



PLANNING MALAYSIA:

Journal of the Malaysian Institute of Planners

VOLUME 24 ISSUE 4 (2026), Page 806 – 826

WHERE DO BIKE LANES WORK BEST? ALTERNATIVE PRIORITIES FOR IMPROVING BIKE LANE SERVICE PERFORMANCE IN URBAN AREA

**Imma Widyawati Agustin¹, Kinanthi Nur Gusti², Risma Khoirunnisa³,
Farzana Rahman⁴, Budi Sugiarto Waloejo⁵**

^{1,2,3,5} *Department of Urban and Regional Planning, Engineering Faculty,
UNIVERSITAS BRAWIJAYA INDONESIA*

⁴ *Department of Civil Engineering,
UNITED INTERNATIONAL UNIVERSITY BANGLADESH*

Abstract

As one of East Java's largest cities, Malang has significant potential for developing bike lanes and eco-friendly transportation. Although a bike lane has been installed on Jalan Besar Ijen, its use remains suboptimal due to several service issues. This study aims to identify priority recommendations for improving bike lane performance on Jalan Besar Ijen using questionnaire-based data collection. Importance Performance Analysis (IPA) is applied to assess service performance, followed by Quality Function Deployment (QFD) to formulate recommendations. The combined findings yield three priorities: (1) installing bicycle lane traffic signs at key locations, (2) establishing protected bike lanes, and (3) providing user-friendly bicycle parking spaces.

Keywords: Bike lanes, service performance, Importance Performance Analysis (IPA), Quality Function Deployment (QFD)

¹ Corresponding author. Email: immasaitama@ub.ac.id

INTRODUCTION

The Malang City Spatial Plan (2022–2042) calls for the construction of bike lanes in eleven Klojen and Lowokwaru subdistricts. There will also be other routes in Klojen, Lowokwaru, Kedungkandang, and Sukun. Future additions to ancillary amenities, such as bike parking, are included. Between 2019 and 2020, the city successfully erected bike lanes in eighteen locations; nonetheless, drivers' exploitation of these lanes as parking spaces has undermined their utility, highlighting the need for stricter enforcement and greater public awareness. (Mahmudan, 2023). In 2021, Jalan Simpang Balapan and Jalan Jakarta in the Ijen region were connected by a circular bike lane. The Jalan Besar Ijen corridor is well known for its colonial architecture and distinct urban character (Faisal & Adhitama, 2018), is already a popular route, especially on Car Free Day (Mahendra, 2023). Its central location and land use, which is dominated by commercial, educational, and public service buildings, make it an ideal place to encourage bicycle transportation (Malang City Government, 2020).

Numerous issues, including motorized vehicle parking, a lack of driver discipline, and the absence of supplementary amenities like bicycle parking and signs, are undermining the effectiveness of the cycling lane on Jalan Besar Ijen and lowering the safety and comfort of cyclists. In response, the Malang City Government established two bicycle lane designs under Regional Regulation No. 5 of 2015 on the Detailed Spatial Planning and Zoning Regulations for the North Malang Urban Area (2015–2035): (1) a bike lane with unique markings that is integrated with motorized vehicle roads; and (2) a bike lane with clear markings and physical separation, both of which are meant to more fully ensure cyclists' safety and comfort. This study develops evidence-based, strategic recommendations for improving bicycle lane services in Malang City by using Quality Function Deployment (QFD) and Importance Performance Analysis (IPA) to enhance the lane's performance.

LITERATURE REVIEW

Bicycle Infrastructure

The goals of transportation development are to minimize expenses, shorten travel times, and enhance user comfort and safety. Air pollution, traffic, and accidents are reduced via sustainable transportation (Ganiron et al., 2024), with non-motorized modes providing a greener substitute (Suryono et al., 2020). In particular, bicycles are marketed as an environmentally friendly everyday means of transportation (Romadhon & Murwadi, 2023) (Suryabrata & Suartika, 2025), cost-effective, health-promoting, emission-free, and fossil fuel-free (Márquez et al., 2021; Prasetyo et al., 2020) (Marditama & Santosa, 2022), and their increasing popularity as a public transportation alternative is indicative of

Indonesia's larger transition to sustainable living (Enrico & Riani, 2021; Zaini et al., 2024).

The growing popularity of cycling highlights the need for the greatest bike lane infrastructure to promote comfort and safety (Dwi Ratnaningsih, 2022), foster an enduring culture of cycling (Praditya et al., 2021), to promote more environmentally friendly modes of transportation (Makatita et al., 2025). The Indonesian government has established a legal framework for this through Law No. 22 of 2009 and Government Regulation No. 59 of 2020. Dedicated bike lanes physically separate cyclists from motorized vehicles and are typically placed on routes with medium to high bicycle traffic levels (Fadly et al., 2020).

Bicycle Lane

A bike lane is a portion of the road designated for bicycles and other non-motorized, human-powered vehicles (Kurniasih, 2023), distinguished by signage that can be modified to fit the local context, colored lanes, or physical barriers (Delbosc et al., 2025; Harris et al., 2025). Bike lanes not only keep automobiles apart but also slow down traffic and lessen collisions (Younes et al., 2024). Both regional and local factors need to be taken into account. Bicyclists have a right to infrastructure that supports order, safety, security, efficient traffic flow, environmental sustainability, and conservation consciousness (Romadhon & Murwadi, 2023), rights that, when respected, encourage a full cycling network and a greater uptake of bicycles.

RESEARCH METHODOLOGY

The study area is situated in Malang City's Oro-Oro Dowo Village on Jalan Besar Ijen. The Malang City Spatial Plan (2022–2042) includes it. With two lanes in each direction, the Type C bike lane covers 136.96 hectares and connects the subdistricts of Oro-Oro Dowo and Klojen. Major problems include low bicycle usage the majority of residents mainly ride for fun or exercise rather than as a regular mode of transportation and frequent motorized vehicle blockage, which endangers cyclists' comfort, safety, and security (Figure 1).

