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## Article

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# Multi-criteria analysis as a method for selecting the best route of hinterland connections: Case study in South Sumatra, Indonesia

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## ABSTRACT

Container Terminal Port of Boombaru is a Port that serves goods in container's shape for shipping, and it is located in Palembang, South Sumatra Province. The results of the projections show that the growth rate of Berth occupancy at the Boombaru Port container terminal is very significant, which is 43.33% in year 2018–2019 and by 2030 it is predicted to be maximum. The port progress factor is determined by the support of hinterland connection, route infrastructure conditions as the main corridor. In overcoming goods distribution problems, which often hampers the port operational performance process due to the long waiting time for ships at the port to wait for heavy transportation vehicles in Boombaru port. The aim, of this study is to find the best selected road from various criteria, such as land use, accessibility, pavement structure, and road geometrics. The method that has been used in this study is Multi Criteria Analysis (MCA). The results show that highest weighted value for successive criteria, namely 3.795 for Geometric, 3.787 for Land Use, 3.521 for Pavement Structure, and 3.157 for Accessibility. Overall, the results show that the best selected route is route B, borderline with Lampung-OKU-Prabumulih- Indralaya-Palembang. The advantage of this route B is because it avoids urban congested area, and it has easy access to industrial area, distribution Centre, warehouses and Ports. Thus, it is less fuel consumption and less gas emission.

## 1. Introduction

Palembang Boombaru Port is a sea port, which is located in river Musi Palembang, South Sumatra province. The Boombaru Port has a function as a gateway for the export and import of containers. Furthermore, incoming goods will be distributed to the hinterland and goods from the hinterland will be sent by ship through the container terminal to the export destination.

The Container terminal port of Boombaru Palembang shows high Berth Occupancy Ratio (BOR), and many queues can be seen around the port area from the terminal entrance to the public streets around the port. As a result of the queue, it often causes congestion problems. The heavy transport vehicles queued for loading and unloading purposes, starting from Letkol Nur amin Street to Mangkubumi Street, where the vehicle traffic was quite heavy. Furthermore, the shoulder of the road was damaged due to the impact of heavy vehicle loads that parked for a long time due to queues.

On the other hand, the condition of many roads in South Sumatra province was damaged due to the increasing volume of heavy vehicles and overloading, especially on routes to the hinterland. Problems like this cause road network services to be hampered in the distribution system of goods from the port to the hinterland or vice versa. Not to mention, the condition of road quality that is not uniform causes the road to be unable to withstand the load of heavy vehicle traffic due to the difference in planning standards and authority in road handling.

So far, the implementation of road handling and management programs using integrated road management system (IRMS) and Provincial and District Road Management System (PKRMS) methods. This road handling program is only based on technical criteria, without considering connectivity to hinterland criteria such as land use criteria, accessibility criteria, Geometrics and Road pavement structure.

Peter de Langen in his study stated that Hinterland Connection is an important issue in the Port because hinterland access is a key factor that can attract port users if the hinterland transportation system is efficient

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and effective (Langen & Chouly, 2004). Erika Buchari in her research, has made a desire line diagram that shows the magnitude of the desire for logistics travel patterns in South Sumatra Province, while the availability of road network infrastructure services has not been able to meet this logistic travel demand because the hinterland connection index condition is still low (Buchari, 2016). In addition, the analysis of Dinar Putranto and Erika Buchari shows that the tidal period and the magnitude of the Musi river has caused the dwelling time to increase (Buchari, Putranto, & Rahman, 2017). Previously, Aulia Rahman and Erika Buchari, stated that the loading and unloading of container goods at the Boombaru port increased by 14.98% every year (Rachman and Buchari, 2016).

Researchers have found that Berth occupancy ratio (BOR) rate of Palembang Boombaru Port Container Terminal in 2018 was 51.6% (Situmorang & Buchari, 2015). Tulus Purwati and Erika Buchari stated, the BOR Growth Rate at the Boombaru Port container terminal is projected by the linear regression method, whose annual growth is very significant, which is 43.33% from 2018–2019 (Purwati, Buchari, & Kadarsah, 2021). After the Covid pandemic, in 2022 BOR began to grow again and in 2030 it is predicted to reach the maximum rate or full. This high value of Berth Occupancy Ratio (BOR) has caused a long queue, so that port productivity is not competitive. From all the mentioned problems, it can be concluded that in many cases the condition of road stability in South Sumatra province is not stable due to the increasing volume of heavy vehicles, one of which is due to long queues at the port.

