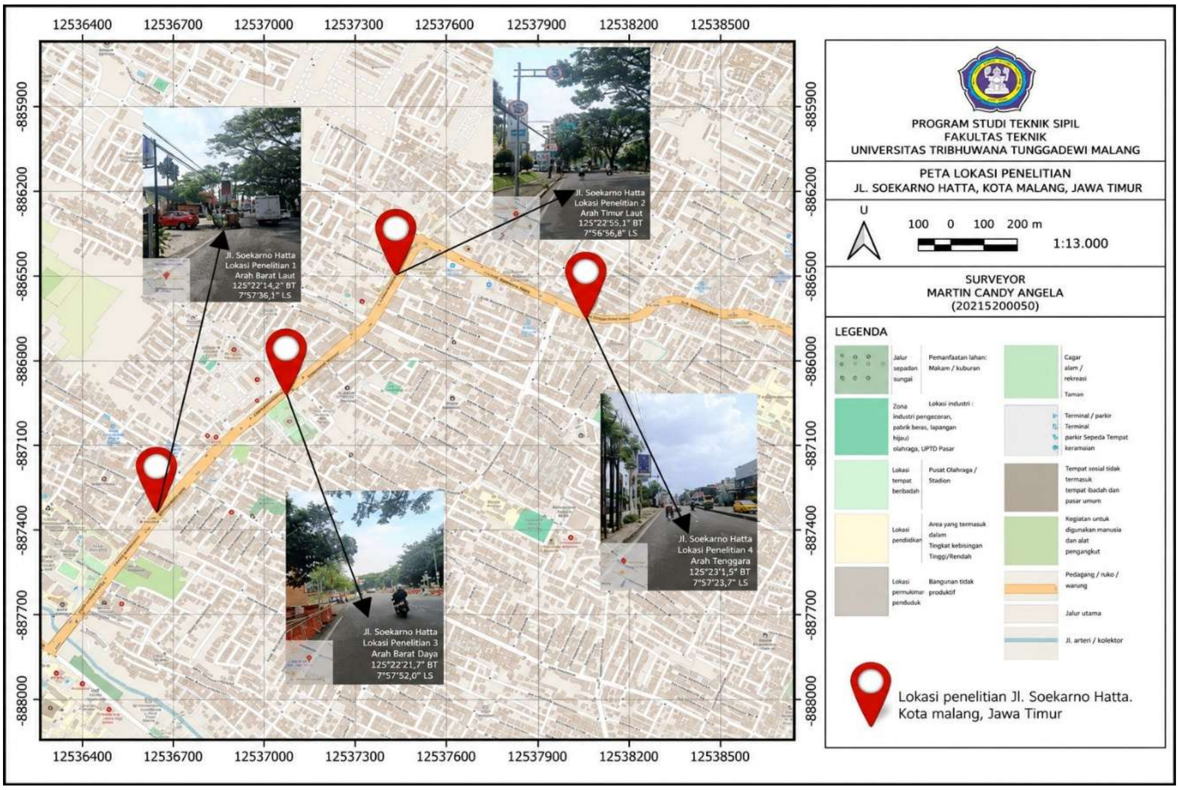

Figure 1. Layout of the Research Site (Soekarno Hatta Street, Malang City)
Source: Results of data analysis, 2025

2.2. Data Analysis Methods

This research was conducted using a qualitative descriptive method with the following techniques:

a. Analysis of corridor conditions and potential bicycle lane development based on technical guidelines from the Director General of Highways Circular No. 05/SE/Db/2021 [9] [10], which includes: road width and remaining space; geometric suitability for the implementation of type A, B, or C bicycle lanes; potential integration with sidewalks or parking areas; and existing surface conditions.

