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Article

Implementation of smart mobility and relationship with transportation planning and regional development: A case study of South Tangerang city

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Abstract: Urbanization and suburbanization have led to high population growth in certain city regions, resulting in increased population density and mobility. Therefore, there is a need for a concept to address congestion, public transportation, information and communication systems, and non-motorized vehicles. Smart mobility is a concept of urban development as part of the smart city concept based on information and communication technology. Through this concept, it is expected that transportation services will be easily accessible, safe, comfortable, fast, and affordable for the community. This research aims to analyze smart mobility and its relationship with regional transportation planning and the development of South Tangerang, as well as to design a policy strategy model for the planning and development of South Tangerang with smart mobility. The research method used in this study is a mixed method, including analyzing the relationships and weighting of relationships between variables using the Cross Impact Multiplication applied to a classification (MICMAC) matrix. Multi-criteria decision analysis (MCDA) with Promethee software is also used to obtain the necessary policies. The results of this research indicate that the measurement of relationships between variables shows that smart mobility influences regional transportation planning, smart mobility affects regional development, and regional planning affects regional development. This research also provides alternative policies that policymakers should implement in a specific order. First, ensure the availability of public transportation; second, improve public transportation safety; third, enhance public transportation security; fourth, improve public transportation routes; fifth, provide real-time information access; sixth, improve transportation schedules; and seventh, increase the number of bicycle lanes.

Keywords: smart mobility; smart city; regional transportation planning; regional development; South Tangerang

1. Introduction

1.1. Background

According to the World Urbanization Prospect (WUP) report, the urban population surpassed the rural population in 2007. The latest update in 2018 revealed that more than half of the world's population, specifically 55%, live in cities and this number is expected to increase to 66% by 2050. The growth of the urban population may seem haphazard, but it underscores the significance of efficient management of urban spaces to improve the provision of essential urban services like energy, transportation, healthcare, and housing. As the urban population continues to surge, it becomes increasingly crucial to address the needs related to energy, transportation, healthcare, and other services (Tariq et al., 2020).

During the process of urbanization and developing countries face disparities between urban and rural areas during the process of industrialization and urbanization. According to the urban bias theory, the development policies pursued by developing country governments tend to favor cities over rural areas, and most urban growth occurs in suburban regions. Refers to this phenomenon as the "suburban planet," where we try to "make the urban world from the outside (Gerten et al., 2019, p. 2). The rapid growth of urban populations and the expansion of cities have an impact on other urban systems, including transportation. Population density has a strong relationship with transportation (Aljoufie, 2021; Brownstone and Golob, 2009). Suburbanization is the process of creating new settlements and industrial areas on the outskirts of urban regions as urban residents migrate in search of housing and places to conduct industrial activities (Rustiadi et al., 1999). Urbanization is the movement of people from rural areas to cities. This leads to rapid population growth, expansion of city boundaries, and merging of small towns. However, growing cities face challenges such as efficient urban transportation, increased car use, lower public transportation use, and traffic congestion during rush hours which makes commuting difficult (Dudycz and Piątkowski, 2018).

Smart cities use technology to improve urban life. They evaluate infrastructure and technology in domains such as healthcare, safety, mobility, recreation, employment, education, and governance. Investments in human capital, social aspects, transportation, and communication infrastructure, and prudent resource management are key to sustainable economic growth and quality of life in smart cities (Billones et al., 2021). The concept of a smart city was formulated to use public services and resources to eventually enhance the quality of services offered to urban citizens (Alqahtani et al., 2021). The important aim of smart city development is to provide a sound and reliably built environment for citizens, which includes buildings, transport infrastructures, and urban infrastructures that deliver an efficient service, save time and money, and have as a result: (a) an increase in productivity and competitiveness; (b) a reduction in the environmental impact; (c) better welfare for its citizens (Ribeiro et al., 2021, p. 2).

Smart mobility is crucial in a smart city for easy navigation, traffic management, and sustainable, eco-friendly options. It offers alternative routes during peak hours and specific routes for critical services. Adopting smart mobility solutions benefits both citizens and governance (Ahad et al., 2020). Smart mobility is a modern concept for cities that utilizes technology-based transportation to make public travel easy, safe, fast, and affordable. It is a part of the smart city framework and focuses on sustainability and low environmental impact (Billones et al., 2021).

To support sustainable transportation, it is important to avoid unnecessary traffic and reduce mobility demand, shift to eco-friendly modes of transportation, and improve transportation systems to address unavoidable needs. Strategies that involve settlement patterns, mixed land use, proximity, and substituting travel with communication are reliable. Additionally, the expansion of alternative transportation modes such as public transport, walking, and cycling can help reduce reliance on personal vehicles (Quentin et al., 2023). The public bike also successfully becomes a part of multimodal transport, connecting with other means of public transport (Macioszek and Cieśla, 2022). Many drivers of motor vehicles often overlook pedestrians, yet they play a crucial role in road traffic. The significance of pedestrians cannot be overstated, as injuries and fatalities involving them carry significant social and economic repercussions (Macioszek et al., 2023).

Transportation is crucial for urban progress, providing access to jobs, education, markets, healthcare, services, and social interaction. It is increasingly important for economic development and technological advancements. Hensher (1998) argued that we shouldn't anticipate public transportation systems to offer a level of service enticing enough to lure many individuals who presently rely on private vehicles (Burian et al., 2018). The diverse needs of cities, evolving technologies, and various types of transportation present new alternatives for urban transportation. Specifically, sustainable transportation is one of the most crucial issues for urban development and urban planning. When city plans are made, environmental, economic, technical, and social factors must be considered (Hamurcu and Eren, 2020).

Isradi et al. (2021) defined regional development as the growth of the economy, job opportunities, and local income. Economic growth encompasses several factors, including the presence of city public transportation, which has a positive impact on the community's economy and can increase income in the transportation sector. Smart mobility cannot be separated from the context of the region and urban development. It is essential to analyze the connection between smart mobility, regional transportation planning, and development. This integration leads to smarter, more efficient, and more comfortable cities. South Tangerang city is growing faster than Banten Province and Indonesia. Suburbanization is creating urban centers. Population growth requires more housing, leading to the expansion of shopping centers, offices, and tourist attractions. Public transportation demand has increased as a result. Between 2017 and 2021, passenger cars dominated the vehicles in South Tangerang city and surrounding areas. Private cars were the most common. Despite being the youngest city, South Tangerang had more vehicles, suggesting high mobility due to significant population growth. The government regulates public transportation, including railways. However, bus routes are left to each region. South Tangerang city's bus routes have not changed since its establishment, despite a 3% population growth rate and expanding residential areas smart mobility policy models are crucial for implementing innovation and intelligent technology in transportation systems. They create a supportive environment that improves efficiency, sustainability, and quality of life for communities. South Tangerang city faces significant mobility challenges that need to be addressed through a detailed investigation of smart mobility. This research aims to resolve mobility issues related to the population, including accessibility to public transportation, the information and communication system of public transportation, and the infrastructure and facilities of public transportation in South Tangerang city.