Lately, data obtained from the Directorate General of Highways South Sumatra Province (BBPJN) stated that road stability in 2021, the IRI value is 89.47%. The length of the road is 1600.18 km, and it consists of 110.5 km (6.91%) of roads in a state of heavy damage and 57.99 km (3.62%) of roads lightly damaged. While the remaining 773.67 km (48.35%) are in good condition and 658.01 km (41.12%) are in moderate condition. Meanwhile, the volume of heavy transportation vehicles is dominated on each hinterland route by an average of 54.04% (BBPJN SUMSEL, 2021). In addition, based on data from the Directorate General of Land Transportation, the percentage of trucks over dimension and over loading trucks in 2018 was 68.13%. Quoting from the words of the Public Works Minister, Mochamad Basuki Hadimoeljono said that every year the country loses IDR 43 trillion due to obesity trucks.

So far, the category of road stability level used by the Directorate General of Highways is a stability road condition based on technical criteria with the availability of sufficient data seen from the parameters of roughness, road width and LHR volume (Fatra, Purnawan, & Putri, 2017). Elviany and Leksmono Putranto in their research discussed the technical criteria index in the preparation of priority sections through the Special Allocation Fund (DAK) (Elviany & Putranto, 2015). Meanwhile, the direction in providing reliable transportation infrastructure is translated into connectivity between districts and stability of road services (Elviany & Putranto, 2015). Through the selection of the best alternative road, the development of the District, accessibility and efficiency can be achieved (Sulistiyorini, 2010).

In the Musi River there are tidal conditions, so there is a waiting time for the tide so that the loading and unloading process can run. If the dwelling time gets longer then there will be a queue at surrounding the Boombaru port. This situation will affect the hinterland road and cause damage.

As it is previously mentioned the condition of national roads based on IRI data in 2021 has only shown 89.47% in a stable condition. While the National Road is only 8% of the total length of the existing overall road network, not including Provincial roads, District roads and Local roads. In determining the priority of handling roads, both national roads, provincial roads and regency roads so far have only used variables of condition from the technical side and have not added variables from the land use, accessibility, pavement structure type and geometric. This handling priority determination will choose road sections whose routes are connected to the hinterland because heavy transportation vehicles are often passed.

Therefore, in accordance with the problem described above and gap analysis, this research will use several criteria that need to be added in selecting the best route, namely Land Use, Accessibility, Road Pavement Structure, and Road Geometrics criteria. By means of Multi Criteria Analysis method, it is expected to get a priority route and consider the best route for hinterland connections in South Sumatra province.

The problem formulation is described as the following:

- How to analyze the performance criteria of the hinterland connection road in South Sumatra province.
- How to determine the best routes based on the reliable conditions of hinterland connection roads in South Sumatra province.

## 2. State of the art

### 2.1. Background research

The condition of hinterland connection infrastructure is very influential on port productivity because it serves to increase accessibility between producing areas, markets, and ports (Bergqvist et al., 2015). Zara and Erika Buchari stated that South Sumatra rubber is the largest export commodity sent through Boombaru ports by 72% to 45 countries (Zara and Buchari, 2015). For this reason, the port master plan cannot be separated from the transportation system and road network (Ramli, Saleh, & Anggraini, 2017), because ports are a transition from land transportation modes and interrelated sea transportation systems and the infrastructure must be in good condition (Salim, 2012).

Hinterland connectivity can serve directly as the backbone of container ports, which can increase the productivity and competitiveness of ports (Notteboom & Yap, 2012). Container ports are competitive if there is a main route to the production center to improve the distribution supply chain (Arvis et al., 2018) (Langen, 2008). Despite, the availability of alternative Railway modes, the Container terminal ports rely heavily on heavy freight to accommodate exporters and importers from transit points hinterland to trading areas (Chen, Jeevan, & Cahoon, 2016). This is mostly due to the port progress factor, which is based on the support of hinterland connection infrastructure for land transportation distribution (Buchari et al., 2019).

The distribution system of heavy vehicles to the port will have a good impact if the service of loading and unloading facilities is optimal and vice versa (Teoritis et al., 2021). For this reason, the availability of good transportation infrastructure will connect the city with production centers throughout the region (Ramitan, Oktaviansyah, & Buchari, 2018). In addition, the development of road networks in industrial estates will increase strategic areas with new economic growth centers (Miri et al., 2014).

On the one hand, the performance of the road network in South Sumatra province has not shown a positive linear relationship with the achievement of road stability as seen from the IRI value in 2019, recorded at 88.76%, and in 2021, the IRI value shows 89.47% (BBPJN SUMSEL, 2021). This shows that the greater value of the project, for the handling program, does not have a direct impact on the high level of road service, especially on hinterland connection routes that are often passed by heavy vehicles. Increased volume of heavy freight vehicles and overloading, resulting in a decrease in the remaining life service from 20 years become 2.6 years (Handayasari & Cahyani, 2016). Meanwhile, the problem of limited funds is also always considered as the main issue causing of less than optimal preservation of all road sections (Elviany & Putranto, 2015).