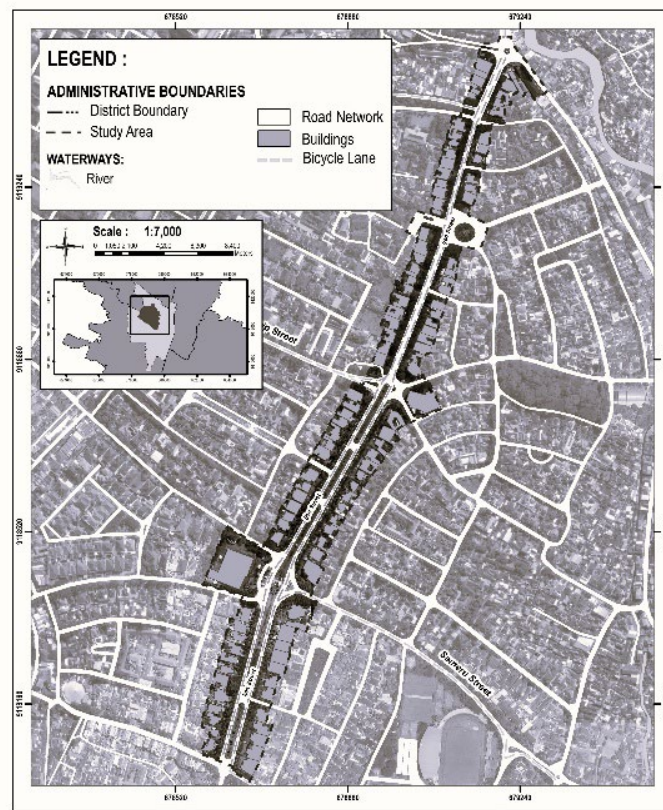


Figure 1: Study Area

Research methods are systematic procedures for obtaining data and information to address the objectives and problem formulation of a study. This study claims that "Where are bike lanes most effective? Quality Function Deployment (QFD) and Importance Performance Analysis (IPA), along with specific sample approaches and research variable selection, are the primary analytical methods employed in "Alternative priorities for improving bike lane service performance in urban areas" (Figure 2). When assessing bicycle infrastructure, IPA (Importance-Performance Analysis) and QFD (Quality Function Deployment) are frequently coupled because they work well together to bridge the gap between user views and the technical actions performed by legislators. The IPA is supposedly used to rank upgrades from the viewpoint of infrastructure users, such as bikers. How It Operates: The IPA evaluates a facility's actual performance in the field as well as its significance. Function: A four-quadrant matrix (such as the "Keep Up the Good Work" or "Concentrate Here" quadrants) is used to plot the results. In order to avoid wasting funds and

resources, this aids planners in rapidly identifying which bike lane amenities are essential for cyclists but are still functioning poorly. Theoretically, QFD is utilized to convert user requirements into engineering blueprint technical specifications. How It Operates: QFD links "What the user wants" (Voice of the Customer, for example, a bike lane free from cars) with "How to technically achieve it" (Voice of the Engineer, for example, the thickness of the concrete road barrier or the width of the lane) through a crucial tool known as the House of Quality (HoQ). Function: QFD makes ensuring that modifications to the bike path's physical or geometric layout appropriately address the issues brought up by cyclists. While QFD acts as a technical solution to develop focused strategies for constructing or enhancing such infrastructure, IPA acts as a diagnostic tool to pinpoint the most urgent problems on bike lanes. QFD is designed to translate consumer needs and desires (Voice of consumer) into technical specifications so that every technical component is in line with user objectives and expectations (Sari, 2021). QFD is carried out by creating one or more House of Quality (HOQ) matrices, which are utilized to ascertain client needs (Margiandistira et al., 2023; Yuliana & Mayasari, 2022). (i) Voice of the Customer (VoC); (ii) Planning Matrix including Goal, Importance to Customer (IOC), Current Satisfaction Performance (CSP), Improvement Ratio (IR), Raw Weight (RW), and Normalized Raw Weight (NRW); (iii) Technical Response, (iv) Relationship Matrix, (v) Technical Correlation, and (vi) Technical Matrix with Contribution, Normalized Contribution, and Absolute Importance.

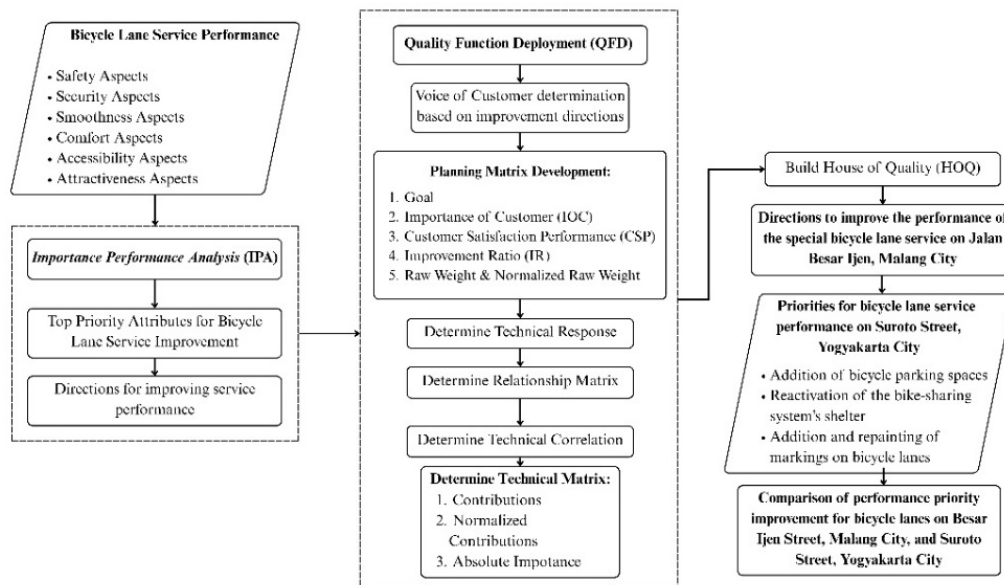


Figure 2: Research Framework

The study's participants are bikers who have used the bike lane on Jalan Besar Ijen in Malang City. Data was gathered using a Likert scale questionnaire that included the lane's service elements. Bicyclists who met predefined criteria and were observed at the research site were selected using accidental sampling, a non-probability technique. Even though there is a chance that some minority groups may be underrepresented, random sampling's strength is its capacity to reduce subjective selection bias and give every member of the population an equal chance of being chosen, guaranteeing that the research findings retain strong scientific validity for generalization. Since the total number of bicyclists using the lane is unknown, the sample size was determined using the Bernoulli formula (Amin et al., 2023).

$$n = \frac{(Z \frac{\alpha}{2})^2 p \cdot q}{e^2}$$

$$= \frac{(1,96)^2 \cdot (0,5) \cdot (0,5)}{(0,1)^2}$$

$$= 96,04 \approx 100$$

The Bernoulli formula was used to get a sample size of 100 responders. Six criteria totaling thirteen factors were used to assess the service quality of the Jalan Besar Ijen bike lane: safety, security, smoothness, comfort, accessibility, and attractiveness (Table 1).

