PLANNING MALAYSIA:
Journal of the Malaysian Institute of Planners
VOLUME 22 ISSUE 5 (2024), Page 293 – 306

POLICY ON THE IMPLEMENTATION OF SMART MOBILITY IN THE SOUTH TANGERANG CITY, INDONESIA BASED ON PUBLIC TRANSPORTATION USING THE PROMETHEE METHOD

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Abstract

The increase in population density and mobility in certain urban areas has underscored the need for a smart mobility concept. As a component of the broader smart city framework, smart mobility aims to enhance transportation services, making them more accessible, safe, comfortable, efficient, and affordable for the public. This research assesses the readiness for implementing public transportation-based smart mobility in South Tangerang and develops a policy strategy model for its transportation planning and development. The study employed a mixed-method approach, incorporating multivariate analysis and Multi-Criteria Decision Analysis. The findings reveal that South Tangerang is currently unprepared to implement smart mobility, as indicated by low scores on its assessment indicators. Recommended policies include improving the availability, security, and comfort of public transportation, reorganizing transit routes, providing real-time information access, adjusting schedules, and promoting bicycle use by adding bicycle lanes. This research highlights the current state of transportation systems in developing countries and emphasizes the importance of implementing policies that benefit a wide segment of the population.

Keywords: Smart Mobility, Smart City, Public Transportation, Policy, South Tangerang

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INTRODUCTION

According to the World Urbanization Prospects (WUP) report, the number of people living in urban areas surpassed those in rural areas in 2007. The most recent revision in 2018 indicated that over half of the world's population, specifically 55%, resides in urban areas, with this figure expected to rise to 66% by 2050 (Alanazi, 2023; Ribeiro et al., 2021a, 2021b). While the growth of the urban population might appear random, it highlights the critical need for effective urban space management to enhance the performance of urban services such as energy, transportation, health, and housing. As the urban population continues to grow, meeting the increasing demands for these services becomes increasingly vital (Tariq et al., 2020).

Cities are often viewed as powerful engines of growth, but the movement of populations to suburban areas can create functional centers with bustling urban activities. Over time, peri-urban areas can evolve into densely populated urban centers, while rural areas can develop urban cores with high levels of centrality and service quality (Gerten et al., 2019). Rapid urban growth and expansion impact other urban systems (Aljoufie, 2021). Suburbanization refers to the creation of new settlements and industrial zones on the outskirts of urban areas as city dwellers seek new places to live and work (Rustiadi et al., 1999).

Furthermore, the Smart City concept is the result of knowledge development and community engagement aimed at creating a better environment with high enthusiasm. Its main goal is to enhance citizens' quality of life by effectively using information and communication technology to mitigate the negative effects of urbanization through the development of infrastructure networks that improve social and business activities (Sutriadi, 2018). A heterogeneous traffic environment is characterized by a mix of different types of road users, including vehicles, bicycles, and pedestrians. This heterogeneity distinguishes traffic conditions in developing countries from those in developed countries (Karwad et al., 2024).

A Smart City can be defined as a modern urban area that seeks to improve citizens' quality of life by integrating information and communication technology. This involves evaluating infrastructure and technology across various sectors, including health, safety, mobility, recreation, employment, education, and governance. Investment in advanced human, social, transportation, and communication infrastructure is crucial for driving sustainable economic growth and enhancing the quality of life in Smart Cities. It also involves prudent natural resource management and governance with community participation (Billones et al., 2021). The Smart City concept has sparked considerable debate among city planners, investors, and local governments, attracting more affluent residents, law-abiding citizens, and potential investors. Efficient resource use in everyday life is another important topic. The availability of facilities, job growth, and higher income opportunities contribute to the expansion of urban populations compared to rural areas (Azmi et al., 2024).