This research is of great importance due to the pressing mobility challenges faced in South Tangerang. The challenges include traffic congestion, inefficient urban transit routes, insufficient municipal transportation options, and route systems that have become disconnected from regional advancements. The study aims to explore the correlation between mobility concerns and regional planning and progress, offering more comprehensive perspectives on regional planning and development within South Tangerang. It is important to note that this research does not cover commuter public transportation like trains. Instead, it focuses on public transportation modes such as buses and city transit.

Based on the background of this study, further research is needed, by making a research question, the research question is how is the relationship and weighting of the relationship between smart mobility, transportation planning, and the development of the South Tangerang city area? and what is the policy strategy for transportation planning and development of the South Tangerang city area with smart mobility? Therefore, the hypothesis of this study can be determined. Smart mobility has a significant impact on transportation planning and the development of the city of South Tangerang, and vice versa.

This article contains several parts, the first part is the background of the problem of this research, then the literature review which describes the theoretical theory needed to strengthen this research, then divided into research methodology there are research designs, sources of population data, and samples and measuring instrument methods to process existing data, In the next section there are results and discussion and finally conclusions and suggestions.

1.2. Scientific literature review

"Smart mobility" refers to addressing transportation issues globally. A research project titled "Transport poverty meets the digital divide: Examining accessibility and connectivity in rural communities" explored how technology can improve accessibility and connectivity in rural areas. The study was conducted in several Scottish cities. This paper will examine the challenges related to accessibility and connectivity in rural communities, highlighting key transport and technology issues. It also explores barriers and opportunities to integrate transport and technology solutions to enhance rural accessibility and connectivity. The research found that providing accessibility and connectivity to rural communities presents significant challenges due to the combination of poverty, transportation, and digital exclusion. In addition to social and economic aspects, this issue involves a strong technological component related to the quality and availability of infrastructure and services in both transportation and the digital sphere. Innovations such as advanced technology and telematics transportation, including passenger information systems that can combine user-generated information and flexible local rates, as well as responsive virtual transport markets, can make a significant contribution to addressing these issues by better utilizing available transport resources (Velaga et al., 2012).

Munhoz et al. (2020) conducted a study on the concept of smart cities—smart mobility indicators. This study evaluated the level of "smart mobility" infrastructure solutions, information infrastructure, city size or per capita budget, urban mobility evaluation, sustainable mobility, urban planning, and measures to reduce the number of vehicles. The research was conducted in 62 cities in Poland and Spain. The aim of this research is to examine the main drivers with the potential to enhance urban mobility intelligence and prioritize them. Following a systematic literature review, we conducted an extensive and detailed bibliography research based on the recommendations of the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) Statement. This research also surveyed 181 professionals working in the relevant field to confirm the importance of different drivers and establish priority levels. The results indicate that 27 drivers identified in the literature are considered important, seven of which, related to urban planning and technical solutions, are deemed most crucial for improving urban mobility intelligence.

Porru et al. (2020) conducted a study titled "Smart mobility and public transport: Prospects and hurdles in both rural and urban settings" to elucidate the distinctions in applying smart mobility solutions in rural and urban areas. Their research approach entailed contrasting one project with another, and the investigation encompassed ten projects spanning various European locations. The study aims to explore the differences in the use of smart mobility solutions between rural and urban areas. The analysis of the project revealed that people in rural areas have significantly fewer public transportation options compared to those in urban areas. While residents in rural areas travel to work, school, medical facilities, and local stores similar to urban dwellers, they primarily rely on cars because they lack access to the transportation infrastructure available in cities. Public transportation services in rural areas are typically provided by responsive bus or transport operators due to the low population density.

Smart mobility is a concept that is being implemented in developing countries with high population density and rapid population growth. A study conducted by Billones et al. (2021), focused on developing a framework called the "Smart Region Mobility Framework" tailored for island regions in the Philippines. It aimed to identify cities suitable for transitioning into smart cities, with a particular focus on enhancing smart mobility and public transportation. The research spanned across 6 provinces, 16 cities, and 114 municipalities in the Philippine islands, pinpointing two cities as potential smart city candidates. Among them, one city was earmarked as the regional center for smart city initiatives. In the context of a smart region, the services available in these designated smart cities, such as employment, education, and healthcare, could be easily accessed by neighboring cities and municipalities through improved transportation and mobility services. Additionally, the study outlined the implementation of a data flow architecture for the smart region mobility framework and a regional traveler information system using mobile and web applications.

Indrawati et al. (2017) have conducted research on indicators for measuring smart mobility from an Indonesian perspective. The study aimed to identify variables and indicators that could be used to measure the implementation of the smart mobility concept. We used a quantitative approach with primary data obtained from interviews and FGD. The research subjects were cities in Indonesia, with experts in smart city concepts as respondents. The results of this study stated that there are 7 dimensions, namely: location efficiency, reliable mobility, health and safety, environment stewardship, social equity, robust economy, and people, and 19 indicators, namely: support for sustainable growth, transit mode share, accessibility and connectivity, multi-modal travel, mobility, reliability, multi-modal service quality, multi-modal safety, design and speed, suitability, pedestrian and bicycle mode share, climate and energy conservation, emissions reduction, equitable distribution of impacts, equitable distribution of access and mobility, congestion effects on productivity, efficient use of system resources, network performance optimization, return on investment, and discipline. These indicators can be used to measure smart mobility in Indonesia.

Smart mobility is being implemented in major Indonesian cities like Jakarta, Yogyakarta, and Bandung (Agni et al., 2021). The purpose of his research entitled "Evaluation of the implementation of smart mobility in Jakarta" is to provide an overview of the level of readiness for the implementation of smart mobility in Jakarta and the improvements that need to be made. The results show that basically, Jakarta is ready to implement smart mobility, but there needs to be improvements and procurement in some aspects of smart mobility.

Taufik (2019) studied smart mobility readiness in Bandung and used both quantitative and qualitative methods to measure its implementation. The purpose of this study is to assess the smart mobility readiness index of Bandung city. The research findings show that the smart mobility index of Bandung city is 61, indicating poor readiness and a need for significant improvement. The lowest score is given to the indicator 'congestion effects on productivity' with a score of 43.48, reflecting a high level of congestion as agreed upon by the majority of respondents. On the other hand, the indicator 'distribution of access and mobility' achieved the highest score of 68.71, indicating fairly good integration, mainly due to the perception of affordable public transportation fares by the majority of respondents.

There are still several common problems in implementing smart mobility, including enforcing uniform mobility laws, regulations, and rules across different regions; involving citizens in mobility programs; using crowdsensing in smart mobility; ensuring interoperability of mobility devices and systems; adapting old infrastructure to support smart mobility; and establishing peaceful cooperation between public and private mobility service providers (Ahad et al., 2020).