Some research from the side of road infrastructure such as, Rosada and Arliansyah (2019) have developed RBFNN model to predict road pavement conditions whose traffic volumes are high, causing a decrease in the level of road conditions (Rosada & Arliansyah, 2019). From empirical experience using traffic survey data, Causes the life service of road to be reduced by 6 - 7 years if more than 50% is passed by heavy vehicles and overloading (Selamat et al., 2019). Based on theory, the

chance of road damage can make it a quartic equation of the load increase on each MST (Bahri, 2011). For example, if the load doubled then the chance of road damages increases to four squared is sixteen (Akbar & M T P, 2018). Where the pavement structure is a layer of material that has been calculated as a function to support traffic loads (Rahman et al., 2021). That the main requirements of each surface layer of road pavement should be safe, comfortable, and economical (Sukirman, 1999) (Putri1, 2) and Eti Sulandari2), no date).

However, road infrastructure must be supported by geometric design that planning typical roads, alignment, profile, and cross-section to safety (Sukirman, 2003). As well as in determining the route by selecting road sections that reduce travel distance and travel time (Yuono, 2014).

The parameter level of roughness can be measured by the international roughness index (IRI) as an important indicator for evaluating the condition of road pavement (Gharieb and Nishikawa, 2021). IRI value describes the performance conditions of road pavement where the greater the IRI value, the more unstable road conditions, and vice versa (Mulyono, 2007). The IRI value is categorized as an assessment the condition of road stability, namely is very good, good, poor, very poor to be a reference for planning in road maintenance (Hardiyatmo, 2009) (Maulidya, 2014). In monitoring road condition data can also be assisted by aerial photo maps in real time using aerial photos of Drones (Buchari & Oktaviansyah, 2019). The road damage database and map are inputted into the Integrated Road Management System (IRMS) Program as the basis for planning the national road program (Kairupan, Sompie, & Timboeleng, 2012). Meanwhile, specifically for the district and provincial road management system, the program is Provincial/ Regency Road Management System (PKRMS) (Afandi, 2020).

This raises a fundamental question about how the standard criteria for determining priority road management programs are according to the level of importance, such as the importance in developing hinterland connectivity on the island of Sumatra which should be a priority program. So that the better the port connection to hinterland areas, the greater the potential to expand the captive area as a whole (Ferrari, Parola, & Gattorna, 2011).

## 2.2. Analytical Hierarchy Process (AHP)

In measuring hinterland performance, several methods have been applied, such as research on the level of importance through the AHP method to plan roads in swamp areas with heavy parameters of land use so that it is more economical for settlements, industry, or other spaces (Indrayani et al., 2018). Furthermore, the analysis of the performance assessment of the access road transportation network from the hinterland to the port using the (IPA) and (CSI) methods based on the KM Sistranas indicator. 49 of 2005 concerning the national transportation system (Humang, 2018). Criteria assessment was also carried out by Ortega et al. in analyzing the accessibility level of PnR with multi-criteria and sub-criteria analysis with the use of AHP-BWM models (Ortega et al., 2021). According to Willumsen, analysis of the relative approach to the needs of travelers in aspects of alternative transportation can be done using the revealed preference and stated preference methods. (Willumsen, 2011). Meanwhile, Khan et al. use multi-dimensional analysis based on road user perceptions and field observations on the correlation between road networks and economic indicators that affect the mobility of an area (Khan et al., 2022).

The multi-criteria analysis method is a structural approach analysis in decision making as a choice of several systematic alternatives to present a hierarchy of criteria and sub-criteria. (Saaty & Hu, 1998). The application of developing a multi-criteria analysis model prioritizes the performance value function and determining relative matrix weights for priority program criteria (Marcelino et al., 2019). The multi-criteria analysis method with stakeholder perceptions of the criteria and sub-criteria can be carried out comprehensively and scientifically in selecting alternative road sections. (Sulistiyorini & Herianto, 2018). Sameer has done a research regarding multi-criteria analysis combined

with a geographic information system for assisting planners and stakeholders in considering various land use factors (Sameer, Abed, & Sayl, 2021).

The role of the hinterland connection is very important in supporting port activities with the distribution of goods imported from all sectors (Anang & Jeevan, 2002). This research is expected to help stakeholders in determining road handling priorities by selected the best route hinterland connection based on the condition of road reliability and stability in South Sumatra province, 4 criteria and 12 sub criteria.