Smart mobility, a key component of the Smart City concept, involves developing technology-based transportation systems using information and communication technology. Its goal is to make public transportation easy, safe, convenient, fast, and affordable through technological advancements. Smart cities with smart transportation systems will facilitate easier travel for citizens by providing innovative and sustainable public transportation with minimal environmental impact. According to identified variables (Billones et al., 2021), smart mobility includes three main components: Accessibility, Information Technology System (ITS) Availability, and Integration (between modes and ITS). Smart mobility aims to reduce car travel and its environmental impact while encouraging alternative travel modes (Müller-Eie & Kosmidis, 2023). However, the introduction of smart mobility raises concerns about the sustainability of urban mobility systems if these new solutions are expected to function alongside existing public transportation options such as buses and metros (So et al., 2023).

Smart mobility involves using technology and data to enhance the efficiency, sustainability, and accessibility of transportation systems. It encompasses various modes of transport, including cars, bikes, buses, and trains. Transportation systems play a strategic role for several reasons: they foster social cohesion, promote economic and employment development, and help balance accessibility across different areas (Labri & Baziz, 2022). Smart mobility solutions aim to optimize existing transportation infrastructure, reduce congestion and emissions, improve safety and accessibility, and enhance the overall mobility experience for users (Wolniak, 2023). This optimization can be achieved by introducing innovative solutions through information and communication technologies (Savastano et al., 2023).

Smart mobility encompasses actions that improve users' mobility by various means of transport, leading to reduced economic and environmental costs (Bıyık et al., 2021). Implementing or supporting policies that increase the use of public transportation and address negative perceptions is crucial. Public transportation services should be more competitive and meet passenger needs and demands. Understanding the factors influencing people's choice of transportation and their attitudes is essential for these improvements. Evaluating passenger perceptions and attitudes towards different modes of transportation is necessary (Burian et al., 2018). Public transportation (PT) plays a significant role in providing mobility and contributing to sustainability by reducing traffic congestion and air pollution. For PT to be effective, it must ensure continuous accessibility and connectivity.

Service reliability is also crucial in encouraging people to switch from cars to PT. The reliability of PT affects user perceptions and their willingness to use these services (Hadas et al., 2023). Improving public transportation positively impacts both public transport passengers and private car users by saving time and costs through enhanced transit services and increased business productivity. Key factors in bus service quality include service mobility and accessibility, the number of bus lines and service frequency, hours of operation, and service reliability.

Designing effective improvements requires modeling user attitudes and satisfaction, considering perceived quality from personal experience and expected changes, which influences user desires for efficient public transport service and impacts the city and country's economy (Alkharabsheh et al., 2021). Compared to cars, public transportation offers clear advantages in terms of road resource use and energy consumption. Prioritizing public transportation development is crucial for addressing urban transportation challenges and supporting sustainable urban growth (Xue et al., 2020). However, in many developing countries, existing public transportation services often fail to attract users because land use characteristics are not adequately considered in planning and designing public transit systems (Motieyan & Mesgari, 2017).

Given this context, a more in-depth study of smart mobility is needed to address mobility issues in South Tangerang. This research aims to tackle problems related to public transportation accessibility, information and communication systems, and infrastructure in South Tangerang. The study is crucial due to the severe mobility challenges in the city, such as congestion, ineffective transportation routes, outdated city vehicles, and misaligned route systems. It will also explore the relationship between mobility problems and regional planning and development, offering broader insights into urban planning for South Tangerang.

The study's objective is to assess the level of smart mobility implementation in South Tangerang City using multivariate analysis with SPSS and to design a policy model for the city's transportation planning and development using Multi-Criteria Decision Analysis (MCDA) with PROMETHEE. PROMETHEE was chosen for its low level of uncertainty in available data, its effectiveness in communicating decision problems and objectives to decision-makers, and its ability to evaluate a balanced sustainability approach while presenting results in an understandable manner (Melkonyan et al., 2022).