Transportation planning entails making choices regarding the design and provision of infrastructure and services across various regions. It forms a crucial component of spatial planning, which aims to establish sustainable frameworks for long-term social, environmental, and economic development. Spatial planning serves dual purposes: regulating and guiding development to foster urban, regional, and national growth, conserve resources, and stimulate investment. Aligned with the Agenda 2030 framework, transportation planning and its decisions should contribute to achieving sustainable mobility for both people and goods. A robust plan ensures coherence among theories, regulations, and their implementation. Success in the process is achieved when planned policies are put into action and prove effective (Russo and Rindone, 2021).

Urban transportation has a strategic role in shaping urban civilization. The problem is that the transportation sector is often not put in the right position. Transportation issues need immediate and serious attention and become a priority in urban development. If the transportation is problematic, all other activities will become problematic. Various problems surrounding transportation that occur in Indonesia, including the level of congestion in the capital city which is one of the highest in the world, economic losses caused by these conditions, and the high traffic accident fatality ratio (Isradi et al., 2021).

Transportation services in South Tangerang city are currently inadequate, particularly for city transportation. There are issues with the quality of city transportation services in various areas of South Tangerang, including the vehicles, services, and crew. To encourage private car users to switch to public transportation, it's essential to improve the quality of service. One way to achieve this is through the implementation of government policies to promote a sustainable transportation system. These policies could include rejuvenating public transportation fleets, particularly city transportation, imposing limits on the age of roadworthy vehicles, constructing terminals (since South Tangerang city lacks a public transportation terminal), adding stops for city transportation, maintaining punctual travel schedules, and collaborating with private entities to address public transportation issues. In 2015, there were 3045 city transportation vehicles and 387 buses available in South Tangerang. While this quantity should be sufficient to serve the general public, people are either disinterested or compelled to use them due to various factors such as the absence of an integrated terminal, unsuitable vehicles (e.g., dirty, unsafe, and crowded), unclear schedules, high fares, and elevated crime rates (Almassawa and Hanny, 2021).

Currently, there is no specific assessment of the smart mobility phenomenon in South Tangerang city. Therefore, more in-depth research is needed on the concept of smart mobility to deal with mobility problems. The purpose of this study is to solve population mobility problems, such as public accessibility to public transportation, public transportation information and communication systems, and public transportation facilities and infrastructure in the city of South Tangerang.

2. Material and method

2.1. Research design

The research design used in this study is observational. The observational design employs various combinations of quantitative and qualitative analyses. This research was conducted from October 2021 to November 2022. The research location was within the South Tangerang city area.

2.2. Population and sample

The sampling technique in this section uses purposive sampling. **Table 1** shows the distribution of respondents to these stakeholders. Interviews and FGD were conducted with 7 (seven) informants. The informants are experts in fields related to smart mobility, regional transportation planning, and regional development.

Table 1. Informant list (Source: Author).

	Institutional	Number
1	Department communication and information service	1
2	Department of Transportation	1
3	Area Development Planning Agency (Bappeda)	1
4	Private operator (Organda)	1
5	Entrepreneurs	1
6	Academics	1
7	Community leaders	1
	Total	7

Table 2 describes the description of the objectives, the types of data used, the analysis techniques and the output of the analysis results. Observations were made in South Tangerang City. The selection of the analysis method is determined by the type of data, the purpose of the research, and the methodological approach applied. By using appropriate methods, researchers will be able to produce valid and reliable conclusions.

Table 2. Objective matrix, data types, analysis techniques, and results output (Source: Author).

Research purposes	Data type	Analysis methods & techniques	Output
Analyze the relationship and weighting of the relationship between smart mobility, regional planning, and regional development of the city of South Tangerang	Primer	• Interview and focus group discussion with 7 (seven) informants • Identification key drivers • Weighting of relationships between variables • The analysis technique uses MICMAC (Matrix of cross impact multiplication applied to classification).	• Key variables of smart mobility, regional planning, and regional development • The weight of the relationship between these variables
Analyze and design a policy strategy model for planning and developing the city of South Tangerang with smart mobility	Primer	• Interview • FGD • Informants (stakeholders) • Analysis techniques: Multicriteria decision making analysis (MCDA), software: Promethee	South Tangerang city planning and development policy model with smart mobility

3. Analyze the relationship between smart mobility and planning and development of the South Tangerang city area

The first objective of this research is to analyze the relationships and weighting of the relationships between smart mobility, regional planning, and regional development in South Tangerang city.

3.1. MICMAC method

To achieve our objective, we will be using a technique called MICMAC (matrix of cross impact multiplication applied to a classification) which was developed by Godet (1994). This technique is widely used for scenario analysis in several developmental contexts, including sustainable development. It can also help in identifying critical variables that play crucial roles in solving problems. The MICMAC approach follows a systematic and analytical approach to address problems. First, the problem is defined clearly, and then the relevant variables, both internal and external, are identified. Subsequently, MICMAC analyzes the relationships among the variables and assigns weights to these relationships based on the extent of mobility and interdependence among the variables (Fauzi, 2019; Feng et al., 2023) explains that the principles of the MICMAC technique assist in:

- Identifying the main influential (influencing) and dependent (influenced) variables essential to a system.
- Mapping the relationships between variables and the relevance of these variables in explaining a system.
- Revealing the cause-and-effect chain within a system.

In the MICMAC method, variables are grouped into four quadrants based on the categories of dependence and influence, as illustrated in the diagram.

When we talk about the four quadrants of variables, we refer to them as determinant, relay, depending, and excluded, it shows in **Figure 1** The determinant variables in quadrant I have a strong influence on the system, but they don't depend on other variables. These variables are essential to the system and can serve as key factors. In quadrant II, we have the relay variables. These variables are also influential, but they depend on other variables to operate. If there are any changes in these variables, they can significantly impact other elements in the system. The variables in quadrant III are the dependent variables, also known as outcome variables. These variables are highly dependent on other variables within the system, but they don't have much influence themselves. They are responsive to changes in influence and relay variables. In quadrant IV, we find the excluded variables, also known as autonomous variables. These variables have low influence and low dependence. They're called excluded variables because they don't affect the operation of the system, nor do they benefit from it. In general, the relationships between variables in MICMAC can be represented in a generic form through a cross-matrix as follows: (Insert Cross-Matrix Representation).

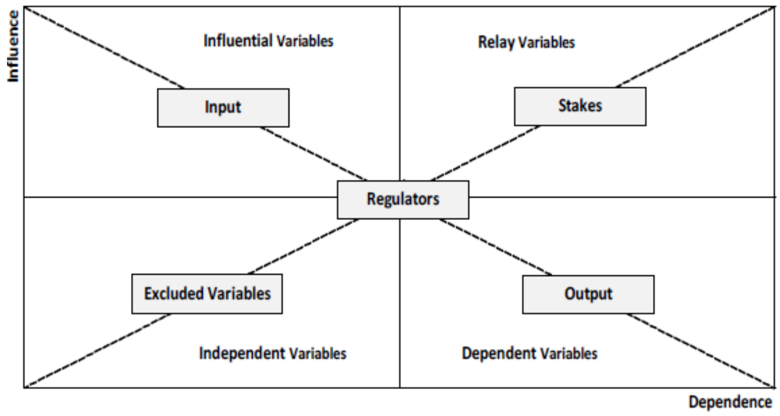

Figure 1. Variable distribution in MICMAC (Fauzi, 2019).

