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THE MODEL FOR INTEGRATING ROAD FUNCTION, ROAD STATUS, AND ROAD CLASS IN THE ROAD NETWORK SYSTEM

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The lack of synchronization between road categories in Indonesia, which includes road function, road status, road infrastructure class, and road load class, results in negative impacts on roads, including air pollution, traffic accidents, congestion, and road deterioration that occurs more rapidly than the planned road lifespan. Another consequence is that the lack of synchronization between logistics transport trips and road function and classifications can lead to violations of the maximum axle load limits for goods vehicles. The objective of this research is to establish an analytical correlation between the identification of road segments based on road function, road status, road load class, and road infrastructure class, as well as the impact variables. Additionally, the aim is to develop a model for determining road function, road status, road infrastructure class, and road load class, along with their impact variables. The primary areas studied in this research are the road networks in Lampung, DIY, East Java, South Kalimantan, West Papua, Maluku, and Southeast Sulawesi. The research employs two quantitative techniques: Importance Performance Analysis (IPA) and Structural Equation Modelling (SEM). Data and information have been gathered through questionnaire surveys, desk studies, and interviews, which confirm Law No. 2 of 2022 concerning Roads, which explains that road function are derived from road status, while road infrastructure class and road load class are also derived from road function. The findings reveal that how roads are classified by their function has a major effect on traffic outcomes. This emphasizes the importance of categorizing roads based on their intended use. Consequently, it is crucial for planners to focus on functional classifications when designing and managing road infrastructure to tackle traffic issues effectively.

Keywords: road function, road status, road network system, transport integration, structural equation modelling

1 INTRODUCTION

The relationship between roads and regional development is integrally dependent on three primary factors i.e. physical, economic, and social. Based on a physical perspective a two-way perspective clarifies the correlation between road infrastructure and regional development. Specifically, road infrastructure plays a role in supporting regional development, while rapid regional development fosters the expansion of the road network. Conversely, the development of new residential areas will lead to a greater intensity in the movement of people and products, resulting in a significant need for expanded road networks. Subsequently, road projects will be implemented in order to increase the number and connectivity of road sections in a given area [1].

Based on an economic perspective, regional growth typically takes the form of a network of roads. A flood of investment in a city usually leads to the development of new space arrangements, such as the growth of residential districts, industrial zones, and tourist destinations. Consequently, this has a tangible effect on facilitating the establishment of new transport routes through the construction of roads that can link the region with the central urban area. From an economic perspective, the economy can be categorized into two primary activities: production and consumption [2]. These two activities, namely economic activities, depend heavily on infrastructure for their efficiency. Strategic considerations about the implementation of economic activities (such as production and consumption) in a region will significantly influence regional growth from an economic standpoint. The road infrastructure in this region is expected to facilitate the research, distribution, and preservation of natural resources, as well as production activities, all the way to distribution and consumption [3]. Road infrastructure plays a crucial role in shaping economic activity, spatial organization, and regional development in response to the community's economic growth requirements [4].

From a social perspective, the connection between regional development and road infrastructure may be observed in how this infrastructure enables the interaction of individuals who are geographically dispersed across various places [4]. The road infrastructure should facilitate the integration and synching of social practices, the preservation of culture, and the consolidation of community groupings within a specific area, resulting in the uniformity of their social characteristics [5]. Improving the road network can facilitate closer relations between two cities, leading to the periodic unification of their social function and characteristics. This, in turn, results in the formation of similar socio-cultural patterns, which serve as the identity or symbol of the developing region. The study was conducted in many European locations, such as Manchester and Liverpool, where the increased ease of travel between the two cities resulted in the progressive development of similar cultural patterns and social interactions among the residents [6].

Effectively managing road infrastructure is crucial for supporting physical, economic, and social development activities in order to facilitate beneficial regional development. It is important to emphasize road design policies and road classification based on function and status [7, 8].To facilitate regional development in key areas like the national capital and national activity centers, it is necessary to have a road network that can support large-scale economic activities, promote national-level community interaction, and accommodate the development of important national infrastructure such as international airports, strategic tourist areas, and densely populated settlements [4] [9].

The problem is caused by the fact that in many developing countries with inadequate governance, the process of planning and assigning the road function, road status, road infrastructure class, and road load class is frequently carried out in a deficient method. Various regions observe significant and unplanned growth due to rapid economic expansion, heightened social engagement and integration, and the creation of new urban spaces [10]. Planners occasionally fail to foresee this, leading to road planning that tends to align with developing trends without thorough deliberation [11]. Many roads are constructed in different locations without doing comprehensive studies to assess whether these roads are suitable in terms of connectivity, integrity, and intelligibility for the surrounding areas and existing road networks [1, 12]. There are studies that discuss key factors that contribute to the lack of support for regional development through road networks [13]. In contrast, regional development frequently results in the deterioration of road infrastructure [14].

Therefore, based on previous research related to road hierarchy and the road network system, this study will focus on formulating a model for determining road segments based on road function, road load class, road infrastructure class, and road status in accordance with the existing road classifications in Indonesia. The main objectives of this study are to identify the analytical relationships between the determination of road segments based on road function, road load class, road infrastructure class, and road status with the influencing variables and to formulate a model for determining road function, road load class, road infrastructure class, and road status, along with their impact variables. This research is expected to provide benefits for the development of civil engineering, logistics transportation, and also for road users. This study contributes to the formulation of policy directions for aligning the road network system and offers solutions to support the smooth flow of logistics transportation for the development of civil engineering science. For logistics transportation, this research proposes a classification model for the road network system in Indonesia. The proposed classification model is expected to contribute to the efficient and effective mobility of logistics transportation, enabling logistics operators to move safely, comfortably, affordably, and quickly. Last, for road users, this research contributes to enhancing road safety and reducing congestion, thereby shortening travel time.