METHOD

The research design used in this study was observational. The observational design uses various combinations of quantitative and qualitative analysis. This research is planned to be carried out from October 2021 to November 2022. Location The research was conducted in the southern Tangerang City Area

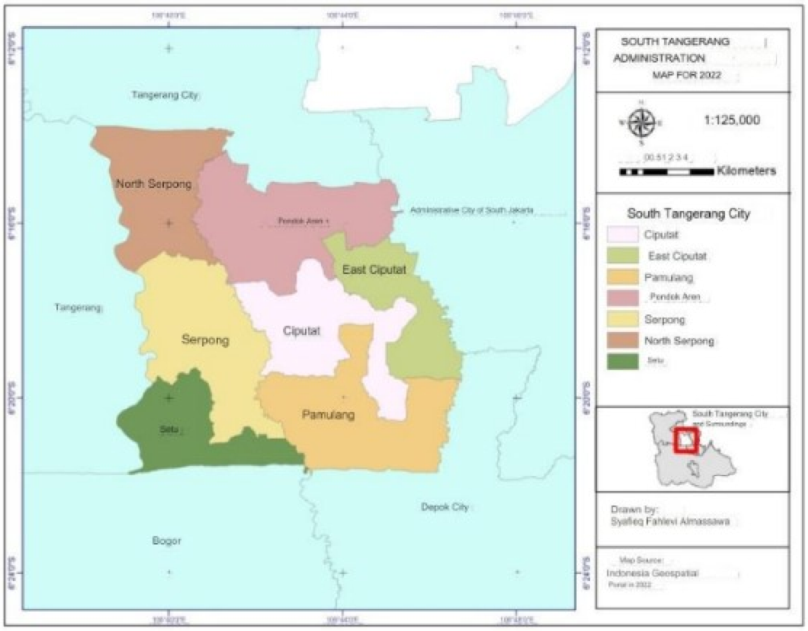

Figure 1: Map of South Tangerang City Area

Figure 1 is a South Tangerang map. South Tangerang City was established based on No. 51/2008 concerning the Establishment of South Tangerang City on September 29, 2008. Located in the eastern part of Banten Province and administratively consists of 7 (seven) sub-districts, 54 (fifty-four) wards with an area of 147.19 km2. The figure used is 147.19 km2 because it is by Law. No. 51/2008 concerning the Establishment of South Tangerang City in Banten Province

Tools and Materials

Table 1 outlines the methodology for assessing and strategizing smart mobility in South Tangerang. The first objective is to evaluate the current implementation of smart mobility by collecting primary data through a structured questionnaire distributed to 100 purposively selected respondents. This data will be analyzed using multivariate techniques and weighting to assess the value and effectiveness of smart mobility applications in the city. The findings will offer insights into the current status and impact of smart mobility initiatives in South Tangerang. The second objective focuses on analyzing and designing a policy strategy for smart mobility planning and development in the city. Primary data from interviews and Focus Group Discussions (FGDs) will be used, with Multicriteria Decision-Making Analysis (MCDA) applied to evaluate and prioritize different policy options. The result will be a comprehensive policy model to guide the future development of smart mobility in South Tangerang.

Table 1: Objective Matrix, Data Type, Analysis Techniques and Results Output

Research Objectives	Data Type	Analysis Methods & Techniques	Output (Output)
Assessing the level of smart mobility implementation in South Tangerang..	Primary (Results of answers from questionnaires)	1. Instrument: Questionnaire 2. Purposive sampling (100 respondents) 10x 10 independent variables 3. Analysis Techniques a. Analyzes Multivariate b. Weighting	1. The Value of Smart Mobility Application in South Tangerang City
Analyze and design a policy strategy model for the planning and development of smart mobility in South Tangerang.	Primary (FGD Results)	1. Interview 2. FGD 3. Analysis techniques: Multicriteria Decision making analysis (MCDA),	Policy Model Planning and development of South Tangerang city with smart mobility

Table 2 presents a comprehensive framework for evaluating smart mobility through various dimensions and indicators. The primary dimension, Local Access, includes several indicators related to public transportation. These indicators cover the availability and ease of access to buses and urban transport, the presence of terminals or stations, the reliability of schedules, the extent of transportation routes, the overall convenience, and the safety of public transportation options