Table 3 shows that in its implementation, filling in the MDI (matrix of direct influence) matrix, which depicts direct relationships between variables, is done by quantifying the relationships between variables (Fauzi, 2019) using a scale from 0 to 3 and P, where:

0 = No relationship
1 = Weak relationship
2 = Moderate
3 = Strong
P = Potential influence (cannot be determined by consensus).

Table 3. Relationship between variables in MICMAC (Fauzi, 2019).

	V1	V2	V3	V*n*	Influence (*Y*-axis)
V1	0	(V1,V2)	(V1,V3)	(V1,V*n*)	
V2	(V2,V1)	0	(V2,V3)	(V2,V*n*)	∑(Var1–*j*)
V3	(V3,V1)	(V3,V2)	0	(V3,V*n*)	
…	…	…	…	…	

Table 3. (*Continued*).

	V1	V2	V3	V*n*	Influence (*Y*-axis)
V*n*	(V*n*,V1)	(V*n*,V2)	(V*n*,V3)	0	
Dependence (*X*-axis)	∑(Var*j*–1)				

3.2. Stages of using MICMAC

From **Figure 2** shows that the MICMAC method involves several stages that need to be carried out to determine key variables and map them. According to Stratigea (2013) in the study of Fauzi (2019, p. 38), there are two main stages of MICMAC analysis. The first stage involves understanding the scope of the problem and the system to be examined. This stage requires the involvement of stakeholders, specialist experts, and the community, which can be done through a focus group discussion (FGD). The results of the first round are then entered into the MICMAC module to identify the key variables, which is the main goal of MICMAC. The results of the MICMAC analysis then become feedback in the second stage of the FGD to confirm the findings of the examined system. These analytical stages can be seen in the diagram.

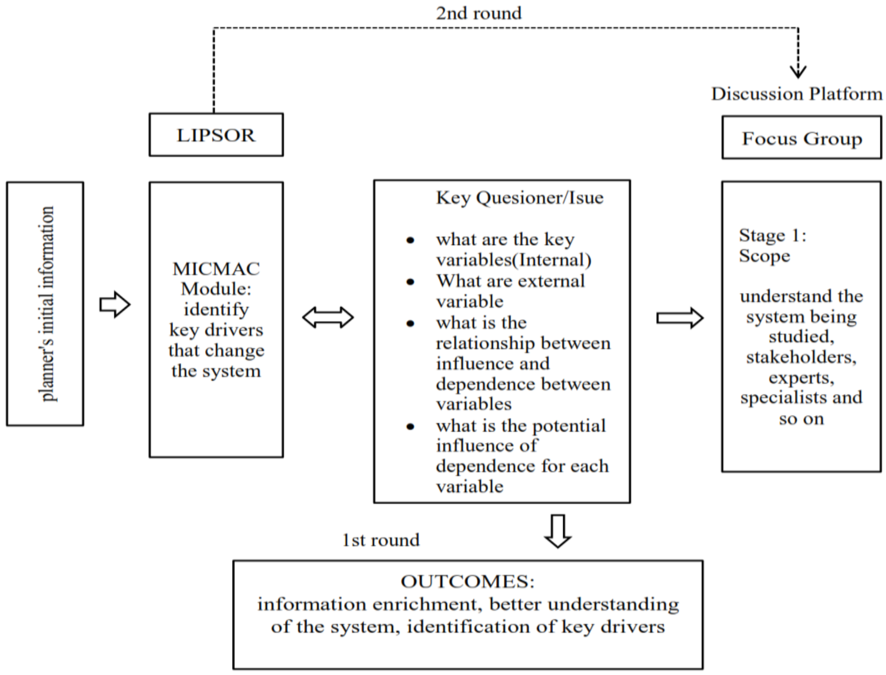

Figure 2. MICMAC framework (Fauzi, 2019).

To achieve the second objective of analyzing the relationships and weightage of variables between smart mobility, regional transportation planning, and the development of South Tangerang city, we have prepared operational definitions of the variables. To gather more information, we will conduct an FGD involving stakeholders such as the Regional Development Planning Agency (Bappeda), the Information and Communication Agency, and the Transportation Agency from the government, entrepreneurs from the private sector, academics, and finally, the community.

The variables from the dimensions of smart mobility, regional transportation planning, and regional development are as follows (see **Table 4**):

Table 4. Smart mobility variable table, regional transportation planning and regional development (Source: The expert).

No	Long label	Sort label	Theme
1	Availability of public transportation	APT	Smart mobility
2	Ease of getting public transportation	EGPT	Smart mobility
3	Existence of terminals/stations	ETS	Smart mobility
4	Public transport schedule	PTSC	Smart mobility
5	Public transportation routes	PTR	Smart mobility
6	Convenience of public transportation	CPT	Smart mobility
7	Public transportation security	PTS	Smart mobility
8	Integrated mode availability	IMA	Smart mobility
9	Availability of access to real-time inform	ARTI	Smart mobility
10	Use of non-motorized bicycles	BIC	Smart mobility
11	Pedestrian use of non-motorized vehicle	PED	Smart mobility
12	Traffic security	TSC	Smart mobility
13	Public transport exhaust emissions	PTEM	Smart mobility
14	Population density	PD	Regional transportation planning
15	Movement pattern	MP	Regional transportation planning
16	Distance and accessibility	D&A	Regional transportation planning
17	Mode of transport available	MTA	Regional transportation planning
18	Traffic condition	TC	Regional transportation planning
19	Transport policy	TP	Regional transportation planning
20	Existing transportation infrastructure	ETIN	Regional transportation planning
21	Technology and innovation	T&I	Regional transportation planning
22	Economy	ECO	Regional development
23	Land and land use	L&LU	Regional development
24	Infrastructure and accessibility	I&A	Regional development
25	Government policy	GP	Regional development
26	Environmental aspect	EA	Regional development
27	Natural resources	NR	Regional development
28	Social and cultural aspects	S&CA	Regional development
29	Education and health	E&H	Regional development
30	Tourism potential	TRP	Regional development
31	Security and order	S&O	Regional development
32	Spatial planning	SP	Regional development

From **Table 4** above, it can be seen that the dimensions are smart mobility, regional planning, and regional development, after that some attributes/variables explain the attributes/variables of these dimensions consisting of long labels (full description) and short labels (abbreviations/initials).

The key questions to be interviewed are:

- What are the key variables (internal environment) of the smart mobility, regional planning and regional development dimensions?
- What are the external variables of the smart mobility dimension, regional transportation planning and regional development?
- What is the potential effect of dependence on each variable of the dimensions of smart mobility, regional transportation planning, and regional development?

The results of the answer to the question above will be processed with MICMAC software so that it can be known what are the key variables, external variables and dependencies between variables.