Table 1. Selection of bicycle lane or path types based on function and road class

Road Type	Highway	Medium Road	Jalan Kecil
Primary arteries	A	A	-
Primary collector	A	A	-
Primary local	C	C	C
Primary environment	C	C	C
Secondary arteries	A/B	A/B	A/B
Secondary collector	A/B/C	A/B/C	B/C
Secondary locale	B/C	B/C	B/C
Secondary environment	B/C	B/C	B/C

Source: Ministry of Public Works and Public Housing, Directorate General of Highways, 2021

Notes:

A = Type of protected bicycle lane (on the roadway or outside the roadway)

B = Type of bicycle lane on the sidewalk

C = Type of bicycle lane on the roadway

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Table 2. Bicycle Lane Provisions

Path Type	Information	Minimum Width
One-way bike lane	Used for single direction on the left side of the road	1, 44 meters
Two-way bicycle lane	If there is enough space and the bicycle traffic is dense	2,00 – 2,50 meters
Bike lane adjacent to parking	Separated by a mark or separator	1,50 meters

Source: Ministry of Public Works and Public Housing, Directorate General of Highways, 2021

b. Analysis of public and road user perceptions uses the Importance-*Performance Analysis* (IPA) method and interviews. The IPA questionnaire is used to measure the importance and performance of various attributes related to bicycle paths, such as safety, security, orderliness, comfort, and ease of integration with other modes of transportation [11].
c. Analysis of supporting strategies for the implementation of bicycle lanes, to formulate strategies that support the implementation of effective, safe, and sustainable bicycle lanes through a synthesis of existing corridor conditions, the results of the IPA questionnaire, and compliance with the technical guidelines for bicycle facilities from Bina Marga. The analysis process includes identifying technical, operational, social, and policy aspects [12] [13].

2.3. Research Flowchart "The implementation of effective."

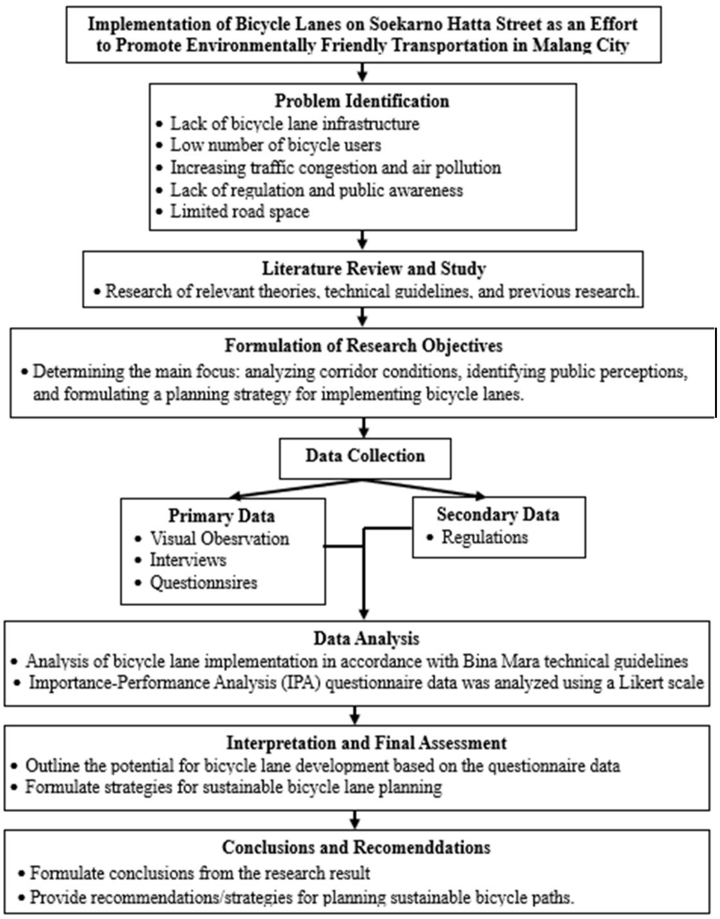

Figure 2. Research Flowchart
Source: Results of data analysis, 2025

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3. Results and Discussions

3.1. Condition of the Soekarno Hatta Road Corridor

The Soekarno-Hatta Road Corridor is a secondary collector road connecting educational, residential, and commercial areas. Traffic is dominated by private vehicles, particularly motorcycles, with a high pedestrian activity in the segments near campus. Although cyclists are present in some locations, their numbers remain low due to the lack of dedicated facilities.

Soekarno-Hatta Road has a total width of 14–20 meters, with two lanes separated by a median and each consisting of two lanes (4/2D). Several segments have shoulders or slow lanes frequently used for access to shophouses and parking areas. The asphalt pavement surface is generally in good condition, although there are minor damages such as hairline cracks and small potholes. Roadside elements such as utility poles, trees, and building access points are quite dense, and some are even too close to the pavement. A drainage system has been installed, but in some locations it is still under construction, resulting in muddy conditions during rainy seasons and affecting traffic flow due to heavy equipment on the road.