In Indonesia, regional development is frequently linked to the diminishing capacity of the road network. As proof, The Greater Jakarta, known locally as Jabodetabek (an acronym of Jakarta–Bogor–Depok–Tangerang–Bekasi, which is the biggest urban area in Indonesia with the highest economic and social magnitude) is gaining recognition for its multitude of infrastructure issues. These issues primarily revolve around traffic congestion, inadequate road maintenance, crashes and accidents, and misuse and degradation of roads [15]. This occurrence is not limited to Jabodetabek or other major urban centers, but is also observed in smaller cities [16].

A shortage of synchronization in determining road function, road status, road load class, and road infrastructure class might lead to many negative implications. This phenomenon can occur in infrastructure projects, particularly in the stages of road planning, design, and construction. Here is a broad summary of the issues at hand:

- Road function
- Issues may arise when the road function established during the initial planning phase are not in alignment with the local environmental changes. For instance, a road initially designated for local usage may need to be repurposed as an arterial route as a result of unforeseen regional expansion.
- Road status
- Lack of synchronization in road condition might lead to ambiguity in road maintenance and repair. If a road is designated as a district road but is meant to be the responsibility of the province or national government, then the administration of the road may be insufficient.
- Road load class
- Incorrectly assigning road load class that do not align with real traffic volumes can lead to accelerated road deterioration and impose unwarranted limitations on heavy trucks, so impeding economic growth and mobility.
- Road infrastructure class
- Discrepancies in assessing the classification of road infrastructure, including factors like lane count, capacity, and supporting amenities, can lead to a misalignment between the road and the requirements of road users. For instance, if a road is furnished with only a single lane while it necessitates multiple lanes, then congestion would ensue.

The desk study findings indicate that issues related to the absence of synchronization between road function, road status, road infrastructure class, and road load class can be described in Table 1 as follows:

Table 1. Matrix of issues between regulation and empirical

No	Issues	Related regulations	Sample case
1	National roads that enter urban areas.	Decree of the Minister of Public Works and Public Housing Number: 367/ KPTS/ M / 2023	• Jalan Lintas Sumatra Bandar Lampung City, Z.A Pagar Alam. • North Ringroad at the intersection of Condong Catur and Gejayan.
2	Provincial roads that are inadequate for heavy traffic.	• Bandar Lampung City Regional Regulation Number 4 of 2021 • South Kalimantan Province Regional Regulation Number 9 of 2015	• Jalan Airan Raya in Lampung Province • Jalan Ir. Prince Mohammad Noor in South Kalimantan
3	The lack of synchronization between road function that connect metropolitan systems and national strategic area/national tourism strategic area.	• Kota Bandar Lampung City Regional Regulation No. 4 of 2021 • Sleman Regency Regional Regulation Number 13 of 2021	• Jl. Way Ratai as a provincial road, although it has the potential to be upgraded to a national road (national tourism strategic area) for Krakatau and its adjacent areas in South Lampung Regency. • Routes that serve Prambanan national tourism strategic areas.

There are several benefits of road classification and access management, such as: Improved capacity and traffic flow (more efficient private and public transport); Improved safety (for all road users, whether vehicles, cyclists or pedestrians); Efficient use of scarce resources (less road construction needed); Equality for all users; Planning certainty for developers; Integrated land use and transport; Social benefits; Environmental quality; and Economic benefits [17]. On the other hand, overlapping regulations and the absence of synchronization between road function, road status, road infrastructure class, and road load class as a result of overlapping regulations causes poor road management, congestion, air pollution [18] [19], road damage [20], and road safety [21] [22] [23].

2 MATERIALS AND METHODS

2.1 Case study

This study was conducted in Lampung Province, Daerah Istimewa Yogyakarta Province, South Kalimantan Province, West Papua Province, Maluku Province, and Southeast Sulawesi Province. The selection of the study's location is based on major cities with significant logistics activity on each of Indonesia's main islands, encompassing all important islands in the country.

2.2 Research tools and data

The type of data used in this research is shown in Table 2.

Table 2. Type of data

Variable Code	Variable Description	Independent Variable	Data Type
V_1	Economic growth	Economy	Numerical, cross section
V_2	GDP per capita	Economy	Numerical, cross section
V_3	Volume of goods	Economy	Numerical, cross section
V_4	Equity	Economy	Numerical, cross section
V_5	Regional fiscal capacity index	Economy	Numerical, cross section
V_6	Total population	Demographics	Numerical, cross section
V_7	Population density	Demographics	Numerical, cross section
V_8	Location	Regional geography	Strings, cross sections
V_9	Travel time	Regional geography	Numerical, cross section
V_{10}	Connected authority areas	Regional geography	Numerical, cross section
V_{11}	Connectivity	Transportation infrastructure	Numerical, cross section
V_{12}	Accessibility index	Regional geography	Numerical, cross section
V_{13}	Urban system	Urban systems and spatial patterns	Strings, cross sections
V_{14}	Industrial area	Urban systems and spatial patterns	Numerical, cross section
V_{15}	Mining area	Urban systems and spatial patterns	Numerical, cross section
V_{16}	Travel cost	Transportation infrastructure	Numerical, cross section
V_{17}	Road width	Transportation infrastructure	Numerical, cross section
V_{18}	Traffic volume	Transportation infrastructure	Numerical, cross section
V_{19}	Drainage system	Transportation infrastructure	Strings, cross sections
V_{20}	Median	Transportation infrastructure	Strings, cross sections