Table 1: Research variable

Aspect	Variable	References
Safety	- Condition of bicycle lane pavement - Bicycle lane height - Availability of traffic signs - Availability of bicycle lane markings	(Windarni et al., 2018)
Security	- Safe from motor vehicles - Safe from crime	
Smoothness	- Free from obstacles - Free from traffic jams	
Comfort	- Availability of bicycle parking - Availability of street lighting - Shade along the road - Availability of sufficiently wide lanes	
Accessibility	Land use affordability	
Attractiveness	Attractive bicycle lane design	

ANALYSIS AND DISCUSSION

The type C bicycle lanes on Jalan Besar Ijen are 1.2–1.34 meters wide and extend around 1.6 kilometers on both sides of the road. They run along the road surface and are divided from traffic by line markings. Marked by bicycle symbols and

green line markings, with broken lines at intersecting openings, the lanes are in fair condition despite some fading, with characteristics further shaped by complementary facilities along the route (Figure 5).



Figure 5: Road Openings with Dashed Line Markings

The Ijen corridor's bike lane markings adhere to both the Directorate General of Highways' 2021 Guidelines for the Design of Bicycle Facilities and PM 59 of 2020 (Table 2).

Table 1: Comparison of Existing Marking Conditions with Standards

Existing Conditions	Policies/Standards
Green lines and a green bicycle symbol are used to designate bicycle lanes along the important Ijen road corridor.	According to PM 59 of 2020, bicycle lanes on the road must at the very least include markers that depict a white or green bicycle.
At each road opening where it joins another road access, the area marking lines seem broken on both sides of the markings.	According to the Directorate General of Highways Concerning the Design of Bicycle Facilities in 2021, bicycle lane markings are intended to be continuous in order to keep motorized vehicles out of the lane.
Although the line color has faded in some places, the lane markings are still in generally good condition.	Dotted lines are used on both sides to indicate area markers at road openings that connect to other road access points (Directorate General of Highways Concerning Design of Bicycle Facilities in 2021).

There are now only two bicycle lane signs, indicated by a cycling emblem, on the left side of Jalan Bandung on the northern stretch of the Jalan Besar Ijen corridor, and no warning signs on the southern portion at Jalan Kawi (Figure 6).



Figure 6: Bicycle lane sign distribution on Jalan Besar Ijen

The bicycle lane traffic signs on Jalan Besar Ijen, despite their scarcity, are in good condition and comply with PM 59 of 2020 and the Directorate General of Highways' Guidelines for the Design of Bicycle Facilities (2021).

Table 3: Characteristics of bike lane users in Jalan Besar Ijen, Malang City

No	Bike Lane Users	Criteria	Total
1	Gender	Male	80
		Female	20
2	Age	< 15 years old	1
		15-24 years old	7
		25-34 years old	27
		35-44 years old	35
		45-54 years old	19
		55-65 years old	9
		> 65 years old	2
3	Type of work	Not working	2
		Student	9
		Civil servant	15
		Housewife	9
		Private Employee	26
		Self-Employed	26
		Retiree	6
		Other	7
4	Travel intensity	Every Day	3
		Once a week	30
		2-5 Times a Week	17
		Once a Month	16
		2-5 Times a Month	10
		Once In 2-5 Months	24
5	Travel destination	School/College	1
		Work	5

No	Bike Lane Users	Criteria	Total
		Medical Treatment	0
		Entertainment/Travel	35
		Exercise	84
		Home	6

According to study results, 80% of bikers on Jalan Besar Ijen are men, and the greatest age groups are 25–34 (27%) and 35–44 (35%). Cycling has not become a primary everyday form of transportation, as seen by the low usage frequency of 30% riding once a week, mostly on Car Free Day, and the remaining riding infrequently. Trip purpose data, which shows that 84% of cyclists ride for exercise, supports this. Cycling exercise here focuses more on cycling activities related to physical activity, and 27% for vacation or leisure. In general, the lane is utilized more for recreational purposes than for regular duties like traveling to work or school (Table 3). Theoretically, the main distinction between cycling as a sport and cycling as a method of transportation is that the former is more concerned with mobility than the latter. The goal of cycling as a mode of transportation is to get the rider from point A to point B quickly, safely, and without using too much energy so they won't feel worn out when they get there. As a result, the bikes utilized are city bikes, commuter cycles, or foldable bikes with fenders and luggage racks. Additionally, the route takes the safest or fastest urban routes, and riders wear work uniforms or informal everyday attire that emphasizes practical comfort. Cycling, on the other hand, is a sport that uses intense physical activity to increase cardiovascular fitness or performance, burn calories, and cause physiological changes in the body. In order to minimize wind resistance and avoid chafing, this sport uses lightweight, aerodynamic specialist bikes, such as road bikes or mountain bikes (MTBs), in conjunction with form-fitting athletic apparel, such as jerseys and padded shorts. In order to keep a constant pedaling rhythm, routes are purposefully selected for their physical challenges, such as steep climbs, off-road trails, or lengthy sections with little traffic.

Bike Lane Services' Performance on Jalan Besar Ijen in Malang City

The Importance Performance Analysis (IPA) qualities in this study were created from user perspectives and categorized into six service sections, which formed the basis for the questionnaire, based on prior research and bicycle lane regulations (Table 4).

Table 4: Important Performance Analysis Service Attributes

Aspect	Attributes	Notation
Safety	Bicycle lane pavement condition	A
	Bike lane height	B
	Availability of traffic signs	C
	Availability of bicycle lane markings	D
Security	Safe from motor vehicles	E
	Safe from crime	F
Smoothness	Free from obstacles	G
	Free from traffic jams	H
Comfort	Bicycle parking areas	I
	Street lighting	J
	Shade along the road	K
	Sufficiently wide lanes	L
Accessibility	Land use affordability	M
Attractiveness	Bicycle lane design	N

The Importance Performance Analysis (IPA), which plots the features onto a Cartesian diagram to determine priorities for enhancing bicycle lane services, is based on these service attributes (Table 5 and Figure 7).