Figure 3. Traffic Conditions on Soekarno Hatta Street
Source: Results of data analysis, 2025

Figure 4. Cross-section of Soekarno Hatta Road
Source: Processed Data 2025

Sidewalks along Jalan Soekarno Hatta are present in most sections, but their quality and width are not yet consistent. In areas near campus, sidewalks are more usable, while other sections exhibit surface damage, such as cracks and unevenness. Furthermore, some sidewalks are used as motorcycle parking or for street vendors, compromising their function as pedestrian spaces. This condition makes the sidewalks less than optimal and makes them unsuitable for use as bicycle lanes due to their insufficient effective width.

Based on observations, traffic markings and signs on Jalan Soekarno Hatta in Malang City are generally still oriented towards regulating motorized vehicles. Longitudinal and transverse road markings are present, but in some sections, they have begun to fade, reducing their legibility and effectiveness. Furthermore, there are no specific markings or signs regulating cyclists or bicycle lanes.

Common problems encountered along the Jalan Soekarno Hatta corridor include high vehicle volumes, which cause congestion, especially at intersections and access points to the campus, as well

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as traffic conflicts arising from the movement of shophouses and boarding houses. This condition is exacerbated by irregular parking on the shoulder or in the slow lane, thereby narrowing the traffic space.

Figure 5. Condition of the Jalan Soekarno Hatta Street Sidewalk
Source: Results of data analysis, 2025

Figure 6. Side Barriers on Soekarno Hatta Road
Source: Results of data analysis, 2025

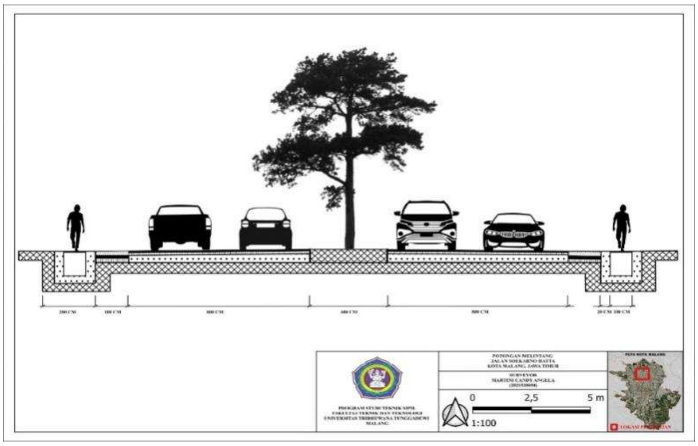

Figure 7. Cross-section (Soekarno Hatta Road, Malang City)
Source: Results of data analysis, 2025

Figure 5 shows the condition of the sidewalk along Jalan Soekarno Hatta, where the corridor is lined with large, mature trees that provide natural shade and enhance pedestrian comfort. Figure 6 documents the side barrier conditions in the Jatimulyo area, Kecamatan Lowokwaru, Malang City, at an altitude of 534.1 m, revealing mixed and heavy traffic, including large trucks, with a recorded vehicle speed of 20.4 km/h, indicating potential conflicts between freight vehicles and other road users. Figure 7 presents the technical cross-sectional drawing of Jalan Soekarno Hatta based on 2025 field data, illustrating the road's geometric configuration, which includes multiple vehicle lanes in both directions, sidewalk zones on each side, and a planting strip with a tree in the median. The cross-section confirms that Jalan Soekarno Hatta serves as both a major arterial road and a pedestrian

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corridor, underscoring the need to evaluate both traffic performance and pedestrian facility adequacy. Overall, these three figures collectively reflect the existing physical and operational conditions of Jalan Soekarno Hatta, which serve as the primary basis for further analysis of road performance and pedestrian infrastructure in this study.

3.2. Analysis of Public and Road User Perceptions

To determine public perception of the plan to implement bicycle lanes on Soekarno Hatta Road, a questionnaire using the Importance-Performance Analysis (IPA) method was administered to identify bicycle lane priorities (safety, security, obstacles/regularity, comfort, and ease of use). A 1-4 Likert scale was used for the importance level (Important), ranging from not important to very important, and for the performance level (Performance), ranging from not satisfied to very satisfied. According to data from [14], the populations of Jatimulyo sub-district and Mojolangu sub-district are 19,791 and 22,562, respectively, for a combined total of 42,281. The number of respondents was calculated using the Slovin formula, with a 10% margin of error. The number of respondents was 100. The respondents in this study included bicycle and motorcycle users and residents living around Jalan Soekarno Hatta.