Variable Code	Variable Description	Independent Variable	Data Type
V_{21}	Signs and markings	Transportation infrastructure	Strings, cross sections
V_{22}	Vehicle class 4	Transportation infrastructure	Strings, cross sections
V_{23}	Vehicle class 6a	Transportation infrastructure	Strings, cross sections
V_{24}	Vehicle class 6b	Transportation infrastructure	Strings, cross sections
V_{25}	Vehicle class 7a	Transportation infrastructure	Strings, cross sections
V_{26}	Vehicle class 7b	Transportation infrastructure	Strings, cross sections
V_{27}	Vehicle class 7c	Transportation infrastructure	Strings, cross sections
Y1	Primary arterial road	-	Ordinal, cross section
Y2	Primary collector road 1	-	Ordinal, cross section
Y3	Primary collector road 2	-	Ordinal, cross section
Y4	Primary collector road 3	-	Ordinal, cross section
Y5	Primary collector road 4	-	Ordinal, cross section
Y6	Primary local roads	-	Ordinal, cross section
Y7	Primary neighbourhood road	-	Ordinal, cross section
Y8	Freeway	-	Ordinal, cross section
Y9	Main road	-	Ordinal, cross section
Y10	Medium road	-	Ordinal, cross section
Y11	Small road	-	Ordinal, cross section
Y12	Class I Road	-	Ordinal, cross section
Y13	Class II road	-	Ordinal, cross section
Y14	Class III road	-	Ordinal, cross section
Y15	Special Road	-	Ordinal, cross section
Y16	National Road	-	Ordinal, cross section
Y17	Provincial road	-	Ordinal, cross section
Y18	Regency/City Roads	-	Ordinal, cross section
W1	Air pollution	-	Ordinal, cross section
W2	Safety	-	Ordinal, cross section
W3	Congestion	-	Ordinal, cross section
W4	Road damage	-	Ordinal, cross section
W5	Road durability	-	Ordinal, cross section

The tools used in this research consisted of AMOS software, SPSS software, survey design, and questionnaires.

2.3 Research procedures

Research procedures consisting of data input, data processing techniques, data sources and results (output) are explained in the following Table 3.

Table 3. Data collection and processing stage

Data	Technique	Data source	Tools	Result
Assessment of importance level and implementation level	• Structured interview • Matrix quadrant Importance Performance Analysis (IPA) • Multicollinearity test	Academics, practitioners, policy makers, associations	Questionnaires, SPSS	Data on the level of importance and the level of implementation of each road segment determination variable in the road network system
Development of road classification model	Compare the level of importance with the level of implementation	SEM Analysis Results	AMOS and SPSS	• Importance level model • Implementation level model • Road classification model with its impact variables
Testing the road function, road status, road infrastructure class, and road load class model in the road network system	Implementing diverse methodologies to classify roads in order to mitigate the typical consequences of traffic on a specific route segment.	SEM Analysis Results	AMOS and SPSS	Models that can be applied to synchronization of road function, road status, road infrastructure class, and road load class, and impact variables

SPSS is widely used for statistical analysis among research. In this study, SPSS helps to diagnose multicollinearity which occurs when two or more predictor variables in a regression model are highly correlated, which can distort the results of the regression analysis. SPSS is also used for data cleaning, managing data, and transforming variables. Proper data preparation is crucial for accurate SEM analysis. Whilst, AMOS software is primarily used in Structural Equation Modelling (SEM) analysis, which is a statistical technique for testing and estimating complex relationships among variables. Users can visually draw models using a graphical interface, making it easier to understand the relationships and dependencies between variables. Figure 1 below explains the procedure of this study.

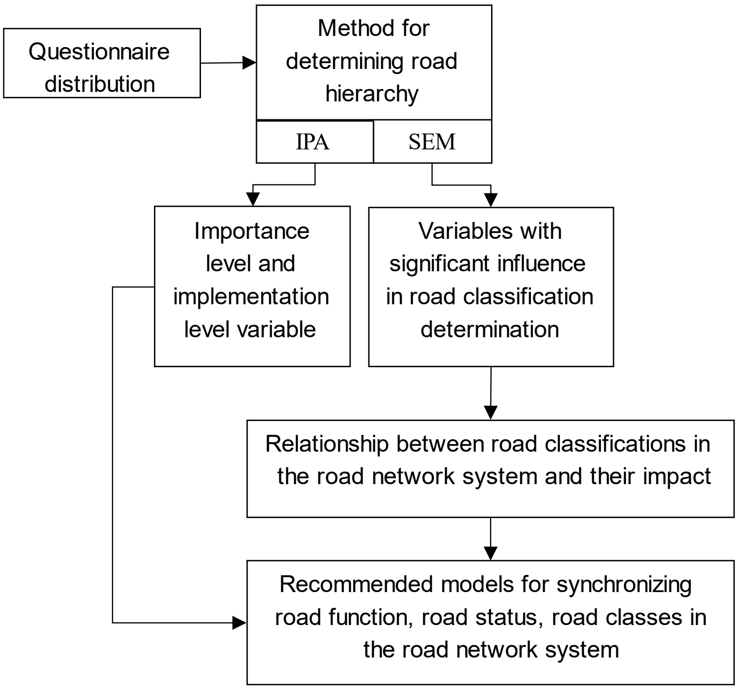

Fig. 1. Research procedures

3 RESULTS

3.1 Characteristics of the respondents

Respondent characteristics are crucial in describing the data profile while examining the synchronization of road function, road status, road infrastructure class, and road load class in a survey. The poll included a diverse group of respondents with different experiences and expertise, making their qualities highly pertinent to the analysis. Figure 2 below provides an account of the attributes of the participants included in this survey:

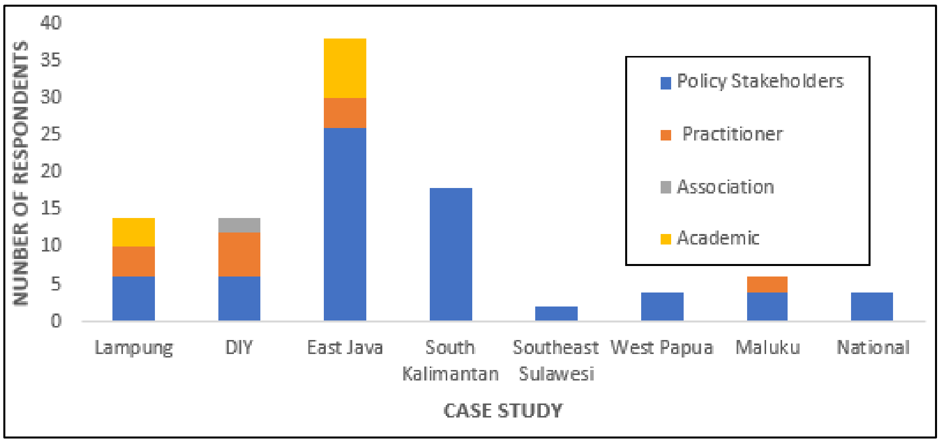

Fig. 2. General description of respondents

3.2 Importance performance analysis and multicollinearity test

The next step of the process is the Importance Performance Analysis (IPA) analysis stage, when the significance of the attributes examined in the research is assessed. The attributes encompass road function, road status, road infrastructure class, and road load class. During this step, participants are presented with inquiries on these characteristics and are requested to evaluate the degree to which these characteristics are deemed significant within the research framework. The outcome of the IPA is a prioritized evaluation of qualities, which serves as the foundation for subsequent analysis. The second step in the analysis is to carry out a multicollinearity test on all independent variables using SPSS software. The multicollinearity test is a crucial step in regression analysis and multivariate statistics. Its purpose is to evaluate the degree to which the independent variables in the statistical model are strongly interrelated and interconnected. The procedure of multicollinearity testing includes computing correlation coefficients among independent variables and employing additional techniques to detect potential multicollinearity issues within the model. The third step in the analysis involves selecting variables based on a combination of the Importance Performance Analysis (IPA) matrix analysis, the results of the multicollinearity test, and the theoretical basis of the model. This allows for drawing conclusions about variables related to road function, road infrastructure class, road load class, and road status synchronization. Figure 3 below explains in general how to read the IPA matrix in terms of level of importance and level of implementation in this study. Through Table 4, the variables that fall into each quadrant of the IPA matrix can be observed.

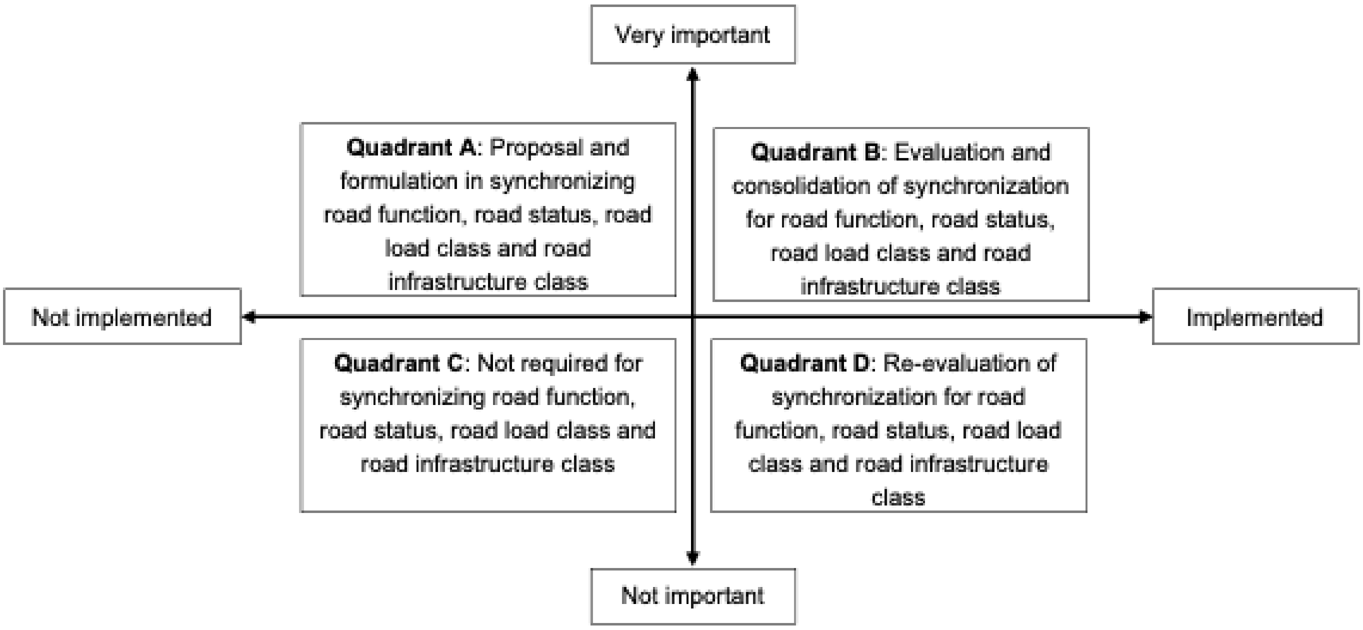

Fig. 3. Explanation of the importance performance analysis (IPA) matrix

Table 4. Summary of importance performance analysis (IPA) matrix

Road function		Road status		Road infrastructure class		Road load class	
Quadrant A: • Economic growth • GDP per capita • Equity • Regional fiscal capacity index • Industrial area • Mining area • Travel cost • Drainage system • Median	Quadrant B: • Volume of goods • Total population • Population density • Location • Travel time • Connected authority areas • Connectivity • Accessibility Index • Urban systems • Road width • Traffic volume • Signs and markings • Vehicle Class 4 • Vehicle Class 6A • Vehicle Class 6B • Vehicle Class 7A • Vehicle Class 7B • Vehicle Class 7C	Quadrant A: • Mining area	Quadrant B: • Economic growth • GDP per capita • Volume of goods • Equity • Regional fiscal capacity index • Total population • Population density • Location • Travel time • Connected authority areas • Connectivity • Accessibility Index • Urban systems • Industrial area • Travel cost • Road width • Traffic volume • Drainage system • Median • Signs and markings	Quadrant A: • Economic growth • GDP per capita • Equity • Regional fiscal capacity index • Mining area	Quadrant B: • Volume of goods • Total population • Population density • Location • Travel time • Connected authority areas • Connectivity • Accessibility Index • Urban systems • Industrial area • Travel cost • Road width • Traffic volume • Drainage system • Median • Signs and markings • Vehicle Class 4 • Vehicle Class 6A • Vehicle Class 6B	Quadrant A: • Economic growth • GDP per capita • Equity • Regional fiscal capacity index • Total population • Population density • Location • Travel time • Industrial area • Mining area • Travel cost • Drainage system • Median	Quadrant B: • Volume of goods • Connected authority areas • Connectivity • Accessibility Index • Urban systems • Road width • Traffic volume • Signs and markings • Vehicle Class 4 • Vehicle Class 6A • Vehicle Class 6B • Vehicle Class 7A • Vehicle Class 7B • Vehicle Class 7C