Table 2: Operational Definitions of Smart Mobility Variables

Variable	Dimension	Indicator
Smart Mobility	**Local Access**	Public Transportation Availability 1. Bus 2. Urban Transport
		Ease of Getting Public Transportation 1. Bus 2. Urban Transport
		Terminal/Station Presence 1. Bus 2. Urban Transport
		Public Transport Schedule 1. Bus 2. Urban Transport
		Public Transportation Routes 1. Bus 2. Urban Transport
		Convenience of Public Transportation 1. Bus 2. Urban Transport
		Public Transportation Safety 1. Bus 2. Urban Transport
	Multimodal Access	Integrated mode availability
	Information and Communication Technology Supporter Mobility	Availability of access to realtime bus information
		Availability of access to realtime information City transport
	Sustainability	Use of Non-Motorized Vehicles 1. Bicycle 2. Walkers
		Traffic Safety
		Exhaust emissions of Public Transportation

Source: Author 2023

The method used in the first goal for measuring the level of smart mobility application involves multivariate analysis, which includes calculating the weight of indicators deemed valid and reliable based on respondents' questionnaire answers. The criteria for determining the validity and reliability of the data are as follows:

Validity Test: Data is considered valid if the calculated r value exceeds the r table value.

Reliability: According to Ghozali (2018: 46), the reliability of an instrument is assessed using Cronbach's Alpha with a single measurement. The classification is as follows:

- If Cronbach's Alpha value > 0.70, the instrument is considered reliable.
- If Cronbach's Alpha value < 0.70, the instrument is considered unreliable

In the second objective, the method used is ranking through Multicriteria Decision-Making Analysis (MCDA). This method is employed to determine the priority of each policy option. The MCDA process involves consolidating data from Focus Group Discussions (FGDs) with informants and inputting this data into a system to generate a ranking of policies based on their relative importance

RESULTS AND DISCUSSION

Instrument Data Test Results

The validity test results for the smart mobility variable indicate that all statements are valid, as the average value of r is greater than the critical value (0.643 > 0.196). Data analysis further shows that the Smart Mobility variable has a Cronbach's Alpha value of 0.953, which exceeds the reliability threshold of 0.70, indicating that the variable is classified as reliable.

Analysis of the questionnaire responses from civil servants, community leaders, private entrepreneurs, and academics reveals several indicators with low or suboptimal weights. The lowest-weight indicator is the availability of city transportation, which received a score of 3.00. This suggests a preference for city transportation with fixed schedules, as predictable timings would facilitate better planning of daily travel. A consistent schedule would help users know when city transportation services are available.

Another low-scoring indicator is the availability of real-time public transportation information, which received a score of 3.05. This reflects a lack of timely and accurate information from relevant agencies, resulting in long waiting times for public transportation. This issue also affects bus services, as indicated by the low score of 3.10 for the availability of bus public transport information.

Additional indicators reveal the suboptimal state of smart mobility in South Tangerang, including inadequate bus routes that fail to cover all areas of the city, low safety and accessibility of city transportation, insufficient cycling infrastructure, and high pollution levels due to poor exhaust emission controls.

South Tangerang City Policy Strategy Model to Implementing Smart Mobility

Following the interviews shows in Table 3, a Focus Group Discussion (FGD) was conducted, involving all informants representing various agencies and community groups. The results of the FGD are included in the table and will subsequently be processed using PROMETHEE software.

Table 3: Focus Group Discussion Results

Criteria / Evaluation	ECO	T&I	PD	S&CA	I&A	GP	MP
Availability of Public Transportation	85%	3	75%	VG	VG	3	3
Public transportation Schedule	70%	2	65%	G	G	1	2
Convenience of Public Transportation	75%	2	70%	VG	G	3	3
Public Transportation Security	80%	3	73%	VG	G	3	3
Use of Non-Motorized Bicycles	55%	1	60%	AV	AV	1	1
Public Transportation Routes	60%	2	55%	G	G	2	2
Availability of Access to Realtime Information	85%	3	70%	AV	AV	3	3

Table 3 categorizes the criteria into three main groups: economic (ECO), population density (PD), and social and cultural aspects (S&CA), which includes social groups. It also encompasses technology and innovation (T&I), infrastructure and accessibility (I&A), and movement patterns (PP), which relate to technical aspects, and government policies (GP), which pertain to institutional aspects.

