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MaaS Implementation in Bandung City: Big Data Collection, Integration, and Utilization

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ABSTRACT

The results of the Eden Strategy Institute 2021 study show that Bandung City is ranked 28th in the world's Top 50 Smart City Government Rankings. However, from the results of the Asian Development Outlook 2019 study, Bandung City is ranked as the most congested city in Indonesia and 14th in Asia. Solutions to problems are offered in the form of Mobility as a Service (MaaS), an integrated system of transportation services, digitization, and the use of big data. The realization of MaaS requires contributions from all parties. The synergy between the government, academia, stakeholders, the media, and the public is called Pentahelix. The research stage includes the collection of primary data and secondary data by conducting a literature review. Then conduct a graphical analysis of multivariate data on Pentahelix with three assessments, namely performance, competence, and involvement. Next, modeling and loading were carried out for a pilot simulation of The Bandung City area in the eastern region using macro or meso-level traffic simulation software, namely PTV Visum 2022 (Student). After comparing with real-time analysis from the Google Maps application, comprehensive results were obtained with real conditions. As a means of controlling public transportation services, an Electronic Device Capture (EDC) hardware digital system is needed that is integrated between modes through software and artificial intelligence. The final stage of this study was carried out a risk analysis matrix for the implementation of MaaS for the city of Bandung with moderate risk results. MaaS is not a new idea, but it is a good solution to overcome congestion and change Bandung's transportation concept.

1. Introduction

The success of Bandung City as one of the smart cities in the world according to the Eden Strategy Institute (2021) at number 28 in the Top 50 Smart City Government Rankings as of March 31, 2021, has not shown a significant effect on congestion problems [1]. Even though this achievement far defeats major world cities such as Adelaide, Australia (ranked 31), Dubai, United Arab Emirates (ranked 34), and even Los Angeles, United States (ranked 40). The challenge of implementing smart cities includes how a city can solve transportation problems, namely unraveling congestion. The Asian Development Bank (ADB) (2019) ranked Bandung as the most congested city in Indonesia and 14th in Asia [2].

When viewed from the complexity of congestion problems in the city of Bandung based on data from the Global Future Cities Programme survey (2018), both population density, ownership of private vehicles, road user behaviour, quality of public transportation, socialization of Angkot (local share-taxi) organizers, inclusiveness, and comfort of using communal transportation and so on, this further enhances the complexity of congestion problems in the city of Bandung [3]. The existence of the Covid-19 pandemic that has occurred in Indonesia since March 2020 until now has not found a final result, which has more or less affected the conditions of reluctance to use communal transportation, including in the city of Bandung [4]. An integrated solution is needed to unravel this complex problem so that it can unravel congestion for the City of Bandung to realize Sustainable Development Goals

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(SGD) number 11: Sustainable Cities and Communities, namely making cities inclusive, safe, resilient, and sustainable. If we continue to ignore this problem, it will lead to economic losses and increased public stress, decreased health, and increased air pollution.

There is a need for a synergy of collaboration strategies from all parties involved from an authority, academics, stakeholders, media, and the community in overcoming congestion [5]. Siswanto and Sayogi concluded that communication and coordination between agencies, the private sector, and transportation users are problems that cause congestion in Bandung City. One form of communication can be done with data disclosure [6][7]. However, this has not yet been realized due to the lack of access to the data needed. This is unfortunate because the availability of data is very important as a source of information [8].

Based on the explanation of the problems above, the author tries to find solutions to these problems using the Internet of Things (IoT) technology approach, communication technology, and artificial intelligence (AI). As well as the use of Big Data in analysis to be able to control the transportation system with minimal latency [9]. Therefore, an integrated system is needed that allows effective monitoring of existing entities, collecting the necessary data, processing data for decision-making, and coherent problem-solving priorities. This paper created by the author is expected to help solve transportation problems in Bandung City up to the risk analysis matrix.