Table 5: Recapitulation of Science Results for the Bike Lane on Jalan Besar Ijen

No.	Quadrant	Notes	Variable	Attributes
1	I	Concentrate Here	Safety	C
			Security	E
			Safety	I
2	II	Keep up The Good Work	Safety	A, D
			Security	F
			Smoothness	G
			Comfort	J
3	III	Low Priority	Smoothness	H
			Comfort	L
			Accessibility	M
			Attractiveness	N
4	IV	Possible Overkill	Safety	B
			Comfort	K

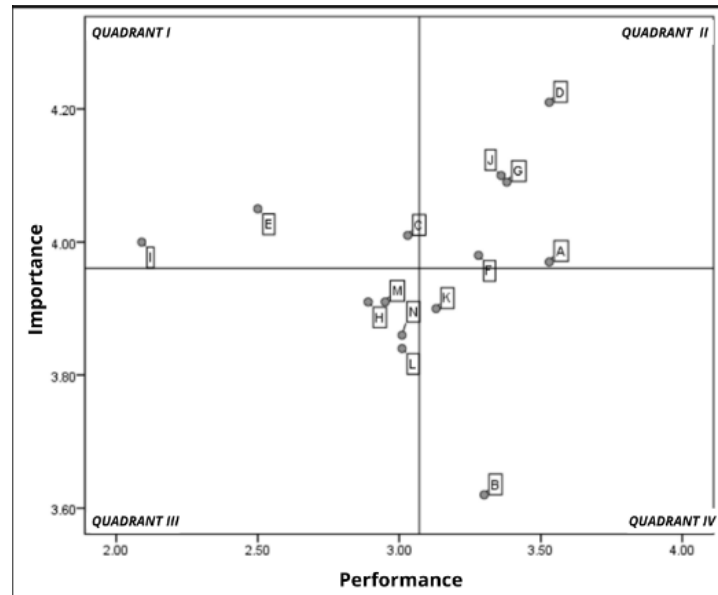


Figure 7: Cartesian Diagram of the Bike Lane Service Performance on Jalan Besar Ijen, Malang City

Bike Lane on Jalan Besar Ijen, Malang City: Quality Function Deployment (QFD) Service Performance

The IPA study's Quadrant I results, which cover the stages of Voice of Customer, Planning Matrix, Technical Response, Relationship Matrix, Technical Correlation, and Technical Matrix, served as the foundation for the QFD analysis for the bike lane on Jalan Besar Ijen. As shown in the House of Quality (HoQ) in Figure 8, three priority recommendations were identified: (1) putting up bicycle lane traffic signs at strategic locations; (2) creating protected riding lanes; and (3) offering user-friendly bicycle parking spaces.

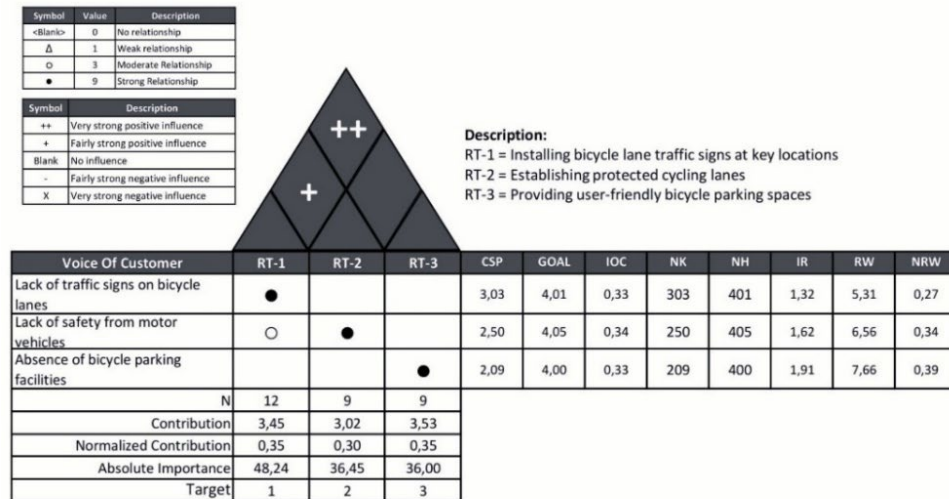


Figure 8: House of Quality: Jalan Besar Ijen, Malang City's Bike Lane Services Performance

A rational, planned, and financially feasible intervention strategy is shown in this priority of bicycle infrastructure upgrades. According to transportation planning theory, this progression starts with inexpensive interventions that have quick psychological effects, proceeds through the creation of auxiliary facilities, and ends with significant infrastructure investments that offer complete safety.

Installing bicycle lane traffic signs at key locations: This is a tactical intervention (legitimacy and visibility). The least expensive type of infrastructure is traffic signs, which are also the easiest to quickly and widely install. From a psychological standpoint, strategically placed traffic signs both provide bicycles a sense of legal recognition and inform other road users (motorized cars) that they are present in the area. Raising public awareness prior to the construction of extensive physical infrastructure is a critical first step.

Establishing protected cycling lanes: This is a structural intervention (long-term convenience and complete safety). The most expensive, time-consuming, and intricate traffic engineering is needed for protected bike lanes, which include physical barriers like bollards, concrete dividers, or median strips. This is the apex of the ecosystem for bicycle mobility. By keeping bicycles' speeds apart from those of cars, physical separation significantly lowers the number of fatal collisions. In order to draw in "beginner or hesitant" cyclists those who are interested but apprehensive who wouldn't dare ride if they had to share the road

with vehicles or buses, this infrastructure is essential.

Providing user-friendly bicycle parking spaces: This reward program is focused on utilities (end-of-trip facilities). The next difficulty is making sure cyclists are secure when they arrive at their destination (end-of-trip amenities) when they start to feel acknowledged on the road (due to First Priority). The goal is to guarantee users' commitment by offering secure parking that satisfies their demands (e.g., close to train stations, office buildings, or shopping centers). Theoretically, people's interest in converting to bicycles as a daily mode of transportation is greatly increased when secure parking is available at destinations since worries about bicycle theft can be reduced.

Comparing the Bike Lane Priority Directions on Jalan Suroto in Yogyakarta City and Jalan Besar Ijen in Malang City

The main recommendations for Yogyakarta's Jalan Suroto corridor, which concentrated on bicycle parking, reinstating a bike-sharing scheme, and repainting lane markings, differ from those for Jalan Besar Ijen. Although both corridors have similar features, such as recreational and sporting use, different user needs highlight the importance of location-specific strategies to effectively address infrastructural requirements.