In Table 4 shows the evaluations are divided into two categories. The first category, technical, includes factors such as the availability of public transportation, public transportation safety, public transportation comfort, and bicycle use. The second category, non-technical, consists of public transportation schedules, public transportation routes, and the availability of real-time information

Table 4: Criteria weighting

Criterion	I(1)	I(2)	I(3)	I(4)	I(5)	I(6)	I(7)	total	Rata2x
Perekonomian	15	14	11	14	12	14	10	90	13%
Technology & Innovation	10	10	10	10	10	10	10	70	10%
Population Density	10	10	10	10	10	10	10	70	10%
Social & Cultural Aspects	17	15	20	17	18	16	20	123	17%
Government Policy	20	20	20	20	20	20	20	140	20%
Infrastructure & Accessibility	17	20	18	18	19	19	19	130	19%
Movement Patterns	11	11	11	11	11	11	11	77	11%

Source: FGD Results 2023

Promethee II Complete Ranking

Table 5: Phi, Phi+, and Phi- values

Rank	Action	Phi	Phi+	Phi-
1	Public Transport Availability	0.2300	0.2300	0.0000
2	Public Transport Safety	0.1967	0.1967	0.0000
3	Convenience of Public Transportation	0.1800	0.1800	0.0000
4	Public Transportation Routes	-0.0300	0.0600	0.0900
5	Real-time Information Access Availability	-0.0733	0.0767	0.1500
6	Public Transport Schedule	-0.1500	0.0600	0.2100
7	Bicycle Usage	-0.3533	0.0000	0.3533

Table 5 displays the ratings and scores for four smart mobility action options. The highest rating was given to improving public transportation availability, which received a score of 0.2300. This was followed by measures to enhance public transportation safety, with a score of 0.1967. The next highest score was for improving equality in public transportation, which received -0.1800.

Route optimization scored -0.0300, while the action to enhance real-time information access received -0.0773. Public transportation scheduling earned a score of -0.1500. The action to promote bicycle use had the lowest score at -0.3533.

Promethee Rainbow

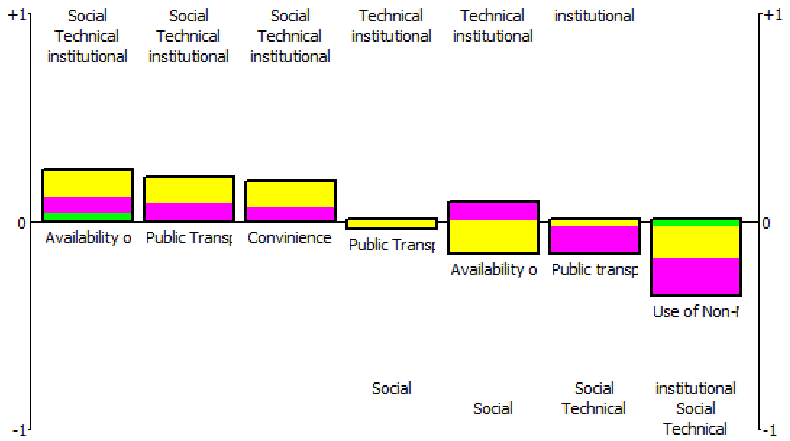

Figure 3: Promethee Rainbow

Figure 3 illustrates that the evaluations for alternatives regarding the availability of public transportation, public transportation safety, and the equality of public transportation fall under social, institutional, and technical groups, indicating that all criteria contribute to these alternatives.

In contrast, public transportation routes and the availability of real-time information access are categorized under technical and institutional groups in Phi+ and under social groups in Phi-. Transportation schedules are included in institutional groups for Phi+ and social groups for Phi-. Finally, the use of bicycles is classified under institutional, social, and technical groups in Phi-.