2. Methodology

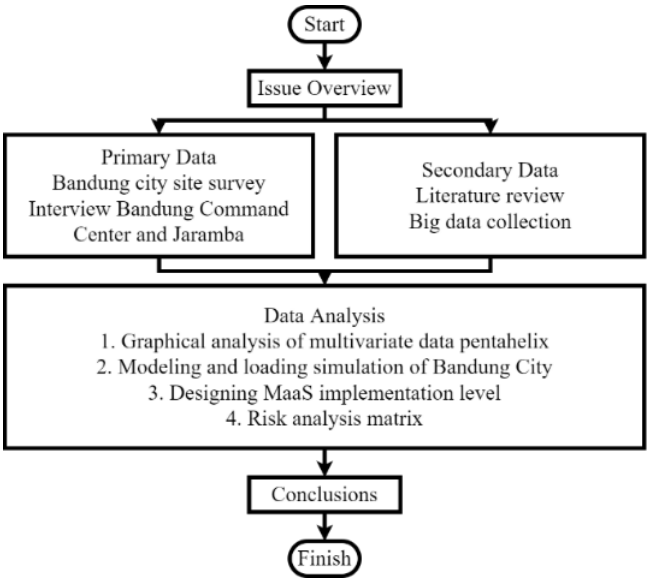

Figure 1. Research Flow Chart

2.1 Scope of Research

The limitations of the research scope include the following:

1. The observation boundary covers Bandung City, West Java. The pilot area includes Sumur Bandung Sub-District, Lengkong Sub-District, Batu Nunggal Sub-District, Regol Sub-District, and Bandung Wetan Sub-District.
2. The period of observation is roughly 2020 - early 2022.

The limitation of the suggested system is to be carried out in Bandung City by considering the existing infrastructure and conditions at the time interval.

2.2 Data Collection

As shown in Figure 1 primary data collection was carried out by conducting a location survey of Bandung City, and free guided interviews with The Bandung City Government, namely The Bandung Command Center (BCC) and Jaramba. BCC is part of The Bandung City Communication and Information Office which aims to realize a smart city and Jaramba is a private technology startup company engaged in transportation. Secondary data collection is done by conducting a literature review.

2.3 Scenario Analysis

The authors used scenario analysis to assess the potential impact of using Mobility as a Service (MaaS) in improving sustainable transportation in Bandung. Scenario analysis explores possible outcomes based on assumed scenarios and actual information [10]. The scenario analysis uses the following steps:

1. Identifying strategic uncertainties. The first important step in scenario building is to identify the strategic uncertainties of the parties that play a role in the realization of MaaS.
2. Determination of MaaS implementation level. The determination of the level of MaaS practice is based on previous research as a reference for the stages of MaaS deployment in Bandung City.
3. Defining the scenario that occurs. Develop a MaaS practice scenario by assuming several aspects.
4. Assess the potential impact of MaaS according to the scenario. Assess each scenario of MaaS implementation in Bandung City using several predetermined assessment points.

3. Results

3.1 State of MaaS Ecosystem in Bandung

The MaaS ecosystem consists of several layers and parties. The parties in the core businesses are MaaS providers, data providers, transportation operators, and users [11]. If we adjust it to the current conditions in Bandung, the parties that play a role can be grouped as shown in Figure 2.

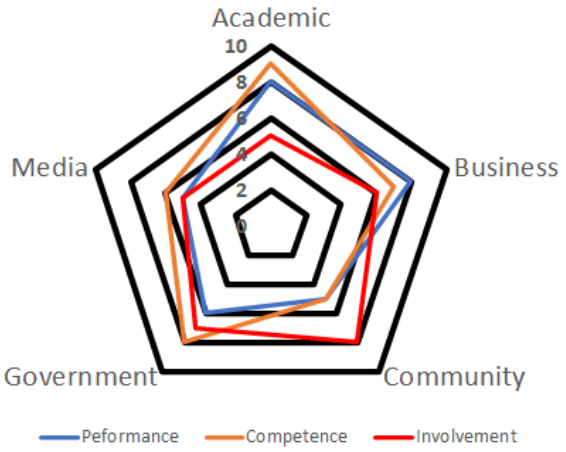

Figure 2. Spiderweb Diagram of Pentahelix Assessment to Stakeholders in the Realization of Smart City

Jaramba

Jaramba plays a role in providing MaaS systems and platforms and acts as a Data provider. Jaramba has been able to provide a platform that allows users to make payments via Quick Response Code (QR Code) and provides information in the form of travel lanes and real-time locations of several Angkot fleets.

However, the platform is still very limited, Jaramba is only a small part of public transportation. From the author's observations and interviews with Jaramba, Jaramba is only available on DAMRI and Angkot from two cooperatives. This is because Jaramba has difficulty in establishing cooperation with transportation operators.