Sub-criteria will be applied conclusively in this study, namely:

- Land Use Criteria (Industrial Estates, Port Areas, Settlement Areas, Agricultural and Plantation Sectors).
- Accessibility Criteria (Continuity between road sections on the route and the level of ease of access achievement on the route)
- Road Pavement Structure Criteria (Tonnage Load, Pavement surface type and Road Conditions).
- Geometric Criteria (Typical road width, Vertical alinemen and Horizontal alinemen).

The novelty of this study is "Getting priority route from several route options of hinterland connections in South Sumatra Province, based on several new criteria, such as land use, accessibility and geometric criteria, other than pavement structure criteria".

This novelty is obtained by: Multi Criteria Analysis to obtain the best route priority in South Sumatra Province.

## 3. Research methodology

The research steps are described in the following Fig. 1.

Fig. 1 shows the series of steps to serve as a guide in carrying out the research, starting from problems in the field and supported by literature studies to illustrate the formulation of existing problems. By using the MCA method, which is supported by accurate data in accordance with the aspects of the planned criteria and sub-criteria so as to get the final destination, namely the best hinterland connection route based on reliability conditions in the province of South Sumatra.

### 3.1. Research area

Based on Central Bureau of Statistics data, South Sumatra Province has an area of 91,592.43 km<sup>2</sup> with a total road length of 1513,653 km, these roads are connected to every District and City in South Sumatra province. There are four hinterland connection routes that are often passed by heavy vehicles for goods distribution. The route connected to potential areas such as production areas, plantation areas, agriculture, and industrial centers with commodities that were shipping through ports. The four alternative routes are a combination of road sections that cross the city and regency areas of South Sumatra Province, which consist of:

Route A = Borderline with Bengkulu –Lubuklinggau -Sekayu - Banyuasin- Palembang.

Route B = Borderline with Lampung –Oku –Prabumulih -Palembang.

Route C = Borderline with Jambi-Sungai Lilin –Betung -Palembang.

Route D = Borderline with Lampung –Oki –Indralaya –Palembang.

Fig. 2 shows a map of the existing road network in the province of South Sumatra. There are four colored lines on the map to indicate alternative routes from the interior to the port in the city of Palembang. The red line is route A, the green line is route B, the blue line is route C and the orange one is route D. These routes will be analyzed for performance scores and weight values for each criterion and sub-criteria.

### 3.2. Survey method

Based on data from Central Bureau of Statistics of South Sumatra province in 2021, the total population is 3567,325, of which about 60%