Road function		Road status		Road infrastructure class		Road load class	
			• Vehicle Class 4 • Vehicle Class 6A • Vehicle Class 6B • Vehicle Class 7A • Vehicle Class 7B Vehicle Class 7C		• Vehicle Class 7A • Vehicle Class 7B • Vehicle Class 7C		
Quadrant C:-	Quadrant D:-	Quadrant C:-	Quadrant D:-	Quadrant C:-	Quadrant D:-	Quadrant C:-	Quadrant D:-

Following that, a multicollinearity test was conducted on all the independent variables utilizing SPSS software. Based on the results of the multicollinearity test on the independent variables, a summary of the variables included in the equation model based on the results of the multicollinearity test can be drawn as follows in Table 5 below.

Tabel 5. The results pass the multicollinearity test of the independent variables.

Code	Description of independent variables
V_3	Volume of goods
V_4	Equity
V_5	Regional fiscal capacity index
V_8	Location
V_9	Travel time
V_{10}	Connected authority areas
V_{11}	Connectivity
V_{12}	Accessibility index
V_{16}	Travel cost
V_{17}	Road width
V_{18}	Traffic volume
V_{20}	Median
V_{21}	Signs and markings

From the combination of the science matrix results, multicollinearity test results, component matrices, and model building theory, it can be concluded that the variables in each equation in road function, road infrastructure class, road load class and road status are selected as follows: From the combination of the matrix results IPA, multicollinearity test results, component matrices, and model building theory can be concluded for the variables in each equation in road function, road infrastructure class, road load class and road status selected as follows:

- Y1 (function) = f (location, travel time, connected authority areas, connectivity, accessibility index, travel cost, road width, traffic volume)
- Y2 (infrastructure class) = f (median, signs and markings)
- Y3 (load class) = f (volume of goods)
- Y4 (status) = f (equity, regional fiscal capacity index)

The selected variables will then be entered into SEM analysis using AMOS software.

3.3 Importance level model from SEM analysis results

Figure 4 illustrates a structural equation model on importance level that demonstrates the correlation and causality between complex entities, using a significant number of indicators. Prior to doing structural equation modelling (SEM) analysis, the number of indicators measured per construct was decreased by factor analysis.