Table 3. Questionnaire Statements (IPA)

No.Attributes	Statement
Safety	
A1	Bicycle lanes can improve cyclists' safety from motor vehicles.
A2	Bicycle lanes should be equipped with clear markings/barriers to avoid conflicts with motor vehicles.
A3	Special bicycle signs are needed to improve bicycle safety.
Security	
A4	Bicycle lanes should have adequate lighting at night.
A5	CCTV is needed at vulnerable points along bicycle paths.
A6	Bicycle safety (including parking and bicycle locks) must be ensured.
Regularity	
A7	Bicycle lanes must be free of motor vehicles.
A8	Bicycle lanes must be free from street vendors or other disruptive activities.
A9	Supervision and enforcement of regulations are important to ensure that bicycle lanes function properly.
Comfort	
A10	Bicycle lanes must be clean, free of potholes, and unobstructed by illegal parking or street vendors.
A11	Bicycle lanes must be equipped with rest areas at certain points.
A12	The environmental conditions along the bike path (trees, shade) contribute to comfort.
Convenience	
A13	Bicycle lanes need to connect residential areas, campuses, parks, and other public facilities.
A14	There is a strong need for safe, strategic bicycle parking facilities.
A15	A map of the bicycle lane network in Malang City must be available online/offline.

Source: Results of data analysis, 2025

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The stages of calculation in the IPA (*Importance Performance Analysis*) method are:

a. Determining the level of conformity between the level of importance and the level of performance quality of the attributes studied by comparing performance scores with importance scores.
The formula used to calculate the level of conformity is:
Tki = Xi/Yi × 100%
Explanation: Tki: Level of Conformity
Xi: Performance Assessment Score
Yi: Importance Assessment Score

Table 4. Level of Suitability (Tki)

No Attributes	Performance Level (Xi)	Level of Importance (Yi)	Level of Suitability (Tki) (%)
A1	270	391	69,05
A2	166	380	43,68
A3	185	370	50,00
A4	258	363	71,07
A5	155	323	47,98
A6	141	310	45,48
A7	171	379	45,11
A8	146	350	41,71
A9	150	311	48,23
A10	165	370	44,59
A11	143	350	40,85
A12	185	352	52,55
A13	259	353	73,37
A14	131	323	40,55
A15	117	279	41,93
Total	**2642**	**5204**	**50,76**

Source: Results of data analysis, 2025

Overall assessment criteria:
0.81 – 1.00 (very good)
0.66 – 0.80 (good)
0.51 – 0.65 (good enough)
0.35 – 0.50 (not good)
0.00 – 0.34 (very bad)

Based on the results of the Suitability Level (Tki) calculation presented in Table 4.1, an overall Tki value of 50.76% was obtained. According to the established assessment criteria, this value falls within the range of 0.35–0.50, which is categorized as "poor." This result indicates a considerable gap between the current performance of existing bicycle lane facilities and the level of importance expected by the community and road users along the Jalan Soekarno Hatta corridor.

b. Quadrant analysis or calculating the average importance and performance ratings for each attribute item using the formula:

$$\overline{Xi} = \frac{\sum_{i=1}^{k} Xi}{n}$$

Description: $\overline{Xi}$ = weight of the i-th performance attribute rating

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n = number of respondents
n = 100
Average performance (A1) = 270 : 100 = 2,7

$$\overline{Yi} = \frac{\sum_{i=1}^{k} Yi}{n}$$

Description: $\overline{Yi}$ = Average weight of the importance attribute rating level i
n = number of respondents
n = 100
Average Importance (A1) = 391 :100 = 3,91

Table 5. Average Assessment Scores for Each Attribute

No Attributes	Performance score	Performance Level (Xi)	Importance Score	Level of Importance (Yi)
A1	270	2,7	391	3,91
A2	166	1,66	380	3,80
A3	185	1,85	370	3,70
A4	258	2,58	363	3,63
A5	155	1,55	323	3,23
A6	141	1,41	310	3,10
A7	171	1,71	379	3,79
A8	146	1,46	350	3,50
A9	150	1,50	311	3,11
A10	165	1,65	370	3,70
A11	143	1,43	350	3,50
A12	185	1,85	352	3,52
A13	259	2,59	353	3,53
A14	131	1,31	323	3,23
A15	117	1,17	279	2,79
Total	**2642**	**0,26**	**5204**	**0,52**