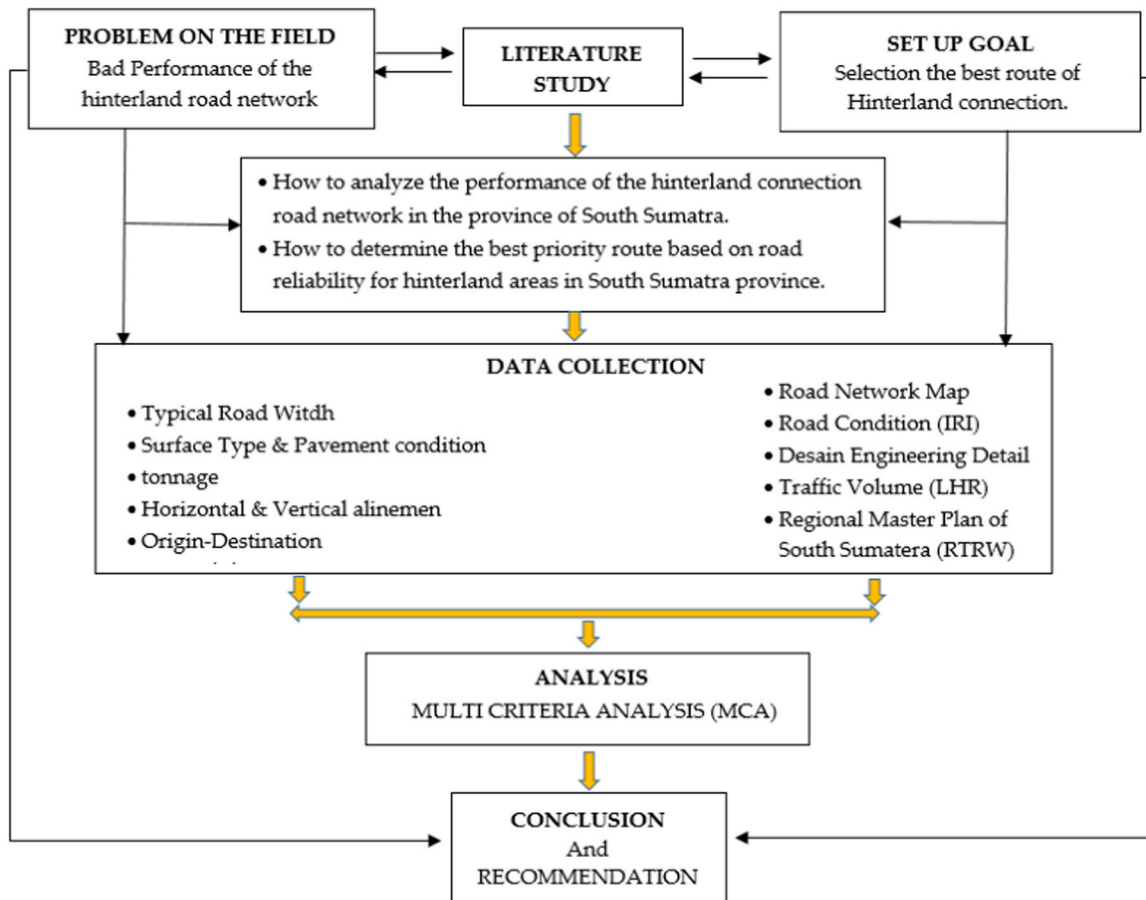


Fig. 1. Flow chart of Research.

of the total population is in the trip age. So that in this study the number of road users to be surveyed was 397.86 people and rounded up the total to 400 samples. This study uses primary and secondary data. Primary data were obtained from questionnaire surveys and interviews with 400 respondents. Interviews were conducted in person. Consists of 4 categories: expert/ lecturers, stakeholders, road observers and road user/ drivers. The questionnaire form will be distributed by stratified random sampling to respondents. Moreover, questionnaires are distributed by surveyors directly to respondents and surveyors also act as interviewers. This is done, so that surveyors can describe the research as a whole, and explain the purpose of the questions on the questionnaire form so that they can help respondents answer them properly and correctly.

The interview data will get a weighted value and performance value from each criterion by respondents (comparative judgment). The process of calculating values by selecting ranks on a scale of 1 to 5. A score of 5 is given to the alternative who is able to meet the requirements with the highest qualification, or vice versa a score of 1 is the lowest. As shown in Table 1.

Surveys are conducted on each route for drivers who are traveling because samples for data collection will be interviewed directly in the field. Road user respondents are determined from a comparison of the population in South Sumatra province, based on data from the Central Bureau of Statistics (BPS). Next, the number of respondents is calculated using the Slovin method (Sugiyono, 2011). While this secondary data is obtained by visiting several agencies to request data related to the implementation of research.

Based on multi-criteria analysis calculations to test all parameters and variables against each route performance. By comparing all aspects of criteria and sub-criteria according to the level of hierarchy as shown in Fig. 3.

Fig. 3 shows a hierarchical level process analysis model of each criterion and sub-criterion using the multi-criteria analysis (MCA) method. At the first level there are 4 criteria, namely land use criteria which have 4 sub-criteria, then accessibility criteria which have 2 sub-criteria, the third criterion is pavement structure which has 3 sub-criteria, and the last criterion is geometric criteria which has 3 sub-criteria. In the process of analyzing the pairwise comparison matrix that uses expert judgment for weighting values and performance scoring between criteria and sub-criteria on each alternative hinterland connection route.