4. Analyze and design a policy strategy model for planning and developing the city of South Tangerang with smart mobility

The second objective of this research is to analyze and design a planning and development model for the city of South Tangerang with smart mobility. This analysis is an analysis based on the perceptions of stakeholders.

4.1. Promethee method

The purpose of this study is to use the multi-criteria decision analysis (MCDA) method with Promethee software, where this method helps make policies by ranking choices from actions in the form of existing options or alternatives based on the degree of preference. Promethee is a well-known method that has been used and developed for almost 40 years (Ogrodnik, 2020).

4.1.1. Work procedure

In the research used is Promethee with promethe visula software, this method was developed by Brans et al. in 1984 (Fauzi, 2019), where this method helps policymakers with the choice of ranking of actions in the form of existing choices or alternatives, based on the degree of preference (preference degree) through three steps as follows:

- Perform computation calculations of each preference between criterion and action.
- Perform computation calculations against many criteria.
- Perform computation calculations globally.

The preference is expressed by p-value and q value from 0 to 1 so that statistical normalization is needed to determine the strength of the relationship of each variable both criterion and action Promethee (preference ranking organization method for enrichment evaluation).

Type I usual—Qualitative Criteria (very bad, bad, etc.)

Type II U-type—Indifferent threshold (quantitative)

Type III V-type—Quantitative when even minor deviations must be taken into account

Type IV—step—Quantitative based between levels

Type V—Quantitative—Threshold desired

Type VI—More complex models (more difficult to determine)

4.1.2. Stages of using Promethee

Like other multicriteria methods, Promethee relies on a decision matrix containing options or alternatives. When this needs matrix is obtained, the user can enter the preference functions required for Promethee analysis. The stages of analysis can be seen in the picture below.

According to Fauzi (2019), explained in **Figure 3** the third stage (decision matrix requires accuracy in determining 'good indicators' (which need to be maximized) and 'bad indicators' (which need to be minimized). At this stage, if you want to create a different scenario (e.g., for a sensitivity test), the user can modify the decision matrix by creating a different scenario.

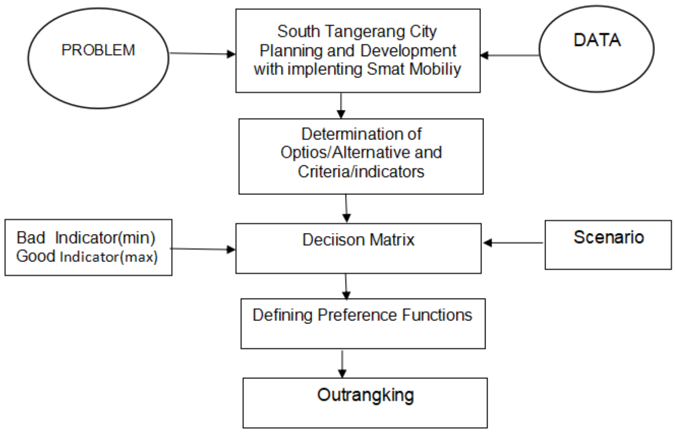

Figure 3. Analysis stages with Promethee (Fauzi, 2019).

The determination of the preference function as described in stage 4 in **Figure 3** is a fairly important stage, this stage will determine the outranking results of the Prometthee analysis. In the use of preference functions of type *I*(usual), determining the threshold values (*q*, *p*, and *s*) will determine the preference values. The value of "*q*" indicates the "indifference threshold", which is the threshold at which the difference between one alternative and another alternative can be ignored. The value "*p*" indicates describing the smallest deviation that is enough to change the preference. This determination in Visual Promethee software can be done more easily by following the "preference assistance" that has been provided by the software.

In general, it can be said that for qualitative criteria such as "good", "very good", "medium", and so on, the use of type I preferences will be more appropriate, while for quantitative criteria, type 2, 3, 4 and 5 preferences are more often used.

Once the decision matrix and preference function have been filled in, the decisive stage in Promethee is to determine outranking, i.e., options or options based on values. Promethee provides various features to discuss outranking results. This stage can be continued with various scenarios and weight changes.

5. Result and discussion

5.1. The relationship between smart mobility and regional planning and development in South Tangerang city

To obtain research results to analyze the weighting of relationships between variables, interviews will be conducted with stakeholders and then the results will be processed using MICMAC. The individuals who will lead focus group discussions

(FGDs) to populate the MDI matrix, which will subsequently undergo processing using the MIC MAC method. During the FGDs, informants will address specific questions aimed at identifying the primary variables that carry significant influence (influence) and the extent to which other variables depend on them within a system. These essential variables play a crucial role in the system, and the FGDs will help map out the relationships between these variables, shedding light on their relevance in explaining the workings of the system and uncovering the cause-and-effect dynamics within the system.

In **Figure 4** you can see a matrix table of relationships between variables, which will be the relationship between the thirty-two variables that will be processed with MICMAC