Source: Results of data analysis, 2025

c. Calculate the average importance and performance ratings for all attributes using the formula:

$$\overline{\overline{Xi}} = \frac{\sum_{i=1}^{k} Xi}{n}$$

Description: $\overline{\overline{Xi}}$ = Average weight of the i-th performance attribute rating
n = number of respondents
n = 15
Total average performance
(A1+A2+….,A15) = 26,42 : 15 = 1,76

$$\overline{\overline{Yi}} = \frac{\sum_{i=1}^{k} Yi}{n}$$

Description: $\overline{\overline{Yi}}$ = Bobot rata-rata tingkat penilaian atribut kepentingan ke-i
n = Number of respondents
n = 15
Total average importance
(A1+A2+….,A15) = 52,04 : 15 = 3,46

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Table 6. Average Assessment Scores for All Attributes

No Attributes	Performance Level (Xi)	Level of Importance (Yi)
A1	2,7	3,91
A2	1,66	3,80
A3	1,85	3,70
A4	2,58	3,63
A5	1,55	3,23
A6	1,41	3,10
A7	1,71	3,79
A8	1,46	3,50
A9	1,50	3,11
A10	1,65	3,70
A11	1,43	3,50
A12	1,85	3,52
A13	2,59	3,53
A14	1,31	3,23
A15	1,17	2,79
Total	**1,76**	**3,47**

Source: Results of data analysis, 2025

The value (Xi) intersects the horizontal axis perpendicularly, reflecting the performance of attribute (X) or the perception of bicycle lane users. Meanwhile, the value (Yi) intersects the vertical axis perpendicularly, reflecting the attribute (Y) or the expectations of bicycle lane users.

After obtaining the performance and importance weights of the attributes, as well as the average performance and importance values, these values are then plotted in a Cartesian coordinate system.

Table 7. Graph Points on the X and Y Axes

	X	Y
X axis	1,76	2,5
Performance	1,76	4,1
Y axis	1	3,47
Importance	2,8	3,47

Source: Results of data analysis, 2025

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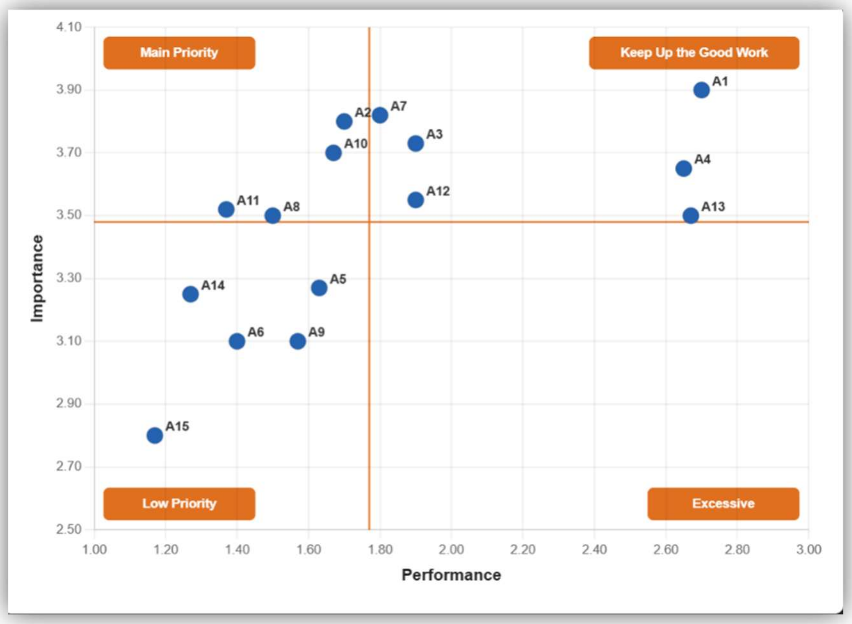

Figure 8. Cartesian quadrants (IPA)
Source: Results of data analysis, 2025

Importance-Performance Analysis for decision-making based on the perceptions of the community and bicycle lane users.