Bandung City Government

The Bandung City Government plays a role in providing transportation and ensuring transportation conditions. From the results of our visit to Kominfo and the results of interviews, the provision of transportation is carried out by several state agencies. Monitoring transportation conditions is done by monitoring conditions through CCTV and tracking the position of the public transportation fleet. CCTV in Bandung City can be integrated with Nodeflux's artificial intelligence to count the number of vehicles. Nodeflux is an Indonesian company engaged in artificial intelligence [12]. While tracking communal transportation that has been carried out by Kominfo is carried out on the Angkot fleet. The purpose of this monitoring is to find out the condition of transportation so that traffic engineering can be carried out if there is a congestion problem based on reliable data.

However, the infrastructure is not being utilized to its full potential. CCTV is not fully operational and Nodeflux's AI-calculated data is not stored due to lack of funding and the Government has not considered that the effort can provide significant benefits for improving transportation conditions in Bandung.

Consumer

The Global Future Cities Program (GFCP) survey found that Jaramba has the potential to provide a platform for easy payment and access to travel information and The Bandung City Government has the potential for data collection and integration. However, Jaramba has obstacles in establishing relationships with public transport operators and The Bandung Government has obstacles in providing efficient and economical means of data collection.

A penta-helix analysis of stakeholders in the realization of smart cities was conducted. The assessment was conducted on performance (target achievement, and job suitability), competence (idea/concept generation, and interest to be involved), and involvement (ease of information sharing, and participation between parties) in a smart city.

3.2 Levels of MaaS implementation

Previous research has determined the stages of MaaS utilization based on the improvement of assimilation practice as well as the stages of execution based on integration fulfilment and cognitive load perceived by users [13][14]. Through these two studies, the author compiled the level of MaaS implementation based on the resources owned by The Bandung City Government in Table 1.

Table 1. Levels of MaaS Implementation in Bandung City

Levels	Method of Implementation
Level 1 Data integration across multiple modes.	Integration can be done by collecting data (your location of occupancy) obtained from payment devices located around the mode. The data is sent to the authority department (for example, Bandung Command Center), which is then presented to transportation users through applications on devices and terminals/stops regarding the condition of communal transportation in real-time.
Level 2 Simple integration (operationa and payment)	The integration of transportation modes can be improved through a uniform payment system between public transportation modes. The author proposes a payment system using cards and QR codes to meet the needs and overcome potential limitations faced by users (e.g., comprehensive smart device ownership).
Level 3 Full integration of multiple pathways	Integration of transportation modes is improved by offering intermodal payment methods in the form of packages, and/or the option to use communal transportation in the form of Pay as You Go (PaYG).
Level 4 Full integration of all modes on all routes	Comprehensive integration can be done after all supporting hardware and software have been installed in all modes. With the data that has been obtained in the previous stage, a study can be carried out to determine the costs and payment packages that suit the needs of Bandung City. Integration of information, prices, and real-time conditions of transportation modes is targeted to run as a whole.

3.3 MaaS Targets and How to Achieve Them

Four scenarios can occur based on two aspects of uncertainty and four levels to analyze the practice of MaaS shown in Figure 3 [15]. Based on the reasoning of existing conditions in the field, Bandung City is in scenario C. The conditions of scenario C were chosen based on the results of interviews with Jaramba founders and BCC representatives, namely the condition of public transportation that does not develop from year to year, and every innovation made does not last long. This condition causes private parties to try to realize MaaS in Bandung City. This scenario means that communal transport operators and MaaS service provider operators contribute more than the authority as the regulator and main MaaS responsible party. This is evidenced by the lack of regulations related to limiting the use of private vehicles and regulations related to increasing the use of public transportation.

The Bandung government has supported Jaramba's plan to provide MaaS in Bandung by signing a Memorandum of understanding (MoU) regarding The Bandung government's recognition of Jaramba as a MaaS player. However, the city authority does not seem to be optimal and synergized in realizing MaaS in Bandung City.