## 4. Results and discussion

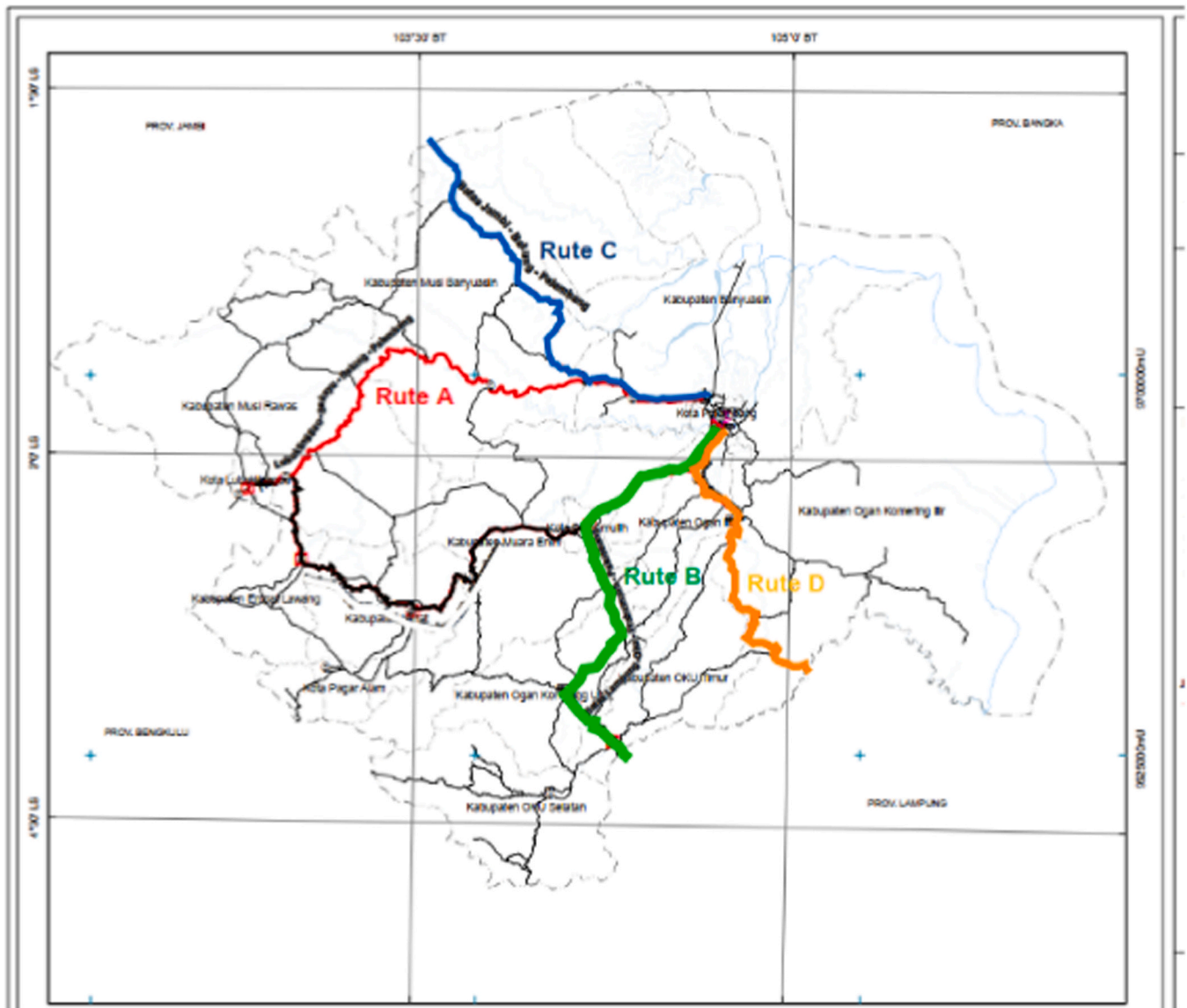
### 4.1. Weighting value

The process of importance weight analysis begins with interviews with experts, road managers and stakeholders. The process of evaluating the weight of respondent prevalence analysis by assigning ratings on a scale of 1 to 5. Then it will be calculated through a pairwise comparison matrix.

From the results of interview surveys to experts, tabulations were carried out where the value of each answer was used as coding data and then the comparison matrix in pairs could be arranged based on the level of importance of one element with another. The pairwise comparison process starts from the hierarchy of main level criteria and sub-criteria at the next level. The calculation of the weight value of the results of the comparison of criteria and sub-criteria, can be seen in Table 2.

Table 2 shows the results of the calculation of the comparison matrix of the weights of criteria and sub-criteria that produce eigenvector values. It can be seen that the value in the eigenvector column for the main criterion, obtained the highest number 0.3978, which is the land





**Fig. 2.** Map of Alternative routes connection to hinterland.

**Table 1**  
Range of Scales.

Scale	Description
5	"Absolutely more important"
4	"Very Important"
3	"Important"
2	"Quite Important"
1	"Less Important"

use criterion. Land use criteria play an important role in road planning and economic zone development. While, the highest number of accessibility sub-criteria is 0.7012 and 0.6493 successfully. This means that smoothness in the hinterland connection route strongly supports regional development in South Sumatra province.

Sensitivity analysis in this research is used to assess how variations in the input data or criteria weights affect the results of a decision-making process. The steps are begun with identifying relevant criteria, which represent the important factors in evaluating and comparing the alternatives. Then the process of assigning weight is followed by sensitivity analysis, which will assess how changes in these weights impact the

ranking or evaluation of the alternatives.

For each pairwise comparison matrix vector value that is obtained, the ratio deviation consistency value will be calculated by analyzing the sensitivity of the matrix results. A pairwise comparison matrix is considered consistent if  $\lambda_{\max} = n$  or ranges  $< 10\%$  then the matrix is perfectly consistent.