Implementation

In response to the HoQ analysis, two QFD priorities the availability of bicycle parking spots and the thoughtful placement of bicycle traffic signs are the main focus of implementation. PM 13 of 2014 about Traffic Signs mandates circular signs with a 45 cm diameter, a blue background, and a white bicycle icon. Figures 9 and 10 depict the recommended installation locations.

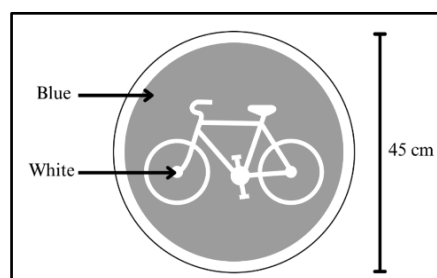


Figure 9: An example of a bike lane sign

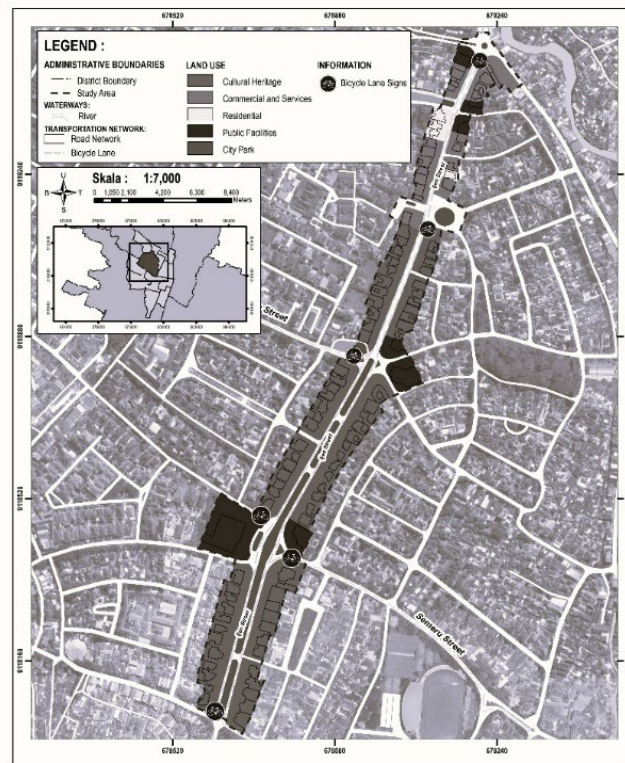


Figure 10: Bicycle Lane Sign Distribution on Jalan Besar Ijen, Malang City

The recommended bicycle parking option for Jalan Besar Ijen is the inverted U design, which has two locking hooks that simultaneously secure the frame and wheels. Its advantages include longevity, convenience of use, and compatibility with many bicycle types, according to international standards used by bicycle-friendly cities like Singapore (Figures 11 and 13).

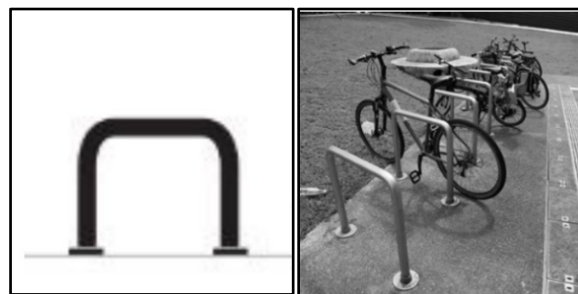


Figure 11: An Illustration of the Design and Execution of Bicycle Parking

Imma Widyawati Agustin, Kinanthi Nur Gusti, Risma Khoirunnisa, Farzana Rahman, Budi Sugiarto Waloejo
**WHERE DO BIKE LANES WORK BEST? ALTERNATIVE PRIORITIES FOR IMPROVING BIKE LANE
 SERVICE PERFORMANCE IN URBAN AREA**

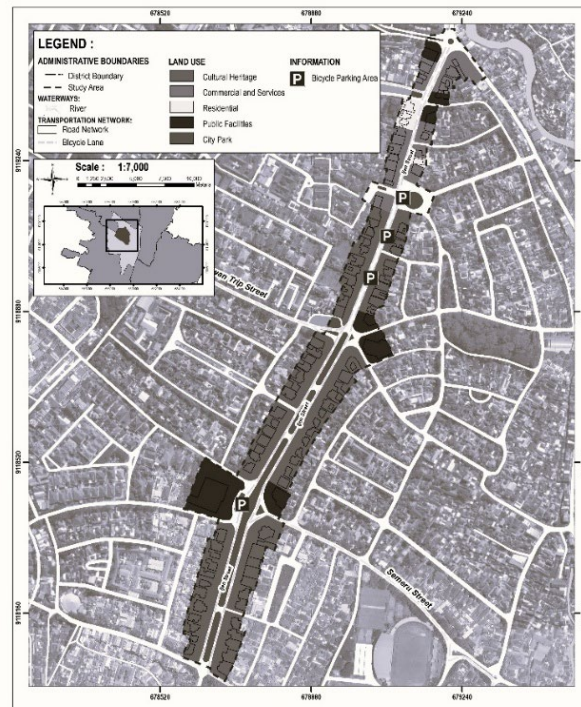


Figure 12: Distribution of Bicycle Lane Parking Points on Jalan Besar Ijen

At five strategic locations on Jalan Suroto in Yogyakarta, N-type bicycle parking racks with two locking points and security cameras were recommended (Figures 12 and 14). Bicycle parking should be introduced in each scenario in compliance with technical guidelines and any applicable laws.