Table 8. Quadrants (IPA) for Bicycle Lanes

Quadrant I **Top Priority** **(Concentrate Here)** Attribute Number: A2, A7, A8, A10, A11	**Quadrant II** **(Keep Up The Good Work)** Attribute Number: A1, A3, A4, A12, A13
Quadrant III **Low Priority** Attribute Number: A5, A6, A9, A14, A15	**Quadrant IV** **Excessive** **(Possible Overkill)** Attribute Number: 0

Source: Results of data analysis, 2025

Quadrant 1 Priority Important-Performance Analysis (IPA) refers to the area in the Cartesian diagram that contains attributes considered very important by bicycle users and the community (having a high level of expectation/importance), but with low performance or satisfaction (not yet implemented properly).

3.4. Strategies for Implementing Effective, Safe, and Sustainable Bicycle Lanes

The results of the questionnaire analysis using the Importance-Performance Analysis method indicate that bicycle lane attributes are distributed across four quadrants. From the results of mapping on the Cartesian diagram, the attributes that fall into Quadrant I (Top Priority / Concentrate Here) are:

- (A2) = Bicycle lanes are equipped with clear markings/barriers to avoid conflicts with motorized vehicles.
- (A7) = Bicycle lanes are free from motor vehicles.

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- (A8) = The bike lane is free from street vendors or other disruptive activities.
- (A10) = Clean bike lanes, free of potholes, and unobstructed by illegal parking or vendors.
- (A11) = The bike path is equipped with rest areas at certain points.

These aspects are highly important but perform poorly, making them the main focus of the bicycle lane implementation strategy in the Soekarno Hatta Road corridor.

The strategic recommendations based on quadrant 1 are as follows:

- Physical Arrangement and Security of Routes
  - Installation of markings and physical separators (bollards or concrete barriers) to separate bicycle lanes from motor vehicles.
  - Regular cleaning and quick repairs (daily sweeping and quick patching) to maintain the smoothness and comfort of the lanes.
  - Regulation of street vendors and illegal parking through supervision and special zones outside bicycle lanes
- Supporting Facilities
  - Provision of simple rest areas on long segments, for example, near campuses and parks.
  - Adequate street lighting and CCTV cameras at vulnerable points to increase user safety.

The results of field analysis and community perceptions provide clear guidance on how bicycle lanes on Jalan Soekarno Hatta should be designed to be sustainable and truly beneficial [15].

Field measurements show that most sections of Jalan Soekarno–Hatta have a total width of 14–16 meters, with two lanes of traffic and a median in the middle. The space on the left side of the road still allows for a one-way bicycle lane with a width of ±1.25–1.50 meters, especially if the road shoulder and sidewalk are rearranged. By maintaining a minimum motor vehicle lane width of 3.25 meters, the rearrangement of roadside elements can be carried out without disrupting the road's main function. This width adjustment is important so that cyclists have safe space to move and are not disturbed by parking activities or other side obstacles. For Jalan Soekarno–Hatta as a secondary collector road with medium to high traffic flow, the most suitable Type of bicycle lane is type C (lane on the road) or a combination of types B and C on certain segments.

- Type C can be applied on roads with sufficient roadside width, requiring only markings and signs without physical separators.
- Type B can be applied in segments with wide sidewalks (for example, in front of campuses or park areas), so that cyclists have a safe lane separated from motor vehicle traffic.

In addition, bicycle lanes must be continuous from intersection to intersection without interruption, and equipped with signs, markings, and consistent lane colors (e.g., light green or brick red in accordance with Bina Marga standards) to improve visibility and safety for cyclists. With this plan, the bicycle lanes on Jalan Soekarno–Hatta will be able to:

- Ensuring the safety of cyclists,
- Maintaining the smooth flow of motor vehicle traffic, and
- Supporting the establishment of environmentally friendly and sustainable corridors in Malang City.