	1 : APT	2 : EGPT	3 : ETS	4 : PTSC	5 : PTR	6 : CPT	7 : PTSE	8 : IMA	9 : ARTI	10 : BIC	11 : PED	12 : TSC	13 : PTEM	14 : PD	15 : MP	16 : D&A	17 : MTA	18 : TC	19 : TP	20 : ETIN	21 : T&I	22 : ECO	23 : L&LU	24 : I&A	25 : GP	26 : EA	27 : NR	28 : S&CA	29 : E&H	30 : TRP	31 : S&O	32 : SP
1 : APT	0	3	3	3	3	3	3	3	1	1	1	2	1	1	3	3	3	3	3	3	3	3	1	3	3	1	1	1	3	3	3	3
2 : EGPT	3	0	1	3	3	3	3	3	3	3	3	3	1	1	3	3	3	3	3	3	1	3	1	3	3	3	1	3	3	3	3	3
3 : ETS	3	3	0	3	3	3	3	3	3	3	3	3	3	1	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3
4 : PTSC	3	3	3	0	1	3	3	1	3	1	1	3	1	1	3	3	1	3	1	2	1	3	1	1	1	1	1	1	1	1	2	2
5 : PTR	3	3	3	3	0	3	3	3	1	2	2	2	3	3	3	3	1	3	2	3	1	3	1	2	2	2	2	2	3	3	3	3
6 : CPT	0	0	0	0	0	0	3	0	1	3	3	3	0	0	3	0	0	1	3	3	1	1	0	1	3	3	1	2	2	3	3	3
7 : PTSE	0	0	0	0	0	0	0	0	1	3	3	3	0	0	3	0	0	1	3	3	1	1	0	1	3	3	1	2	2	3	3	3
8 : IMA	3	3	3	3	3	3	3	0	0	3	3	3	3	3	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
9 : ARTI	3	3	3	3	3	3	3	3	0	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3
10 : BIC	0	0	0	0	0	0	0	0	1	0	3	3	3	0	2	1	2	2	3	3	1	1	0	1	3	3	1	2	2	3	2	3
11 : PED	0	0	0	0	0	0	0	0	0	3	0	3	3	0	2	1	2	2	3	3	1	1	0	1	3	3	1	2	2	3	2	3
12 : TSC	3	3	3	3	3	3	3	3	3	3	3	0	1	1	3	3	3	3	3	3	3	3	1	3	3	3	2	3	3	3	3	3
13 : PTEM	0	0	0	0	0	3	3	0	0	3	3	2	0	0	0	0	0	1	3	0	0	1	0	0	3	3	2	2	3	3	1	3
14 : PD	3	3	3	3	3	3	3	3	3	3	3	3	3	0	3	3	3	3	3	3	2	3	3	3	3	3	3	3	3	3	2	3
15 : MP	3	3	3	3	3	3	3	3	3	3	3	3	3	3	0	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3
16 : D&A	3	3	3	3	3	3	3	3	3	3	3	3	3	1	3	0	3	3	3	3	3	3	3	3	3	2	1	3	3	3	3	3
17 : MTA	3	3	3	3	3	3	3	3	1	1	1	3	3	1	3	3	0	3	3	3	1	2	2	2	2	2	1	2	2	2	2	2
18 : TC	3	3	3	3	3	3	3	3	3	3	3	3	3	1	3	3	3	0	3	3	3	3	3	3	3	3	3	3	3	3	3	3
19 : TP	3	3	3	3	3	3	3	3	3	3	3	3	3	1	3	3	3	3	0	3	3	3	3	3	2	3	3	3	3	3	2	3
20 : ETIN	3	3	3	3	3	3	3	3	3	3	3	3	1	1	3	3	3	3	3	0	1	3	1	3	3	3	1	3	3	3	3	3
21 : T&I	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	0	3	3	3	3	3	3	3	3	3	3	3
22 : ECO	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	0	3	3	3	3	3	3	3	3	3	3
23 : L&LU	3	3	3	3	3	3	3	3	3	3	3	3	0	3	3	3	0	3	3	3	3	3	0	3	3	3	3	3	2	3	2	3
24 : I&A	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	0	3	3	3	3	3	3	3	3
25 : GP	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	0	3	3	3	3	3	3	3
26 : EA	1	1	3	1	1	3	3	3	3	3	1	3	3	3	3	1	1	3	3	3	3	3	3	3	3	0	3	3	3	3	3	3
27 : NR	2	2	2	2	2	2	2	2	1	2	2	1	1	3	3	3	3	3	3	3	3	3	3	3	3	3	0	3	3	3	3	3
28 : S&CA	3	3	3	2	2	3	3	2	3	3	2	3	3	3	3	3	3	2	3	3	3	3	3	3	3	3	3	0	3	3	3	3
29 : E&H	1	1	3	3	3	2	2	2	3	3	3	3	1	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	0	3	3	3
30 : TRP	3	3	3	3	3	1	1	3	1	3	3	1	2	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	0	2	3
31 : S&O	3	3	3	3	1	1	3	1	1	3	3	3	1	1	3	1	1	3	3	1	3	3	3	3	3	3	3	3	3	3	0	1
32 : SP	1	1	3	1	3	1	2	1	2	3	3	3	1	3	2	3	1	3	3	3	2	3	3	3	3	3	3	3	3	3	1	0

Figure 4. Matrix results of relationships between variables.

0 = no relationship (non-existent); 1 = weak relationship (low direct influence); 2 = equal relationship (medium direct influence); 3 = strong relationship (high direct influence); P = potential (potential influence).

Direct influence/dependency matrix of direct influence (MDI):

In **Figure 5**, quadrant I outline the five indicators of smart mobility: ARTI (availability of real-time information access), EGPT (ease of accessing public transportation), KMT (availability of integrated modes of transportation), PTR (public transportation routes), and APT (overall availability of public transportation). In addition, there are four indicators related to regional transportation planning: PD (population density), T&I (technology and innovation), D&A (distance and accessibility), and MTA (available modes of transportation). This quadrant also includes two indicators for regional development: NR (natural resources) and L&LU (land and land use). The mentioned indicators fall under the influence variable, which describes variables that have a significant impact with little dependence. These variables are crucial because they act as key factors in the implementation of smart mobility. Factors such as availability of real-time information access, ease of accessing transportation, availability of integrated modes of transportation, public transportation routes, and overall availability of public transportation are influential in people's decision-making regarding the use of public transportation. In terms of regional transportation planning, indicators such as population density can affect the availability of public transportation and public transport routes. Additionally, innovation technology can influence the availability of real-time information access. The regional development variables, including indicators of natural resources, land, and land use, can affect public transportation routes and the distance and accessibility of public transportation. Moreover, all indicators in this quadrant can affect indicators in other quadrants, for example in providing the availability of public transportation will affect transport policy, economy, social, and cultural aspects, and spatial planning.

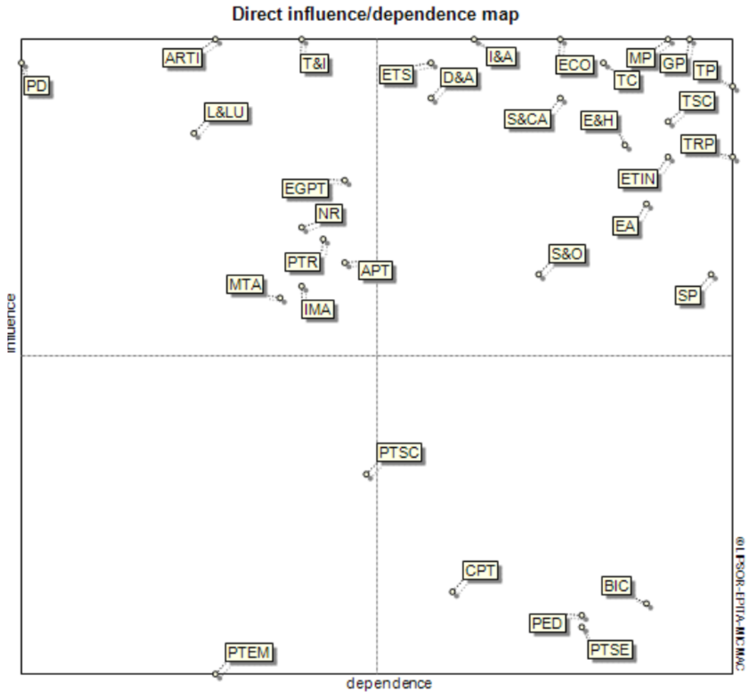

Figure 5. Map of direct influence/dependency matrix of direct influence (MDI).

In quadrant II of the figure, there is a single smart mobility variable, TSC (traffic security). Additionally, there are four regional transportation planning indicators: TC (traffic conditions), MP (movement patterns), TP (transportation policy), and ETIN (existing transportation infrastructure). In this quadrant, there are also nine regional development indicators: I&A (infrastructure and accessibility), Eco (economy), GP (government policy), E&H (education and health), TRP (tourism potential), S&CA (social and cultural aspects), EA (environmental aspects), S&O (security and order), and SP (spatial planning). These indicators are part of the relay variable, which is an influential but highly dependent indicator. Any change in this indicator has significant consequences for other variables. In this quadrant, variables are often categorized as factors that describe instability. For example, traffic conditions can affect the economy due to high levels of congestion, leading to stagnant business activities. Another example is transportation policy indicators, such as an increase in public transportation tariffs that burden the community, leading to a decrease in their income.