When reflecting on other countries that have tested and implemented MaaS such as Sweden and Finland, these governments have implemented regulations regarding data disclosure, restrictions on private vehicles, and other MaaS-related regulations [15]. The experiments conducted in Australia (2013) and Sweden (2019) were conducted for 6 months by implementing a pay-as-you-go payment option in the first month and looking for bundling variations in the following month based on the data collected in the previous month. The Finnish experiment is successful, started in 2011 until now in the form of an application called Whim which is already available in Finland, Belgium, Japan, Switzerland, Austria, and England [16].

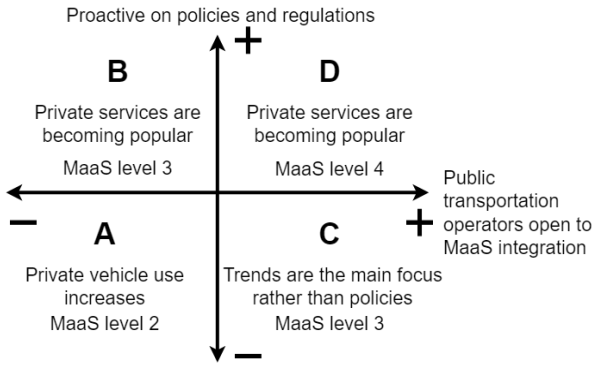

Figure 3. MaaS Implementation Scenario

3.4 Realization of MaaS System in Bandung (Data Collection, Integration, and Utilization System)

To achieve MaaS in Bandung City, real-time and accurate data integration and retrieval are required. Real-time data is needed so that decisions can be made quickly. Meanwhile, accurate data is important so that the decisions chosen are by existing conditions.

Real-time and accurate data collection can be realized through the installation of a digital system that can later be applied to all modes of transportation in Bandung City. The digital system that the author offers requires hardware in the form of Electronic Devices Capture (EDC) that uses the Android operating system and

supports 4G connectivity. The EDC can later be used as a means of payment using a barcode scan or card tap system. In addition, EDC connected to the internet can be used as a data retrieval of occupancy, location, and movement data (travel matrix/origin-destination matrix) from communal transportation in Bandung City. The following is a flowchart of how EDC works in public transportation.

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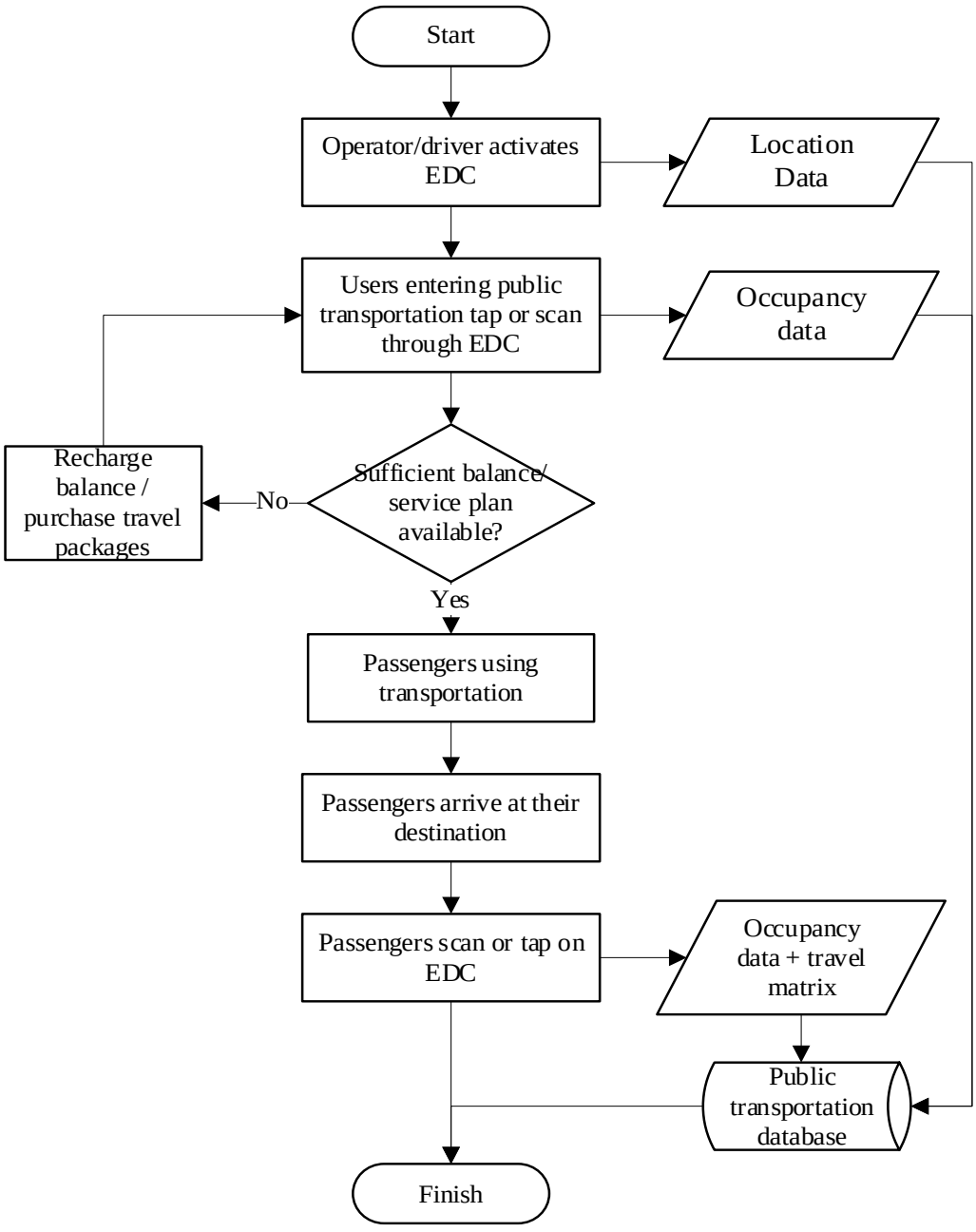