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Table 9. Bicycle Lane Implementation Strategies

No	Variable	Existing	Theory/Policy	Analysis Results	Efforts/Strategies
1	Existing infrastructure conditions and spatial potential	• Soekarno Hatta Road is a type 4/2D secondary collector road. • Bicycle lanes are not yet available, and road space is dominated by motor vehicles. • High side barriers due to street vendors, illegal parking, and loading and unloading activities. • Road surfaces are generally good, but there is minor damage and standing water. • Potential space is on the left side of each direction, allowing for one-way bicycle lanes.	• The concept of bicycle lanes and supporting infrastructure • Road layout criteria (Bina Marga, 2021) • Law No. 22 of 2009 (Concerning Road Traffic and Transportation)	• Soekarno Hatta Road is a type 4/2D secondary collector road with heavy traffic flow. • A dedicated cycling space is not yet available. • High-side barriers (street vendors, illegal parking, and loading and unloading activities). • The road surface is fairly good, but there are puddles and minor damage. • The largest space potential is on the left side of each direction, allowing for one-way bicycle lanes.	• Provide a one-way bicycle lane on the left side in accordance with the direction of traffic. • Arrangement of side barriers: control of street vendors and illegal parking. • Road surface maintenance and minor repairs • Reorganize road space to provide safe space for cyclists.
2	Perceptions of the public and road users (IPA)	• Respondents rated safety, clear markings, lane cleanliness, freedom from street vendors, and freedom from motor vehicles as the most important attributes. • Existing performance is considered low due to the absence of bicycle lanes and high side barriers. • Public support for implementing bicycle lanes is quite high.	• Safety, comfort, and accessibility factors for cyclists. • Importance Performance Analysis (IPA) method.	• Key priority attributes (Quadrant I) include: clear markings/barriers; free of motor vehicles; free of street vendors; clean, level paths; and the availability of rest areas.	• Provide markings and physical separators on the lanes. • Enforce order among motor vehicles entering bicycle lanes. • Control of street vendors and side obstacles. • Providing supporting facilities such as lighting and rest areas.
3	Strategies for implementing effective, safe, and sustainable bicycle lanes	• There is sufficient space for a one-way bicycle lane on the left side of the road. • The geometric conditions allow the use of physical separators in high-volume segments. • The main issues to address are side barriers and illegal parking. • Connectivity to campuses and public facilities supports implementation.	• Guidelines for Bicycle Facilities (SE 05/SE/Db/2021).	• The recommended width of a bicycle lane is 1.44 m (one-way) and includes the lane markings. • A physical separator is needed in the dense segment. • The track surface must be level and free of obstacles. • Important connectivity to the campus and public transportation stops. • Supporting facilities, such as lighting and signage, need improvement.	• Geometric Strategy: rearranging road space, providing one-way left lanes, and installing elastic separators/bollards. • Operational Strategy: surface repair, drainage management, routine cleaning. • Safety Strategy: bicycle signs, green markings at intersections, and enforcement of roadside parking. • Integration Strategy: connecting to activity centers (campus, bus stops, commercial areas).

Source: Results of data analysis, 2025

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Figure 9. Map of Existing Road Markings and Traffic Signs on Soekarno Hatta Road
Source: Results of data analysis, 2025

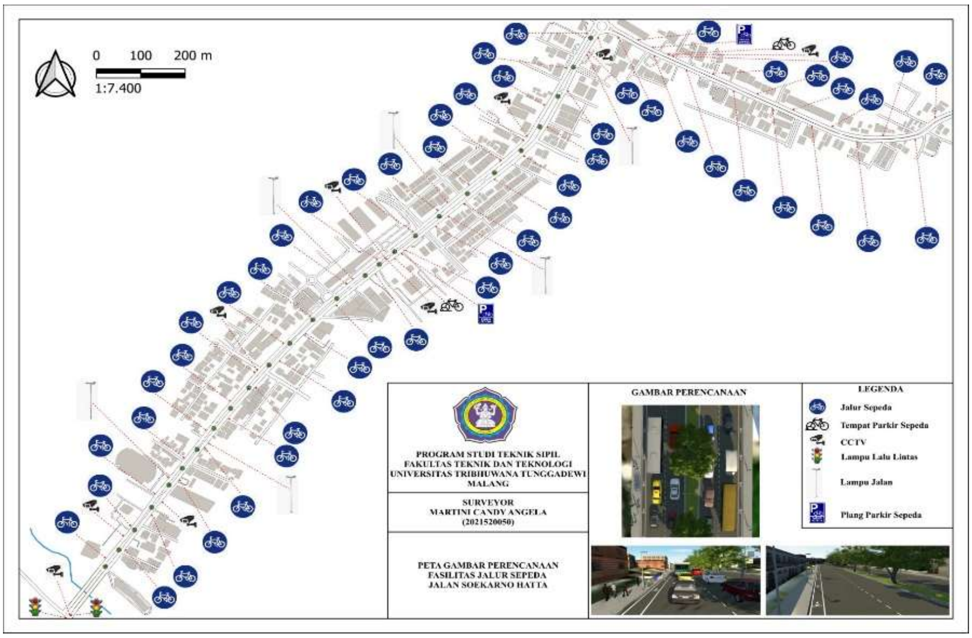

Figure 10. Map of the Soekarno Hatta Road Bicycle Lane Facility Plan
Source: Results of data analysis, 2025