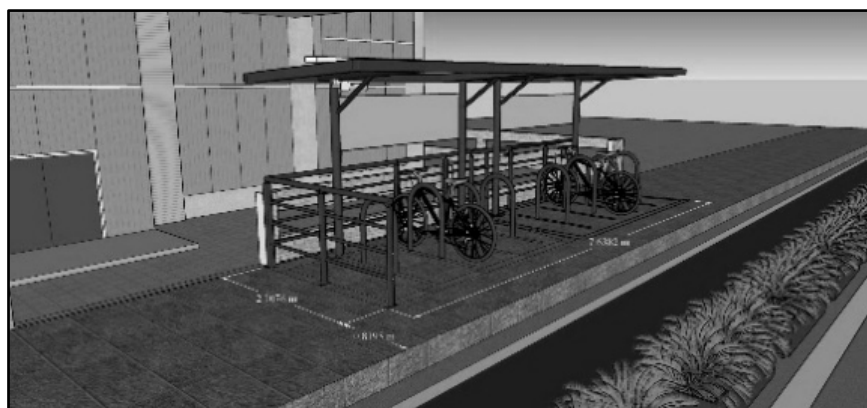


Figure 13: Suroto Street Bicycle Parking Area

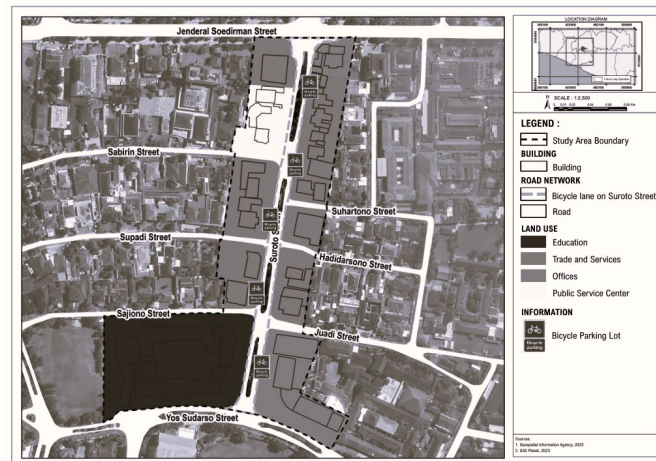


Figure 14: Strategic Locations for Adding Bicycle Parking Spaces

Jalan Suroto's second goal is to revive bicycle rental stations in public areas like parks and road medians through a bike-sharing system. This would encourage sustainable mobility and increase bicycle accessibility for residents and tourists (Figure 15).

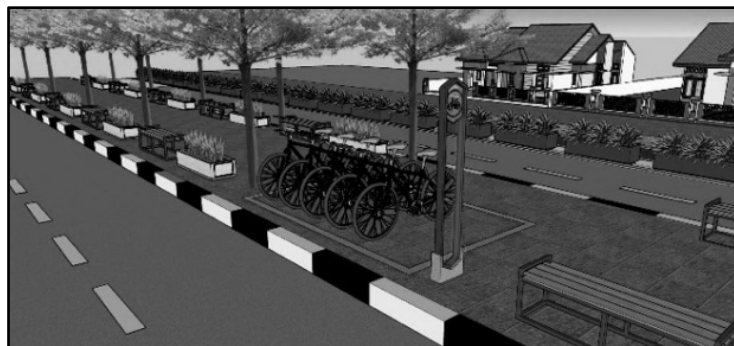


Figure 15: Bike-Sharing Jalan Suroto

The final goal for Jalan Suroto is to add area markings, arrow symbols, and "bike lane" inscriptions in addition to repainting the entire road with yellow thermoplastic paint and adding planter boxes. By increasing lane safety and clarity for both motorized vehicle users and bikes, these improvements are expected to lessen disruptions (Figure 16).

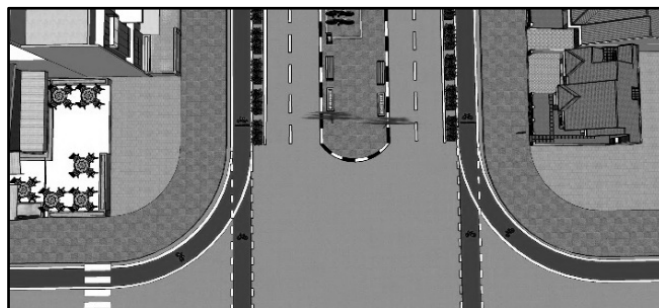


Figure 16: Better Markings for Bicycle Lanes on Jalan Suroto

Physical infrastructure is insufficient to establish a publicly accepted and safe cycling habitat. A legally binding framework of regulations and policies is required. The three key foundations for turning cycling from a "recreational option" into a "legally recognized primary mode of transportation" are laws pertaining to network integration, lane protection, and law enforcement.

More robust policies for law enforcement (strong enforcement)

Without legal certainty, even the best infrastructure will be useless. Ensuring the rule of law for vulnerable road users and addressing road space infractions are the goals of strict law enforcement measures.

1. **Enforcement Against Lane Occupation:** A regulation that penalizes motor vehicles that park or drive in bike lanes with severe fines, automatic towing, or electronic traffic tickets (ETLE).
2. **Strict Liability Rules:** Adopting a legal principle that, unless the cyclist is proven to have committed a purposeful and fatal violation, larger and faster vehicles carry higher legal culpability in the case of an accident involving a cyclist.
3. **Urban Speed Limit Regulations:** In order to lower fatalities, motor vehicle speed limits in heavily populated regions or mixed-use bicycle-pedestrian zones should be lowered to 30 km/h.

Track Protection & Design Requirement

This regulation requires physical barriers in place of the road design standards that were previously based on road markings (standard bike lanes).

1. **Physical Protection Mandate:** An urban planning rule requiring bike lanes with structural barriers (such concrete curbs, median strips, or variations in road elevation) rather than just white painted lines to be included in any significant road construction or rehabilitation.

2. Exclusive Access Rights: Laws that declare bike lanes to be barrier-free, exclusive areas (e.g., barring the establishment of utility poles, trash cans, or street vendors on bike lanes).
3. Safe Intersection Design (Protected Intersections) is a regulation that mandates the installation of specific bicycle markings and traffic signals at intersections, which are the locations where accidents occur most frequently, in order to give cyclists an earlier start time than cars (bike boxes/advanced stop lines).

Guidelines for Network Integration (Integration into the Wider Network)

The goal of this strategy is to guarantee that bike lanes are integrated into a coherent and interconnected urban transportation system rather than being dispersed (disconnected).

1. Policies requiring connectivity between bike lanes and major public transit hubs (train stations, bus terminals, MRT/LRT) are known as multimodal integration. Regulations permitting folding bikes to be loaded aboard train cars or the availability of sufficient "Park and Ride" facilities for bicycles facilitate this.
2. Land-use regulations that forbid the construction of bike lanes that are broken up in the middle of the road are an example of a cohesive and continuous network. Every route must be planned to go straight from residential neighbourhoods (origin) to hubs of activity like workplaces, educational institutions, and commercial districts (destination).
3. The 15-Minute City Concept is an urban design strategy that incorporates land use and places amenities for everyday requirements within a 15-minute walking or bicycling distance.