Figure 4. Flowchart of EDC Usage

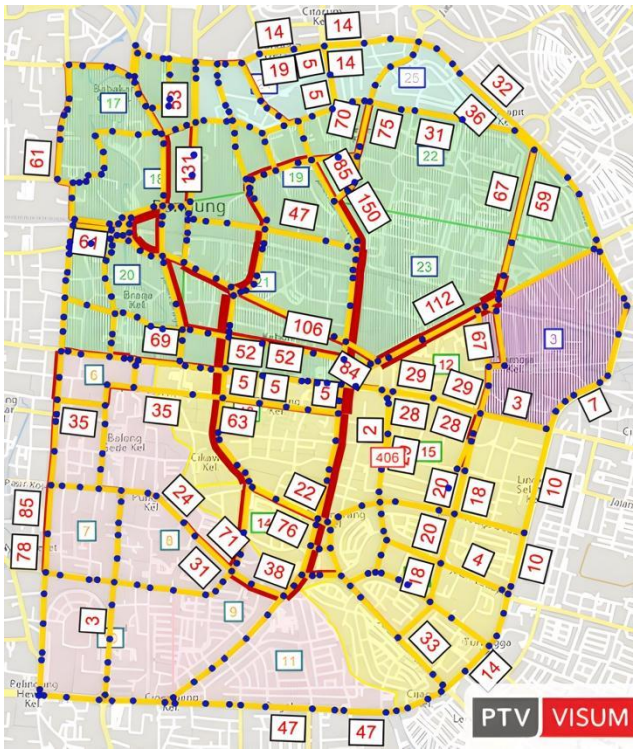

Figure 5. Simulation Using PTV Visum by Author

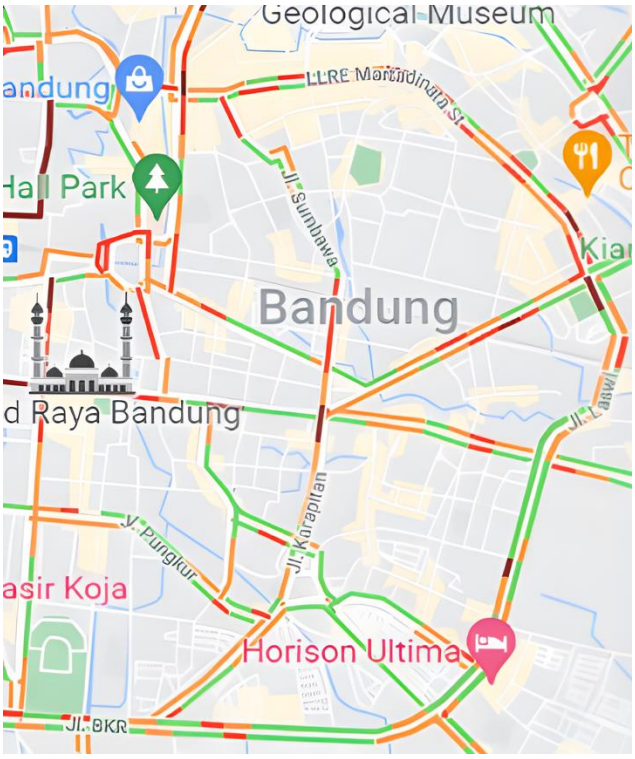

Figure 6. Traffic Conditions in Bandung City on 11/12/2021 at 16:19 WIB According to Google Maps

Through the digital system that the author describes in the flow chart above, at least three pieces of data are obtained, namely location, occupancy, and movement data. Location data is used to provide information to prospective passengers about the position of the transportation mode. This can help consumers to choose the most suitable mode of transportation. Next, occupancy data can be used to provide information about the availability of transportation modes and can also be used to monitor the performance of health protocols regarding restrictions on communal vehicle passengers during the Covid-19 pandemic. The last data is movement data obtained through barcode scans or card taps made by passengers when entering and exiting the transportation mode. The travel matrix data can be used to determine the paths that need to be added or reduced to transportation modes. If added to the overall travel matrix of Bandung residents, it can be done a traffic simulation in Bandung to help carry out traffic engineering and road construction planning and procurement of new modes of transportation.

The combination of these three data if added with operational integration will realize MaaS at least at the 3rd level, especially if it can be done in all modes of transportation that will reach the 4th level. This happens because this system can realize integrated digital payments between modes, help operational alliance between modes, and integrate transportation mode information in Bandung City. In addition, travel matrix data can be used to simulate traffic if it is added to the personal transportation travel matrix. The author tried to simulate Bandung traffic using travel matrix data obtained through Base Transceiver Station (BTS) signals in the paper of Tamin et al. using macro or meso-level traffic simulation software, namely PTV Visum [17]. The simulation was carried out by creating a road network, creating zones based on