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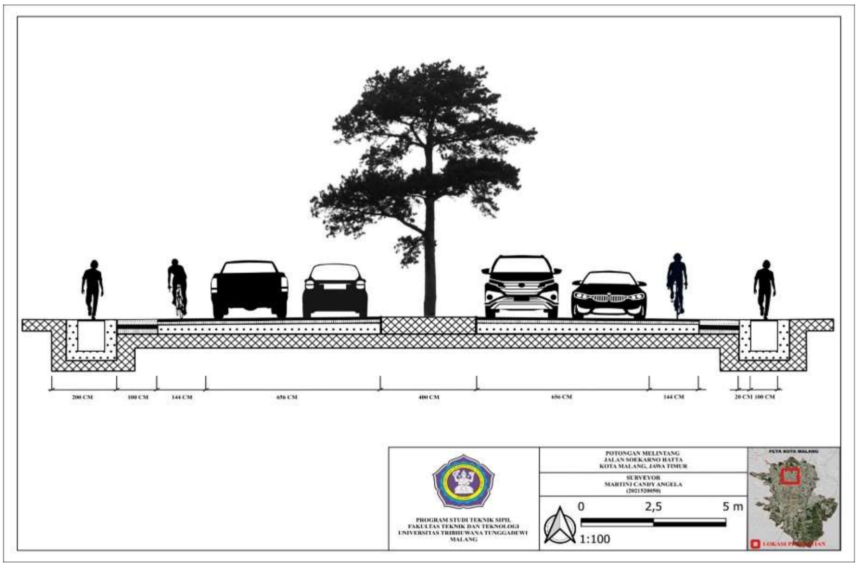

Figure 11. Cross-section of the bicycle lane on Soekarno Hatta Road
Source: Results of data analysis, 2025

4. Conclusions

Soekarno Hatta Road has strong potential for bicycle lanes, given its relatively flat terrain, adequate road width, and high daily traffic volume. However, the main obstacles are still illegal parking, side obstacles, uneven facility quality, and high traffic volume.

Public perception shows strong support for the implementation of bicycle lanes, with priority given to safety, surface comfort, separation from motor vehicles, cleanliness, and the availability of supporting facilities.

The implementation of effective and sustainable bicycle lanes should consider technical aspects, including lane width, physical separation, surface improvements, and integration with activity centers, and be supported by operational management and safety policies.

The implementation of bicycle lanes on Jalan Soekarno Hatta should begin with road space planning, including controlling illegal parking and reducing side obstacles. Local governments are advised to provide physical separation, clear markings, and improved lane surfaces to enhance cyclists' safety and comfort. The integration of bicycle lanes with campus areas, public transportation, and commercial areas needs to be strengthened, accompanied by the provision of supporting facilities and enhanced traffic regulations and education. Further research is recommended to investigate geometric design or traffic simulation to produce more applicable bicycle lane planning.

These findings are in line with and can be compared to the study by Pinalam, Soesiantoro, and Hariyoko [11] on bicycle lane implementation in Surabaya City, which similarly concluded that the main obstacles to effective bicycle lane operation in Indonesian urban corridors are the lack of physical separators between cyclists and motorized vehicles, low user discipline, and the absence of adequate supervision and enforcement. Both studies converge on the importance of physical separation, clear road markings, and operational management as non-negotiable prerequisites for safe cycling infrastructure. However, a distinguishing aspect of the Jalan Soekarno Hatta case in Malang is the additional dimension of side barrier problems, particularly illegal parking and street vendors, which are more pronounced in this corridor than in Surabaya, where the challenges are more concentrated on motorized vehicle encroachment into designated lanes. This suggests that while the fundamental technical requirements are similar, the implementation strategy for Jalan Soekarno Hatta must place greater emphasis on space management and the enforcement of roadside order as a precondition for physical bicycle lane construction to be effective.

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