Promethee GAIA

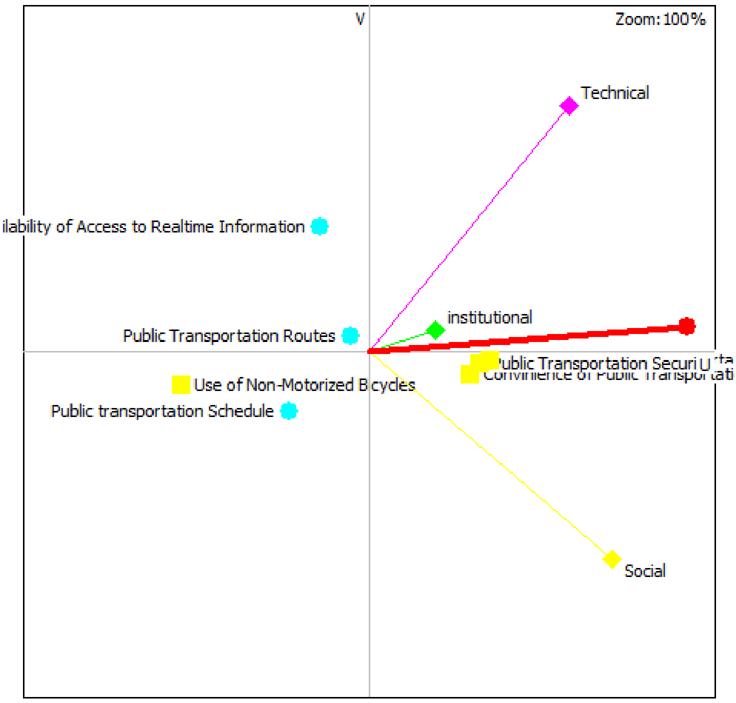

Figure 4: Promethee GAIA

In figure 4 there are three color axes, namely the red axis of the decision axis, the yellow axis for social groups, the green axis for institutional groups and the magenta color axis for technical groups. The best alternative course of action is on the yellow criterion axis on social groups, namely the safety and comfort of public transport

CONCLUSION

In implementing smart mobility in South Tangerang, several indicators reveal significant shortcomings. The lack of a fixed city transportation schedule means residents cannot rely on timely urban transport for daily activities. Furthermore, the absence of dedicated inner-city bus routes forces people to use buses from Jakarta or other areas. The city's public transportation, including Urban Transport, is inconvenient due to an outdated fleet and unprofessional crews, compromising both comfort and safety. Additionally, there is a lack of real-time information on public transportation, leaving arrival and departure times unknown. Bicycle lane facilities are also insufficient, discouraging cycling and leading people to use private vehicles instead. Finally, high exhaust emissions from public transportation contribute to poor air quality. These issues underscore the need for comprehensive improvements to enhance smart mobility readiness in South Tangerang.

Based on the research results, several policy strategies are necessary to transform South Tangerang into a smart mobility city. First, improving the availability of public transportation is crucial, which may involve rejuvenating the city's fleet or upgrading older vehicles that are still in good condition. Second, ensuring the security of public transportation is essential, requiring fixed and reliable safety measures. Third, enhancing the comfort of public transportation is necessary so that passengers have a pleasant experience. Fourth, adapting public transportation routes is important to accommodate the growing population and new developments by establishing new routes. Fifth, providing accessible real-time information on public transportation will allow residents to easily access schedule and route details. Sixth, establishing fixed public transportation schedules is crucial for reliability, enabling people to depend on public transport for their daily activities. Lastly, promoting bicycle use can be achieved by expanding bicycle lanes and implementing safety measures to protect cyclists. These policies collectively aim to improve smart mobility and address existing transportation challenges in South Tangerang.

SUGGESTIONS

To effectively implement smart mobility in South Tangerang, it is crucial for all stakeholders—including the government, parliament, the community, and the private sector—to be actively involved. Achieving the goal of transforming South Tangerang into a smart mobility city will be challenging without the collaboration of all these parties. The government must enhance the transportation system by improving city transportation schedules, optimizing bus routes to meet current demands, and upgrading transportation facilities to ensure safety and comfort. Additionally, real-time information about public transportation should be made available to provide residents with accurate updates. To encourage bicycle use, efforts should be made to increase bicycle sales and expand bicycle infrastructure. To reduce exhaust emissions, the government should promote the use of public transportation and bicycles. These strategies reflect smart mobility policies already implemented in Jakarta, where public transportation has been integrated with modern information technology systems, enabling residents to access online information about schedules, routes, and other public transport services.

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Received: 28th April 2024. Accepted: 29th August 2024