This calculation is based on the CI (Consistency Index) value and CR (Consistency Ratio) value which are adjusted to the results of the random index (RI) value obtained from calculating the average of the Main Eigen values ( $\lambda$  max) and criteria elements ( $\eta$ ) against the partial weights in each variable. As in [Table 3](#), it shows the calculation of the consistency of variable values in the land use criteria.

The consistency index calculation values listed in Table 3 show the calculation of the total consistency vector for each variable with a value of  $\lambda_{\max} = 16.2816$ ,  $CI = 0.0234$  and a  $CR$  value = 0.260 This shows that it is quite good and acceptable if the value is  $< 0.1$  or no more than 10%.

#### 4.2. Performance Scoring

The process of calculating the performance value of each route is

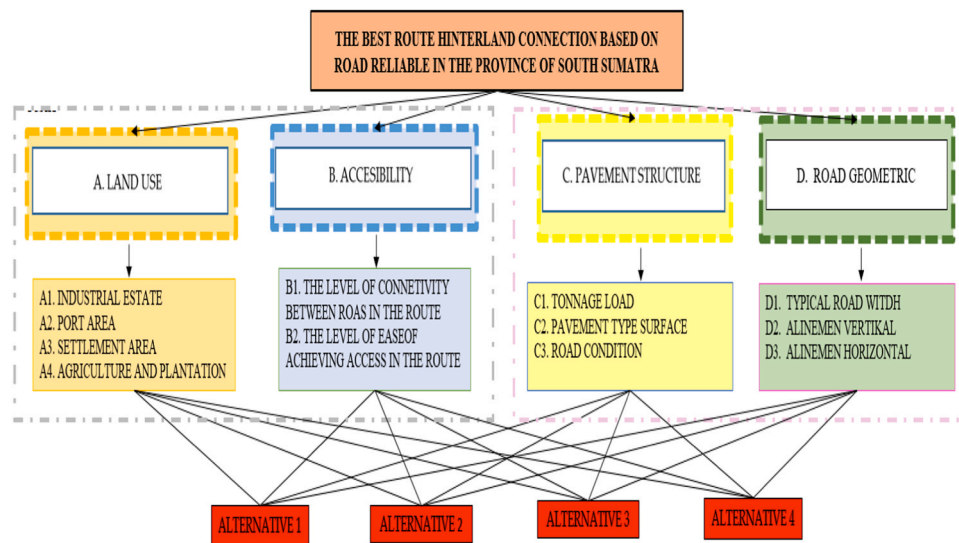


Fig. 3. Level of hierarchy criteria and sub-criteria.

**Table 2**  
Weighting calculation for criterion and sub-criterion levels.

Eigen Vector Value						CI	CR
Criterion	Sub-Criterion	1	2	3	4		
Land Use		0.3978	0.3269	0.3234	0.1891	0.0234	0.0260
Accessability		0.2449	0.6493	0.7012	*	0.0000	0.0000
Pav. Structure		0.1668	0.4132	0.3619	0.2248	0.0297	0.0513
Geometric		0.1905	0.4164	0.3590	0.2244	0.0205	0.0354

**Table 3**  
Calculation of Consistency Index.

Hierarchy Level	$\lambda$ maks	$\eta$	RI	CI	CR
Main Criteria	16.2816	4	0.9	0.0234	0.0260

calculated based on the selection of the highest score value sub-criteria of each route. Then the final score of each performance value on each route is added with the weighting results based on the eigenvector value. The calculation can be seen in Table 4.

Based on the calculation results in Table 4, it is the result of the assessment calculation between route performance and the eigenvector value of each sub-criterion. It can be classified that each route has advantages against each criterion. The calculation results show the highest number of 2570 in sub-criterion B1, namely connectivity on route C. While the highest number is found in sub-criterion D1, namely typical road body 1638 on route D. This shows that accessibility and geometric criteria are the most influential parameters because they get a higher score than other criteria even though the difference is not too significant.

Furthermore, the results of the performance value of each sub-

criterion are summed according to the main criteria. The results of the calculation of the performance of the route will be paired with the weight value of each criterion. After that, the results of the performance value of the criteria are added to get the total value of each criterion as the best route. Then the values are averaged to determine the level of significant of each route and each criterion. This can be seen in Table 5, which is a calculation of the total determined from the sum of the final scores of each alternate route against all points of view of the criterion elements.