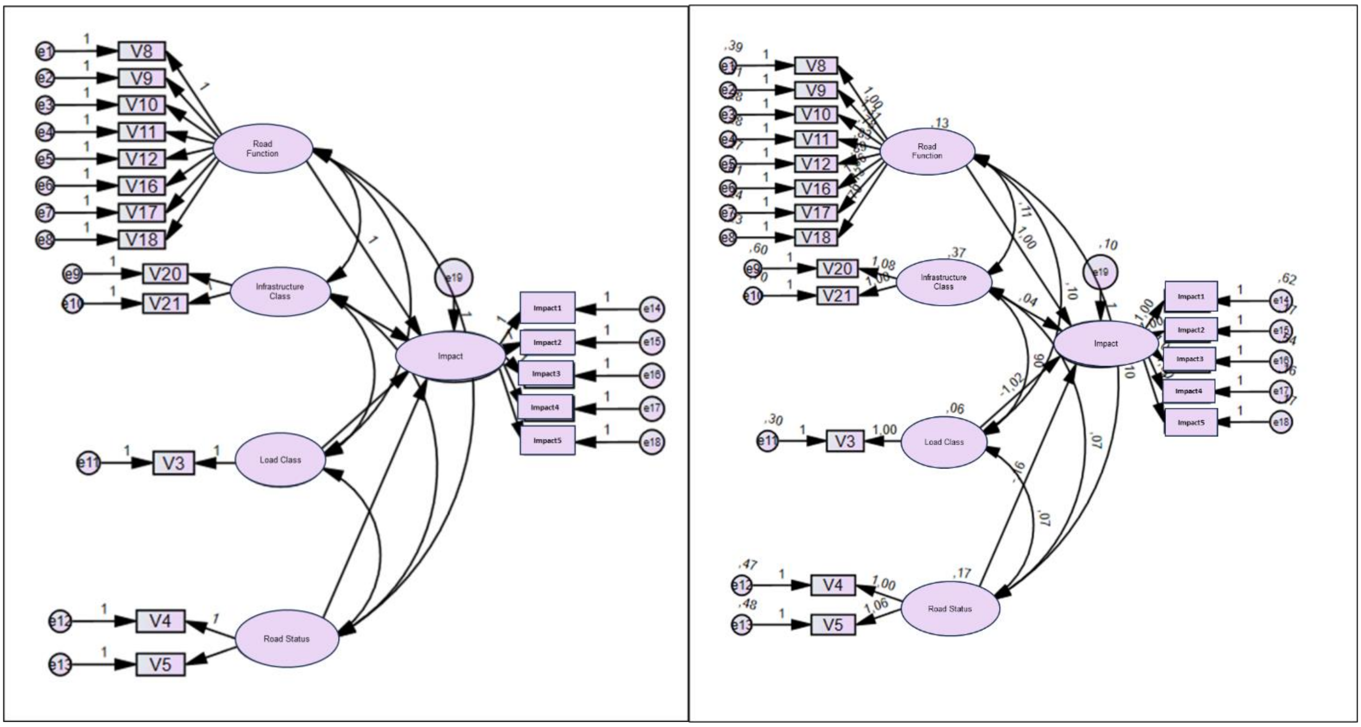

Fig. 4. Initial (left) and result (right) of SEM model on importance level

In this model, the impact value that occurs between Impact 1 to Impact 5 appears uniform, namely 1.00. The road classification that causes significant and positive impacts is road function (1.00), while the one that causes significant and negative impacts is road load class (-1.01). Meanwhile, the relationship between road infrastructure class (0.23) and road status (-0.19) with the impact variables is not significant. Based on this model, it can be identified that the travel cost variable is the variable that is considered to have the most significant and positive level of importance in determining road function. In determining the class of road infrastructure, the significant variable is the road median variable. In determining road load classes, a significant and positive variable is the goods volume variable. Meanwhile, in determining road status, a significant and positive variable is the regional fiscal capacity index variable.

Apart from that, a model of the relationship between road function, road infrastructure class, road load class and road status were also formulated. Based on the correlation results, it is known that the correlation between factors is weak. The closest relationship is between determining road infrastructure class (β=0.11), road load class (β=0.10), and road status (β=0.10) with road function class in terms of level of importance. Relationship between road infrastructure class (β=0.07) and road load class (β=0.07) with road status.

In terms of level of importance, in general the model is as follows:

– Structural model

$$\text{Impact} = Y_{function} + 0{,}41Y_{infrastructureclass} - Y_{loadclass} - 1{,}62\beta Y_{status} + zi \quad (1)$$

– Measurement model

$$Y_{function} = V_8 + 1{,}3V_9 + 0{,}78V_{10} + 0{,}83V_{11} + 0{,}89V_{12} + 1{,}36V_{16} + 1{,}13V_{17} + 0{,}79V_{18} + ei \quad (2)$$

$$Y_{infrastructureclass} = V_{20} + V_{21} + e_i \quad (3)$$

$$Y_{loadclass} = V_3 + e_i \quad (4)$$

$$Y_{status} = V_4 + 1{,}06V_5 + e_i \quad (5)$$

3.4 Implementation level model from SEM analysis results

Figure 5 illustrates a structural equation model on implementation level that demonstrates the correlation and causality between complex entities, using a significant number of indicators.

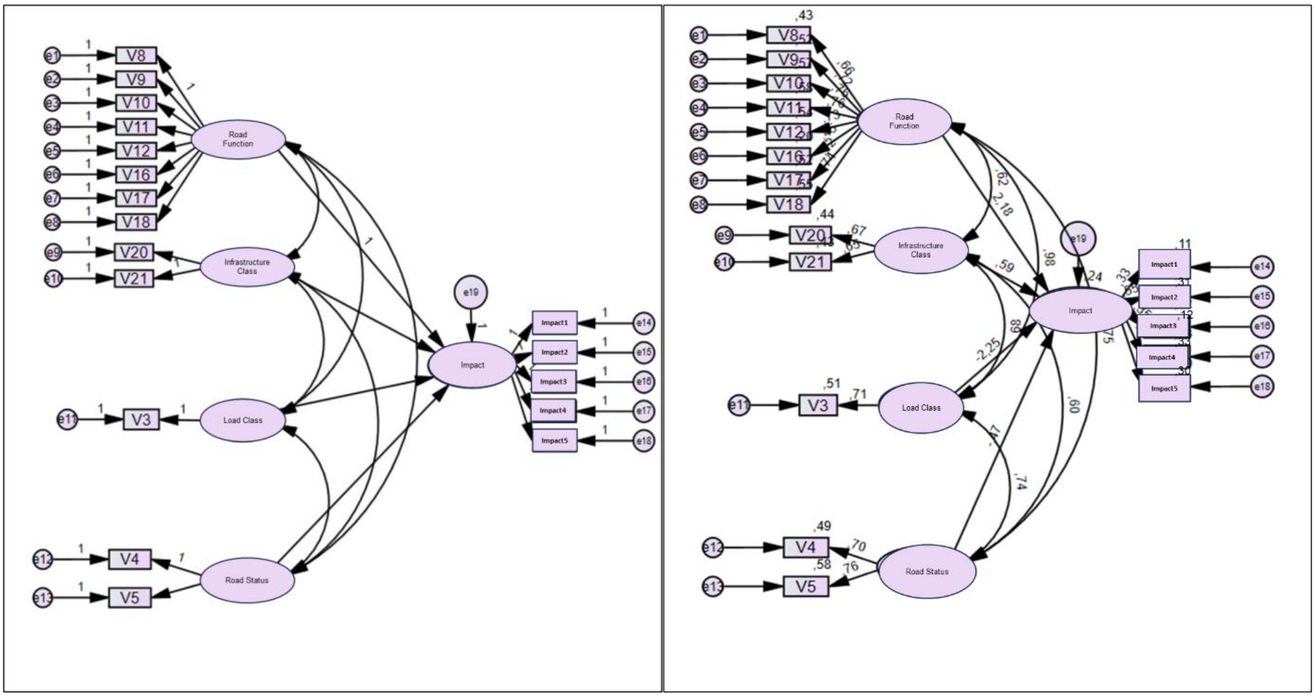

Fig. 5. Initial (left) and result (right) of SEM model on implementation level

Based on this model, it can be identified that the regional authority connected and connectivity variables are the variables that are considered to have the most significant level of implementation in determining road function. In the implementation of determining road infrastructure classes, according to respondents the significant variable is the median variable. In determining road load class, a significant variable is the volume variable. Meanwhile, in determining road status, the significant variable is the fiscal capacity index variable.

The correlation analysis reveals that the strongest association is observed between determining road function (β=0.98) and road load class. Additionally, there is a notable link between road status (β=0.75) and road function, as well as between road status (β=0.74) and road load class. Subsequently, the correlation between determining road infrastructure class (β=0.68) and road load class, as well as road infrastructure class (β=0.60) and road status, is examined.