Sub-Districts, creating public and private transportation systems, filling in the travel matrix, and calculations. The author experienced obstacles in the form of a limited number of zones and road networks due to the student version of the software. However, the results of the simulation turned out to be able to describe the traffic of Bandung City comprehensively with real conditions. This can be seen from the comparison of the PTV Visum simulation results and the Google Maps map in Figure 5 and Figure 6 respectively. In Figure 6 the numbers are simulations of four-wheeled vehicles passing through the road. The data is obtained from the total number of four-wheeled vehicles in Bandung City and the travel matrix data from Tamin et al. [17]. The redder the net, the more congested the road will be.

3.5 Mode of Transportation Preference Shift

The transportation condition of Bandung City with the dominance of private vehicles up to 98% is one of the

challenges in implementing MaaS. Therefore, it is necessary to shift the mode of transportation from private vehicles to communal vehicles [18].

One way to make people in Bandung switch from private to public transportation is to improve communal transportation modes. Based on a survey conducted by GFCP in Bandung, 11 public transportation problems were found that need to be improved. One of the main problems is data assimilation whose solution the author proposes is through a digital system that can retrieve and integrate data. However, it will be better if other problems can be solved simultaneously so that MaaS can be implemented optimally in Bandung. The following Figure 7 is a prioritized graph of improvement recommendations according to the GFCP survey with the X-axis representing the percentage of respondents choosing, while the Y-axis illustrates what needs to be improved.

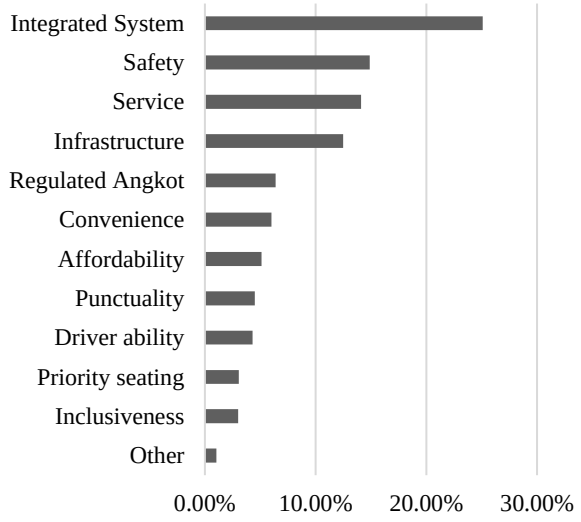

Figure 7. Recommendation for Improvement

3.6 Risk Analysis of MaaS Implementation in Bandung

The author conducted a risk analysis based on ISO 31000 - Risk Management for the MaaS system that will be carried out in Bandung City. ISO 31000 analysis can map problems to minimize and mitigate existing risks [19].