Together, these three policies form a cycle: designated bike lanes provide a sense of physical safety, legal enforcement ensures comfort and equity on the roads, and network integration provides the practical functionality needed for bicycles to be truly effective for daily movement.

CONCLUSION

Three Quadrant I priority attributes are identified by the IPA analysis: traffic sign availability (C), motor vehicle safety (E), and bicycle parking (I). Three associated improvement solutions are identified by QFD research: (1) putting bicycle lane traffic signs at strategic locations; (2) creating protected riding lanes; and (3) offering bicycle parking spots that are easy to use. Different priorities can be seen when comparing Yogyakarta's Jalan Besar Ijen and Jalan Suroto. Even though both routes need extra parking, Jalan Suroto prioritizes parking above

Jalan Besar Ijen. These variations highlight the significance of context-specific approaches to bicycle lane building since they represent unique user characteristics and desires.

A coherent and thorough urban planning strategy for creating a sustainable transportation ecosystem is formed by these three key areas for enhancing bike infrastructure. Through the construction of traffic signs, the first phase aims to increase public awareness and create legal legitimacy for bikes on the road. In order to guarantee complete safety against the possibility of motor vehicle accidents along the route, this step is subsequently structurally reinforced by the installation of protected bike lanes. In order to guarantee the provision of end-of-trip amenities and to make the public feel comfortable, safe, and eventually motivated to convert to bicycles as their daily method of transportation, it is ideal to finish this sequence of actions by offering secure bicycle parking at destination locations.

ACKNOWLEDGEMENT

This article forms part of a research project funded by the Faculty of Engineering, Universitas Brawijaya (FTUB), under Research Contract Number: 11/UN10.F080UB/PT/2025. The authors gratefully acknowledge the institutional support from the Department of Urban and Regional Planning, Universitas Brawijaya.

REFERENCES

- Amin, N. F., Garancang, S., & Abunawas, K. (2023). Konsep Umum Populasi Dan Sampel Dalam Penelitian. *Jurnal Pilar: Jurnal Kajian Islam Kontemporer*, 14(1), 15–31. <https://doi.org/10.21070/2017/978-979-3401-73-7>
- Delbosc, A., Goh, Z. S., Naseri, M., & Powers, T. (2025). Can curbside bicycle lanes buffer COVID-19 ridership losses? A case study from Melbourne, Australia. *Transportation Research Part A: Policy and Practice*, 195, 104438. <https://doi.org/10.1016/j.tra.2025.104438>
- Dirga, F. H., Tosungku, L. O. A. S., & Fatimahhayati, L. D. (2023). Analisis Kualitas Pelayanan Menggunakan Metode Servqual Dan Importance Performance Analysis (IPA) (Studi Kasus: PDAM Tirta Tuah Benua Kutai Timur). *Jurnal Teknik Industri*, 9(1).
- Dwi Ratnaningsih. (2022). Perencanaan Jalur Sepeda Di Jalan Soekarno Hatta Kota Malang. *Jurnal Teknik Ilmu Dan Aplikasi*, 3(2), 125–129. <https://doi.org/10.33795/jtia.v3i1.86>
- Enrico, K., & Riani, D. (2021). *Lingkungan Universitas Palangka Raya*. 5, 45–53.
- Fadly, G., Widodo, S., & Mayuni, S. (2020). Analisis Efektivitas Lajur Khusus Sepeda pada Kawasan Perkotaan Pontianak Studi Kasus (Jalan Gusti Sulung Lelanang - Kh. Ahmad Dahlan - Johar - Hos Cokroaminoto). *Jurnal PWK, Laut, Sipil, Tambang*, 7(1), 1–8.

- Faisal, M., & Adhitama, M. S. (2018). Aktivitas Jalur Pedestrian pada Koridor Jalan Ijen , Malang. *Jurnal Mahasiswa Jurusan Arsitektur*, 6(3).
- Ganiron, T. U., Eciija, B. M. A., Quisao, S. L. F., & Romero, H. L. E. (2024). Bicycle Lanes Design for Road User Safety. *Design, Construction, Maintenance*, 4, 52–58. <https://doi.org/10.37394/232022.2024.4.6>
- Harris, M. S., Harvey, J., Roberts, L., Lee, J. B., & Pettit, C. (2025). Community perceptions on the contribution of bicycle paths to street quality in cities new to cycling infrastructure. *Case Studies on Transport Policy*, 21, 101560. <https://doi.org/10.1016/j.cstp.2025.101560>
- Kurniasih, D. (2023). Pemenuhan Jaminan Perlindungan Pesepeda di Kota Sepeda. *Hakim: Jurnal Ilmu Hukum Dan Sosial*, 1(3). <https://doi.org/10.51903/hakim.v1i3.1318>
- Mahendra, I. M. D. R. (2023). *Sejarah dan Fakta Unik Jalan Ijen, Jejak Peninggalan Belanda di Kota Malang*. <https://tugumalang.id/sejarah-dan-fakta-unik-jalan-ijen-jejak-peninggalan-belanda-di-kota-malang/>
- Mahmudan. (2023). *Empat Tahun, Kota Malang Punya 18 Titik Jalur Sepeda*. Radar Malang. <https://radarmalang.jawapos.com/kota-malang/811091784/empat-tahun-kota-malang-punya-18-titik-jalur-sepeda>
- Makatita, G. G., Ratuna, M., Pertiwi, D., & Syahzuni, B. (2025). Pengaruh Kesadaran Lingkungan Dan Green Transportation Terhadap Dampak Perekonomian. *Jurnal Riset Akuntansi Politika*, 8(1), 188–198. <https://doi.org/10.34128/jra.v8i1.428>
- Mardalena, O., & Andryani, R. (2021). Analisis Kualitas Layanan Website Pada Universitas Terbuka Palembang Menggunakan Metode Webqual 4.0 Dan Importance Performance Analysis (IPA). *Journal of Information Systems and Informatics*, 3(4), 615–633. <https://doi.org/10.51519/journalisi.v3i4.204>
- Marditama, A., & Santosa, W. (2022). Penentuan Tingkat Pelayanan Lajur Sepeda Di Jalur Dago Kota Bandung. *Jurnal Transportasi*, 22(3), 181–190.
- Margiandistira, G. B. A., Waloejo, B. S., & Sutikno, F. R. (2023). Evaluasi Kinerja Operasional Dan Kinerja Pelayanan Angkutan Kota Batu Trayek Bjl Dan Bg. *Planning for Urban Region and Environment*, 12(2), 45–56.
- Márquez, L., Cantillo, V., & Arellana, J. (2021). How do the characteristics of bike lanes influence safety perception and the intention to use cycling as a feeder mode to BRT? *Travel Behaviour and Society*, 24, 205–217. <https://doi.org/10.1016/j.tbs.2021.04.005>
- Ong, J. O., & Pambudi, J. (2014). Analisis Kepuasan Pelanggan Dengan Importance Performance Analysis Di Sbu Laboratory Cibitung Pt Sucofindo (Persero). *J@Ti Undip : Jurnal Teknik Industri*, 9(1), 1–10. <https://doi.org/10.12777/jati.9.1.1-10>
- Malang City Government (2020). *Pemkot Malang Akan Perbanyak Jalur Khusus Sepeda*. <https://malangkota.go.id/2020/12/22/pemkot-malang-akan-perbanyak-jalur-khusus-sepeda/>
- Praditya, N., Rahmadona, E., Sudarmadji, S., & Pratama, A. S. (2021). Karakteristik Pengguna Sepeda Lipat Terhadap Pemilihan Moda Transportasi Di Kota Palembang. *Bearing : Jurnal Penelitian Dan Kajian Teknik Sipil*, 6(4), 218–225. <https://doi.org/10.32502/jbearing.3216202064>
- Prasetyo, A., Nugroho, M. W., Amudi, A., & Yulianto, T. (2020). Kajian Awal Perencanaan Lajur Khusus Sepeda Dengan Menggunakan Metode IPA (Importance Performance Analysis) dan SWOT. *Publikasi Riset Orientasi Teknik Sipil (Proteksi)*, 2(2), 41. <https://doi.org/10.26740/proteksi.v2n2.p41-47>