In terms of level of implementation, in general the model is as follows:

– Structural model

$$\text{Impact}=Y_{\text{function}} + 0{,}41Y_{\text{infrastructureclass}} - Y_{\text{loadclass}} - 1{,}62\beta Y_{\text{status}} + zi \quad (6)$$

– Measurement model

$$Y_{\text{function}} = 0{,}66V_8 + 0{,}72V_9 + 0{,}76V_{10} + 0{,}76V_{11} + 0{,}73V_{12} + 0{,}45V_{16} + 0{,}72V_{17} + 0{,}794 + ei \quad (7)$$

$$Y_{\text{infrastructureclass}} = 0{,}67V_{20} + 0{,}65V_{21} + e_i \quad (8)$$

$$Y_{\text{loadclass}} = 0{,}71V_3 + e_i \quad (9)$$

$$Y_{\text{status}} = 0{,}70V_4 + 0{,}766V_5 + e_i \quad (10)$$

3.5 Road classification model with its impact variables

Furthermore, the relationship between the road classification model and the impact variables caused was also identified. The impacts included in the model are the impacts of congestion, air pollution, safety, road damage and road durability. The level of importance of road function, road infrastructure class, road load class, and road status according to respondents together have an impact (congestion, air pollution, safety, road damage, and road durability) with the following mathematical model:

$$W_1 + W_2 + W_3 + W_4 + W_5 = Y_{\text{function}} + 0{,}40Y_{\text{infrastructureclass}} - Y_{\text{loadclass}} - 0{,}16Y_{\text{status}} \quad (11)$$

As can be seen in formula 11, road load class and road status have a negative relationship with the impact variables, meaning that the lower the road load class and road status, the smaller the value of the impact variables that will occur. Meanwhile, road infrastructure class and road function have a positive relationship to impacts variables, meaning that the higher the road infrastructure class and road function, the greater the impact variables that will occur in general.

3.6 Empirical comparison of road classification models with their impact variables

In this stage, research is first carried out to examine the relationship between road classification and the impacts of problems that arise in traffic. The relationship referred to here is that various approaches in classifying roads are considered to have the effect of reducing the impacts that generally arise due to traffic on a road section.

Table 6. Summary of the results of the regression weights analysis of levels of importance

Dependent variable		Independent variables		Total effect	Indirect effect		Direct effect
Impact	<---	Function	H1	- Sig.	-	-	- Sig.
Impact	<---	Infrastructure class	H2	+ Not Sig.	-	-	+ Not Sig.
Impact	<---	Load class	H3	+ Not Sig.	-	-	+ Not Sig.
Impact	<---	Status	H4	- Not Sig.	-	-	- Not Sig.

In general, the results of the analysis in Table 6 illustrate that there is an inverse relationship between the interest in strengthening the implementation of road classification based on road function and the traffic impacts that occur on road sections. The logic behind these findings explains that road classification, if grouped correctly, will reduce the negative impact of traffic and increase the efficiency of the transportation system [24]. It is explained that regulating road classification based on function is important in improving road safety [25]. By differentiating the specific roles and function for each type of road, such as primary arterial roads and local roads in residential areas, it can reduce the risk of traffic accidents.

The only road classification category that shows significant influence on traffic impacts, based on the results of the regression analysis, is the road classification category based on its function. In Indonesia, formally, the classification of roads based on their function is divided into 4 (four) which have two types of systems, primary and secondary, namely: arterial roads, collector roads, local roads and neighborhood roads [26]. Primary arteries effectively connect between national activity centers or between national activity centers and regional activity centers, while secondary arteries connect primary areas with first secondary areas, first secondary areas with first secondary areas, or first secondary areas with second secondary areas. This is the case with collector, local and environmental roads, which are also divided into primary and secondary road systems according to their function. The justification that road function is important in influencing impacts can be seen from empirical studies which prove how efforts to organize road use based on function, as applied in many case studies using a sample of 11 cities in Asia, have an effect on reducing emissions and pollution, accidents, traffic jams, and so on. with the quality of the road and its damage [27].

4 DISCUSSION

The graph depicting respondent characteristics reveals that the professional group reflects a diverse range of perspectives that could impact the research outcomes. The graph indicates that the policy stakeholders group holds a significant proportion at each study location. This group includes respondents who play roles or have responsibilities in designing, implementing, or influencing policies related to the research topic, coming from government agencies, non-governmental organizations, or the private sector. Policymakers can offer valuable insights into the policy implications of the research findings and have the potential to drive concrete policy changes. In the summary of the IPA matrix, it can be seen that all variables fall into the group with a high level of importance, including road functions, road infrastructure class, road load class, and road status. However, at the level of implementation, there are some differences of opinion regarding each road function, road infrastructure class, road load class, and road status. The summary of the IPA matrix clearly indicates that respondents generally regard all variables as highly important. This consensus of importance is so strong that none of the variables have been placed in quadrant C or quadrant D, which typically represent areas of lower priority or concern.