ISO 31000 risk analysis is divided into three: identification, analysis, and evaluation. The risk identification stage is carried out by studying the problems that occurred in the previous MaaS exertion. After that, the risk analysis was carried out by weighting the impact, namely the impact if the problem occurs and the likelihood (likelihood), namely the possibility of the problem occurring in Bandung City. The weighting is included in the weighting matrix in Table 2 to determine the risk level. The results of the risk analysis in the form of risk level, impact, and handling can be seen in Table 3. Based on the analysis, there was one low risk (green), eight medium risks (yellow), and three high risks (red).

4. Conclusion

In this paper, the author proposes MaaS as one solution to transportation problems in Bandung City. Based on the selected scenario, it can be concluded as follows: (1) Bandung City has the potential to implement MaaS; (2) Synergy is needed between the government as a regulator and provider of public transportation, the private sector as a transportation provider and the community as a user; (3) To achieve MaaS at the 4th level, it is necessary to integrate information, data, and operations of all modes of transportation in Bandung; (4) Utilization of a digital system to implement MaaS in Bandung City is needed, along with improvements in public transportation modes; (5) Among the highest risks of MaaS implementation in Bandung City are regulations that limit public transportation innovation, politics and conflicts of interest, bureaucratic red tape, and taxation schemes that favour private transportation.

Table 2. Risk Weighting Matrix

Likelihood	Certain	5		R04, R09	R03		
	Likely	4		R02	R12		R06
	Possible	3				R07, R11	R01
	Unlikely	2		R05		R10	
	Rare	1					R08
Description		Low	1	2	3	4	5
		Medium	Insignificant	Minor	Moderate	Major	Catastrophic
		High	Impact				

Table 3. Possible Risks, Impacts, and Responses of MaaS Implementation in Bands

Level	ID	Possible Risks	Impact	Solution
Macro	R01	Laws and regulations that limit the authority of communal transportation providers	No innovation in transportation	Making a study of existing regulations and legislation
	R02	There is no explicit sectoral responsibility for public transport development.	Lack of support for MaaS application by the government	Creation of a special government team for MaaS succession
	R03	Taxation schemes that favour private vehicle use	Lack of interest in communal transportation	Reorganization of taxation to fit the MaaS program
	R04	Lack of understanding of MaaS vision and mission	Misunderstanding of MaaS embodiment	Increased awareness of mobility issues through social and mainstream media
Meso	R05	Lack of collaboration between private and government	Difficulty integrating data between modes of transportation	Dialogue and data disclosure between transportation service providers
	R06	Complicated bureaucracy and politics regarding public vehicle authorities	Difficulty in making new policies	Simplification of bureaucratic processes
	R07	Lack of innovation culture in communal transportation application	The realization of MaaS has been slow	Increased awareness of mobility issues through social and mainstream media
	R08	Low trust between private providers and the government	Collaboration in realizing MaaS can be hindered	Dialogue and data disclosure between transportation service providers
Micro	R09	A mismatch between MaaS offerings and people's needs	The MaaS program is not fully operational	An in-depth survey of the mobility needs of the people of Bandung City was conducted.
	R10	Tedious socialization processes and overly complex systems	MaaS is not well implemented	Simple socialization of the MaaS system
	R11	The habit of using private transportation is still high in Bandung City	People are reluctant to change or use public transportation	Increased awareness of mobility issues through social and mainstream media
	R12	Lack of awareness of costs incurred for travel especially using private vehicles	People are reluctant to change or use communal transportation	Increased awareness of cost and environmental issues caused by private vehicles

MaaS is not a new idea, but it is a good solution to overcome congestion and change Bandung's transportation concept. The author hopes that the use of the MaaS system can meet the needs of public transportation integration in Bandung City and support good environmental quality by increasing public interest in using public transportation.

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