- Rizkilawati, N., Fajriaty Ramadhani, M., Fitria Andriani Maryam, E., Sasqia Azzahra, F., Adrian Lanoghan Tarigan, B., Aziz Husyairi, K., & Nur Ainun, T. (2024). Analisis Kepuasan Konsumen Berbasis Metode Importance Performance Analysis (IPA) terhadap Hagu Coffee & Space Kota Bogor. *Journal of Comprehensive Science (JCS)*, 3(5). <https://doi.org/10.59188/jcs.v3i5.701>
- Romadhon, R. A., & Murwadi, H. (2023). Evaluasi Layanan Jalur Sepeda pada Rute Jalan Ryacudu Kota Bandarlampung. *MARKA (Media Arsitektur Dan Kota) : Jurnal Ilmiah Penelitian*, 6(2), 75–84. <https://doi.org/10.33510/marka.2023.6.2.75-84>
- Sari, Y. L. (2021). Analisis Kualitas Sistem Knowledge Management Metode Quality Function Deployment (Studi kasus:PT.Pupuk Sriwidjaja Palembang). *Matics*, 12(2), 104–110. <https://doi.org/10.18860/mat.v12i2.9567>
- Sihotang, F. P., & Oktarina, R. (2022). Penggunaan Metode Importance Performance Analysis (IPA) dan Customer Satisfaction Index (CSI) dalam Menganalisis Pengaruh Sistem E-Service Terhadap Tingkat Kepuasan Pelanggan. *Jurnal Teknologi Sistem Informasi*, 3(1), 1–12. <https://doi.org/10.35957/jtsi.v3i1.2439>
- Suryabrata, I. M. S., & Suartika, G. A. M. (2025). Optimalisasi Program Pengembangan Jalur Sepeda Berbasis Keberlanjutan di Kota Denpasar. *Jurnal Pembangunan Wilayah Dan Kota*, 21(2), 229–246. <https://doi.org/10.14710/pwk.v21i2.68756>
- Suryono, T. A., Rahayu, P., & Rini, E. F. (2020). Tingkat Kesiapan Kota Surakarta sebagai Kota Nyaman Bersepeda. *Desa-Kota*, 2(1), 100. <https://doi.org/10.20961/desa-kota.v2i1.32260.100-116>
- Wibowo, A. A., Prawatya, Y. E., & Uslianti, S. (2021). Rancang Bangun Alat Pemanggang Daging Sistem Tuas Menggunakan Metode Quality Function Deployment Dan Pendekatan Antrophometri. *Jurnal Teknik Industri Universitas Tanjungpura*, 5(1), 170–177.
- Windarni, I. P., Wulandari, A., & Hernovianty, F. R. (2018). *Tingkat Keinginan Masyarakat Menggunakan Jalur Sepeda di Kota Pontianak*. 1–14.
- Wisudawati, N., Irfani, M. G., Hastarina, M., & Santoso, B. (2023). Penggunaan Metode Importance-Performance Analysis (IPA) Untuk Menganalisis Kepuasan Masyarakat Terhadap Pelayanan Administrasi Kependudukan. *Integrasi : Jurnal Ilmiah Teknik Industri*, 8(1), 32–39. <https://doi.org/10.32502/js.v8i1.5969>
- Younes, H., Andrews, C., Noland, R. B., Xia, J., Wen, S., Zhang, W., Metaxas, D., Von Hagen, L. A., & Gong, J. (2024). The Traffic Calming Effect of Delineated Bicycle Lanes. *Journal of Urban Mobility*, 5, 100071. <https://doi.org/10.1016/j.urbmob.2024.100071>
- Yuliana, L., & Mayasari, I. (2022). Pelatihan Desain Produk Dengan Metode Quality Function Deployment. *Jurnal Abdi Masyarakat Multidisiplin*, 1(1).
- Zahra, P., & Hanifa, F. H. (2021). Analisis Kualitas Layanan Dengan Menggunakan Metode Importance Performance Analysis (Ipa) Studi Pada Pengunjung Plasa Telkom Putri Hijau Medan Tahun 2021. *E-Proceeding of Applied Science*, 7(4).
- Zaini, A. K., Fadillah, M. A., & Muttaqin, M. Z. (2024). The Implementation of Bicycle Lanes in Pekanbaru City. *International Journal of Multidisciplinary Approach Research and Science*, 2(02), 973–993. <https://doi.org/10.59653/ijmars.v2i02.842>

Received: 11th March 2026. Accepted: 14th April 2026