Based on the importance level model, several key variables emerge as critical in determining different aspects of the road network system. For road function, the travel cost variable stands out as having the highest level of significance and positive impact. This suggests that the cost associated with travel is a major factor influencing how roads are utilized and prioritized within the network. High travel costs may indicate congestion or inefficiencies, which can affect road function and planning decisions. In terms of road infrastructure class, the road median variable is identified as the most significant. This implies that the presence and characteristics of medians play a crucial role in defining the infrastructure class. Medians can impact road safety, traffic flow, and overall road functionality, thus influencing how roads are categorized within the infrastructure system. For determining road load class, the volume of goods transported is a significant and positive variable which indicates that roads with higher volumes of goods traffic are classified into more robust load categories. The capacity to handle substantial freight volumes is essential for categorizing roads based on their load-bearing requirements and usage. Finally, in assessing road status, the regional fiscal capacity index emerges as a significant and positive variable. This suggests that the financial resources available in a region influence the status and maintenance of roads. Regions with higher fiscal capacity are likely to have better road conditions and status, reflecting their ability to invest in and maintain road infrastructure effectively. Based on the implementation level model, several key variables have been identified as crucial for determining different aspects of road network. For road function, regional authority connected and connectivity are deemed the most significant variables. This indicates that effective regional authority connections and the degree of connectivity between different areas are critical for ensuring optimal road function. Strong connectivity and coordination among regional authorities likely enhance road planning, maintenance, and overall performance, ensuring that roads serve their intended functions efficiently. For road infrastructure class, the median variable is highlighted as significant by respondents. This suggests that the presence and design of medians play a crucial role in how roads are categorized within the infrastructure system. Medians can influence factors such as safety, traffic flow, and the structural classification of roads, thereby affecting their designation and management. For road load class volume variable is identified as significant in determining road load classes. This implies that the amount of traffic or goods volume that roads are expected to handle is a critical factor in classifying them according to their load-bearing capacity. Roads with higher traffic or goods volumes need to be classified appropriately to ensure they are designed and maintained to accommodate these demands. For road status, the fiscal capacity index variable is significant for determining road status. This indicates that a region's financial resources have a substantial impact on the condition and status of its roads. Regions with higher fiscal capacity are likely to have better-maintained roads and a higher overall status, reflecting their ability to allocate resources effectively for road upkeep and improvements.

The analysis between the road classification model and the impact variables reveals distinct relationships between road characteristics and impact variables. The formula shows that both road load class and road status are negatively correlated with impact variables. This means that as the road load class and road status decrease, the values of the impact variables also decrease. Essentially, roads with lower load-bearing capacities and poorer statuses tend to generate less significant impact variables. This relationship suggests that deteriorating road conditions or inadequate load capacity result in less pronounced effects or benefits, likely because such roads are less effective in fulfilling their intended functions or supporting economic activities. Conversely, road infrastructure class and road function exhibit a positive relationship with impact variables. This indicates that as the classification of road infrastructure improves and the functionality of the road increases, the impact variables tend to be greater. Higher infrastructure class and better road functionality are associated with more significant impacts, reflecting that well-maintained and effectively utilized roads have a greater influence on their surrounding environment, economic activity, or overall performance. The regression analysis results indicate that among the various road classification categories, only the classification based on road function shows a significant influence on traffic impacts. This finding suggests that how roads are categorized according to their intended use, such as whether they are primary or secondary road, has a notable effect on traffic outcomes. Road function classification likely impacts traffic flow, congestion levels, and overall road performance because it directly relates to the role each road plays within the network. For instance, primary roads are designed to handle higher volumes of traffic and are crucial for long-distance travel, while secondary and tertiary roads typically manage local traffic. Therefore, the function-based classification helps in understanding how different types of roads contribute to or mitigate traffic impacts. In contrast, other classification categories, such as those based on road status or road load class, do not exhibit a significant influence on traffic impacts according to this analysis. This implies that while these factors may affect road conditions or infrastructure management, they do not have as direct an effect on traffic dynamics as the functional classification does.

One of the important findings from this research which is reflected in the results of the regression analysis of road classification in the context of importance and implementation is the difference in significance of the classification variables: road function, road status, road load class, and road infrastructure class. As seen in Table 7 below, almost all variables have different positions from a function and implementation perspective. For example, the road function variable, as discussed in the previous section, shows a lack of synchronization in the results, where this variable is considered urgent and important to be implemented in ensuring road performance that eliminates traffic impacts, but when seen from its implementation it does not have a significant influence. On the other hand, the road load class variable which is not considered important actually has a significant contribution when applied in influencing efforts to eliminate traffic impacts.

Table 7. Summary of comparison of the position of road classification variables in the context of their importance and implementation

No.	Importance			Implementation	
	Track	Sig./Not Sig.	Direction	Sig./Not Sig.	Direction
1	Infrastructure class→Impact	Not Sig.	+	Not Sig.	+
2	Load class→ Impact	Not Sig.	+	Sig.	-
3	Status→ Impact	Not Sig.	-	Not Sig.	-
4	Function→ Impact	Sig.	-	Not Sig.	+

However, the challenges of urban planning and transport management have a broader role. Congestion is often caused by a combination of factors, including land use patterns, population growth, inadequate public transport options, and reliance on private vehicles, behavioral patterns that require gradual change and cannot be implemented immediately to produce results. Thus, often something that is considered important and urgent to be used as a tool to overcome traffic problems, often does not function as it should or its implementation does not immediately have a positive influence on efforts to reduce traffic impacts.

5 CONCLUSIONS

This study provides a comprehensive analysis of the synchronization of road function, road status, road load class, and road infrastructure class within the road network system. Our findings reveal that road function classification significantly influences traffic impacts, highlighting the critical role of categorizing roads by their intended use. This insight underscores the need for planners to prioritize functional classifications when designing and managing road infrastructure to effectively address traffic challenges. However, it is important to note that our study is limited by its focus on specific regions, as described in the study location characteristics, which may affect the generalizability of the results. Future research should explore the application of these findings in diverse contexts and investigate additional factors that may interact with road function to impact traffic dynamics. Ultimately, this study contributes to a deeper understanding of road network management and offers valuable guidance for optimizing road infrastructure to enhance traffic flow and efficiency. Based on the results above, this study can provide suggestions for improvements in the synchronization of road class designation and further studies, including the need for evaluating the variables that are the criteria for determining road classes, including road function, road infrastructure class, road load class, and road status, so that there is no overlap. It is suggested to reduce the classification of roads to be based solely on road status, which can then be broken down into road function, road infrastructure class, and road load class. Based on the analysis, one of the causes of the lack of synchronization in the implementation of road class classification is the involvement of several agencies related to road classification. Therefore, a better coordination system is required in road network planning involving both central and regional governments, including agencies responsible for roads and spatial planning (related to the determination of activity centers).

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