In quadrant III, there are four indicators of smart mobility, which are PTC (public transportation convenience), BIC (use of non-motorized bicycle vehicles), PED (use of non-motorized pedestrian vehicles), and PTS (public transportation security). These indicators depend on variables or outcome variables. This means that these variables have a high dependency, but a small influence. Additionally, these variables are quite sensitive to changes in the influence variable and relay variables.

In quadrant IV of the figure, it is evident that two indicators of smart mobility, namely PTSC (public transportation schedule) and PTEM (public transportation exhaust emissions), are present. This quadrant is used to describe excluded variables, also known as “autonomous variables,” which are variables that have little influence and dependence. These variables are excluded because they will not hinder the system from functioning or utilizing the system itself.

Direct influence chart:

In **Figure 6**, the variable APT (availability of public transportation) strongly influences CPT (convenience of public transportation), PTR (public transportation routes), I&A (infrastructure and accessibility), and GP (government policy). On the other hand, NR (natural resources), L&LU (land and land use), I&A (infrastructure and accessibility), E&H (education and health), GP (government policy), S&CA (social and cultural aspects), S&O (security and order), TP (tourism potential), and EA (environmental aspects) are influenced by other variables and also influence each other. The study results demonstrate the significant impact of the Availability of Public Transportation on the convenience of public transportation. When public transportation is available following the needs of passengers for work, travel, and recreation, it positively affects convenience. Additionally, government policy significantly influences tourism potential. For example, when government policies related to public transportation routes include tourist destinations, it increases public interest and accessibility with good public transportation facilities. Based on the results above, it can be seen that smart mobility has a direct influence on regional development, namely the availability of public transportation influences infrastructure and accessibility as well as government policy and vice versa. Government policy influences government policy.

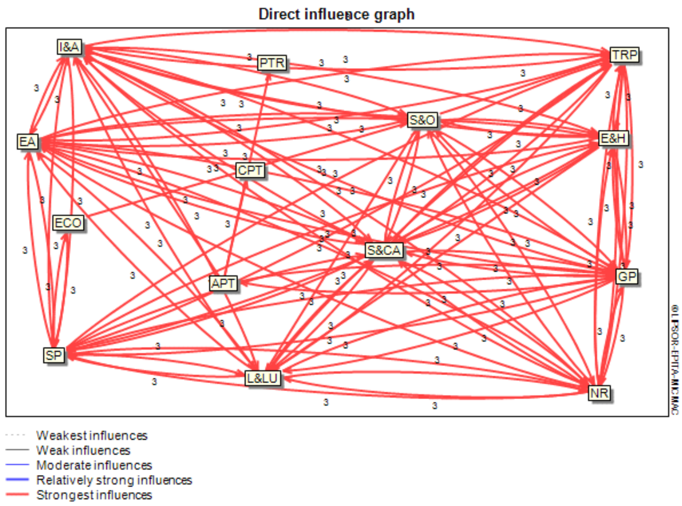

Figure 6. Direct influence graph, this graph is arranged starting from the MDI direct influence matrix.

5.2. South Tangerang city planning and development policy strategy model with smart mobility

As a result of goal one, interviews and FGDs will be conducted with stakeholders, to determine actions/alternatives and criteria which will later be entered into the Promethee software to produce choices and rankings so that we will know which alternatives must be carried out first to determine handling policies. smart mobility issues, planning, and development in the city of South Tangerang (see **Table 5**).

Table 5. Result FGD (Source: FGD Result, 2023).

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

The criteria in **Table 5** above are divided into 3 groups, economic (ECO), population density (PD), and social and cultural aspects (S&CA) including social groups. Technology and Innovation (T&I), infrastructure and accessibility (I&A), and movement patterns (MP) are included in the technical group and finally, government policy (GP) is included in the institutional group. The evaluations above are divided into 2 groups, the first is the technical group consisting of the availability of public transportation, the safety of public transportation, the comfort of public transportation, and the use of bicycles, and the second is the non-technical group consisting of public transportation schedules, public transportation routes, and availability. access real-time information.

Table 6 is the weight of the criteria resulting from the FGD with 7 (seven) informants, which will later be included in the Prometheus.

Table 6. Criteria weighting.

Criteria	*I*(1)	*I*(2)	*I*(3)	*I*(4)	*I*(5)	*I*(6)	*I*(7)	Total	Average
Economy	15	14	12	13	12	14	11	91	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	18	21	16	18	16	20	126	18%
Government policy	20	20	20	20	20	20	20	140	20%
Infrastructure & accessibility	17	22	19	18	16	17	19	126	18%
Movement pattern	11	11	11	11	11	11	11	77	11%

Detail: *I*(1) = Department communication and information service; *I*(2) = Department of transportation; *I*(3) = Area development planning agency (Bappeda); *I*(4) = Private operator (Organda); *I*(5) = Entrepreneurs; *I*(6) = Academics; *I*(7) = Community leaders.

5.2.1. Promethee II complete Ranking

Table 7 shows the ratings and scores of the four smart mobility action options. The highest opinion was given to the action of public transportation availability at 0.2300, followed by public transportation safety measures with a score of 0.1967, then the equality of public transportation with a score of −0.1800, then next was the route action with a score of −0.0300, then followed by the action of availability of Realtime information access with a score of −0.0773, the next action was the public transportation schedule with a score of −0.1500, and the last was the use of bicycles with a score of −0.3533.

Table 7. Phi, Phi+, and Phi− values.

Rank action	Phi	Phi+	Phi−
Public transport availability	0.2300	0.2300	0.0000
Public transport safety	0.1967	0.1967	0.0000
Convenience of public transportation	0.1800	0.1800	0.0000
Public transportation routes	−0.0300	0.0600	0.0900
Real-time information access availability	−0.0733	0.0767	0.1500
Public transport schedule	−0.1500	0.0600	0.2100
Bicycle usage	−0.3533	0.0000	0.3533

Based on the results above, the sequence of actions for implementing smart mobility can be identified. The first step is to ensure the availability of public transportation, which makes it easier for the community to travel every day. The next activity involves ensuring the safety and comfort of public transportation. If public transportation is safe and comfortable, the community will be more inclined to use it, thereby reducing congestion and air pollution. Following this is the establishment of public transportation routes that cater to the community's needs, especially in accessing important locations such as hospitals, schools, government offices, and recreational areas. Additionally, real-time information access should be made available for people to easily obtain information about public transportation schedules, routes, and fares. It's also important to consider offering 24-hour public transportation to reduce travel costs. Lastly, promoting the use of bicycles is crucial. By expanding and improving bicycle road facilities, more people will incorporate cycling into their daily activities, leading to a healthier community and reduced congestion and air pollution.

5.2.2. Promethee network

Within the Promethee network perspective, every action is depicted as a node, and the preferences among them are depicted using arrows. These nodes are positioned in a way that aligns with the promethee II complete ranking, making it visually evident how the flow values compare in terms of proximity.

In **Figure 7**, you can observe the Promethee smart mobility network, which shows the actions and their corresponding Phi+ and Phi− values. The action with the highest Phi+ value is the availability of public transportation at the node, followed by security measures and the convenience of public transportation. Subsequently, two actions are followed simultaneously: the public transportation route action and the availability of real-time information access. The second simultaneous action is the public transportation schedule, and the final action is the use of bicycles. The direction and distance of the arrow lines indicate the stage and timing of the actions.

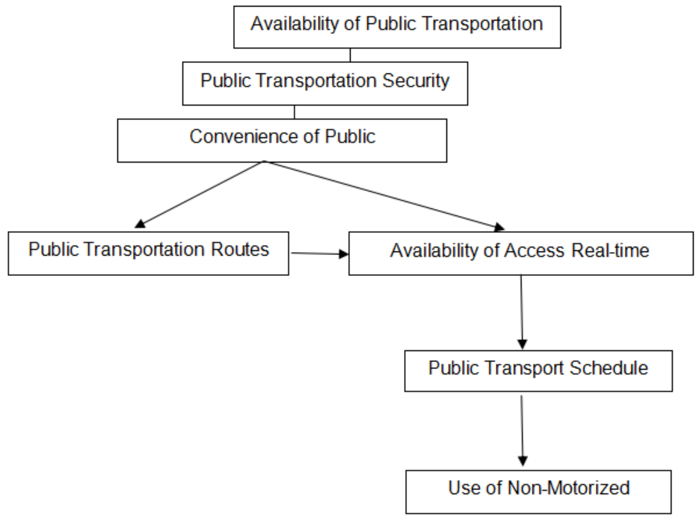

Figure 7. Promethhe network.

The results of the Promethee network reveal the sequence and distance of the actions in the network, allowing for the determination of the necessary initial action and the time period for its implementation. The primary action to be taken is ensuring the availability of public transportation, which will facilitate its use by the public. Subsequently, attention should be given to ensuring the comfort and safety of public transportation. Following this, the next action is to establish routes that aid people in reaching specific locations, along with providing real-time information access and an accurate schedule to minimize wait times for public transportation. Finally, the action involving the use of bicycles can also contribute to implementing smart mobility.

6. Conclusions

To assess smart mobility, regional planning, and regional development, we need three indicator categories. The first is five smart mobility indicators, including real-time info access, public transport ease, modes integration, routes, and availability. The second category has four transportation planning indicators—density, tech, distance, and modes. The third is two regional development indicators—natural resources and land use. These drivers have a significant impact on the outcome with minimal dependence.

Smart mobility is crucial for transportation planning, and traffic safety is key. Regional planning has four indicators: traffic conditions, movement patterns, transportation policies, and infrastructure. Regional development has nine indicators, including infrastructure, economy, policies, education, tourism, social and cultural aspects, environment, security, and spatial planning. The four indicators of smart mobility are the convenience of public transport, non-motorized bikes, and vehicles for pedestrians. These indicators have a high dependency and a small influence and are sensitive to changes in other variables.

Smart mobility is measured by indicators like public transportation schedules and emissions, known as "autonomous" and "excluded" variables. Smart mobility has a direct influence on regional development, particularly the availability of public transportation, which influences infrastructure and accessibility, as well as government policy. Government policy also influences smart mobility. Smart mobility has a very strong and relatively strong indirect influence on regional planning and development on the variables described above. Similarly, regional planning and regional development have a very strong and relatively strong indirect influence on smart mobility.

The second objective of this research is to produce a policy model for regional planning and regional development with smart mobility for the city of South Tangerang. Determining alternative/action/policy evaluations that must be carried out as well as determining the criteria that support or influence them. So, it is concluded that the sequence of policies that must be implemented first is the availability of public transportation. This illustrates the need to rejuvenate city transportation and if it can still be improved, we can use old fleets that are still suitable for use. The second policy is public transportation security, where the security of public transportation must be improved. Next is the public transportation comfort policy where people who use public transportation must feel comfortable when using public transportation. The next policy is public transportation routes. In this case, with the increase in population and new settlements, new public transportation routes are needed. The next policy is the availability of real-time information access where all public transportation information can be accessed by the public easily. The next policy is related to public transportation scheduling, where there is no definite schedule for public transportation so people cannot rely on public transportation to carry out their activities. The final policy is the use of bicycles. People will use bicycles if there are more bicycle lanes and there are provisions that make bicycle users safe when traveling. In implementing the policy, according to Promethee network, the order of implementation is according to the ranking, but there are different distances for implementing the policy. In implementing the policy, it should be carried out with top priority and at a time that suits need, in this case, the policy to fulfill the availability of public transportation, the safety of public transportation, and the convenience of public transportation can be carried out simultaneously, then followed up with other policies.

The implementation of smart mobility in the city of South Tangerang must be carried out by all stakeholders, be it the government, community, and private sector, because otherwise what is hoped to make the city of South Tangerang a smart mobility city will be difficult to realize. The government must conduct a city-wide study of mass transportation, including additional routes/transport routes and the South Tangerang city government should discuss and design follow-up actions in a business feasibility study on smart mobility in the city of South Tangerang. The government must also carry out comparative studies of cities that already have urban mass transportation networks and representative urban transportation with good planning and implications and it is hoped that the government and other stakeholders can find modes of urban public transportation that can accommodate all levels of society, such as comfortable, safe, cheap and integrated city and bus transportation. government must also conduct a survey regarding the needs of South Tangerang city people for public transportation. The survey must be comprehensive, detailed, and involve all societal levels so that a modern, integrated and affordable transportation system will be available. The government must make regulations on public transportation and online transportation so that the two transportation facilities can serve the community together.

This research has study weaknesses, namely, the difficulty of obtaining secondary data from the relevant agencies so the author has to use primary data because of difficulties in searching and availability of this data. To continue this research, further studies can be carried out, for example by applying this research to other regions in Indonesia, adding research variables that have not been researched, and using secondary data available from the relevant agencies.

The results of this study align with the findings of the literature review, which assesses smart mobility indicators to measure the level of smart mobility implementation in a city. However, different research methods and locations have led to varying results. For instance, in Indonesia, when comparing cities of similar size, the implementation of smart mobility has not been fulfilled. On the other hand, in the capital city of Indonesia, the level of smart mobility implementation has been met. Similarly, research in the Philippines indicates that some regions or cities have not achieved smart mobility implementation. In developed countries like Poland and Spain, which have good infrastructure and per capita budget, the application of smart mobility is very good due to smaller city sizes and population density compared to developing countries like Indonesia and the Philippines. This study focuses on South Tangerang, a small city in the province of Banten, Indonesia. Previous research has shown that public transportation users in South Tangerang are dissatisfied with the current facilities and seek improvements to attract more users. Enhancing public transportation can help reduce congestion and air pollution.

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