From the calculation results in Table 5, it can be seen that the value for the highest land use criterion is 3521 obtained by route B, and for accessibility criteria the highest value of 3787 is obtained by route B, as well as the pavement structure criterion the highest value of 3157 obtained by the same route, namely B. While for Geometric criteria the highest value is obtained by route D of 3812. As for other routes, obtaining the value of the calculation of criteria with a not very significant comparison of numbers. When viewed from the average value of the level of significant between criteria, geometric criteria were obtained at 3.797. This states that the geometric criteria according to the respondents both from the point of view of experts and drivers are still very important criteria. Because comfort and safety are major factors for

**Table 4**  
Calculation of performance sub-criteria for each route.

DESCRIPTION	SUB CRITERIA											
EIGEN VECTOR	A1	A2	A3	A4	B1	B2	C1	C2	C3	D1	D2	D3
	0326	0.323	0.189	0.160	0.649	0.701	0.413	0.361	0.224	0.416	0.359	0.224
Route A	0449	0467	0814	0377	2131	1157	1104	0852	0552	1599	1379	0798
Route B	1243	1177	0808	0292	2478	1309	1421	1166	0570	1612	1390	0793
Route C	1195	0913	0508	0199	2570	1127	1392	1129	0542	1589	1370	0849
Route D	1337	1062	0439	0173	2121	1122	0755	0759	0520	1638	1412	0762

**Table 5**  
Final Calculation of The Best Alternative Route Selection.

Code Route	Alternative Route	$\Sigma A$ Land Use	$\Sigma B$ Accessibility	$\Sigma C$ Pavement Structure	$\Sigma D$ Geometric	Level of Significant
A	Bonderline with Bengkulu–Lubuklinggau–Sekayu–Banyuasin–Palembang	2107	3288	2507	3776	2919
B	Bonderline with Lampung–Oku–Prabumulih–Palembang	3521	3787	3157	3795	3565
C	Bonderline with Jambi–Sungai Liliin–Betung–Palembang	2815	3697	3063	3808	3346
D	Bonderline with Lampung–Oki–Indralaya–Palembang	3011	3243	2034	3812	3025
	Level of Significant	2863	3.504	2690	3797	

road users.

The advantage of the chosen route B is because it avoids urban congested area, and it has easy access to industrial area, distribution Centre, warehouses and Ports. Thus, it is less fuel consumption and less gas emission.

Furthermore, the route B has shorter distances compare with other routes, and it can save travel time because it has many connections and accesses, which have positive impacts and road users satisfactions. Less road damage on Route B can save vehicle components such as tires, brakes and suspension, thus it can reduce maintenance and repair costs.

The disadvantages of alternative route A, because they have less access to the industrial areas and warehouses. These routes often experience congestion at urban borders, resulting in higher energy consumption and operational costs as well as unpredictable travel times. Lack of accessibility near exits can also cause dissatisfaction for many users. Then route C has a longer distance than route A and there are often traffic jams and there are many locations prone to landslides. Meanwhile, for route D there are still many roads that are not wide and the road conditions are often damaged and traffic jams often occur.

Meanwhile, when it is viewed from the average value of the level of significant between routes, the highest value obtained by route B was 3565. This means that route B as an alternative hinterland connection route has a very important role in supporting the logistics system to the port as a gateway for exports and imports as well as supporting the economy in South Sumatra Province.

The policy in Pavement Management System that consider the performance of road by taking into account soil condition and the axle loads are not enough. This paper finding is that in preparing policies to support the Global Road management system it needs additional factors from three other aspects, namely: land use aspects, accessibility aspects and geometric aspects.

The recommendation for future research is to make research regarding application system of Global Road management System which include new criteria, such as land use aspects, accessibility aspects and geometric aspects in Road management system, becoming Global Road management System.

The important thing in this study is to pay attention on the accuracy of the selection of criteria that will be used in the study in accordance with the direction of the research. Further research has been planned to overcome these limitations. The Criteria which are based on experiences and some references have to be examined by analyzing the relationship of road performance as dependent variable with the independent variables with the multi-linear method. The Multi linear regression process will choose several strong correlated variables as criteria.

There are limitations in the application of the MCA method in this study, many of which involve the use of qualitative criteria which are often subjective because they involve human judgment, perception and interpretation. When many stakeholders are involved in the decision-making process, conflicts of interest and opinion may arise, making it difficult to reach consensus regarding the weighting of criteria and evaluations. Perspectives are diverse and varied among stakeholders which makes it a challenge to balance and standardize subjective input.

Despite that, Criteria selection and weighting should be done carefully, since only experienced researcher can identify and select the criteria. Identifying and defining the relevant criteria can be complex.

Assigning appropriate weight to criteria can be challenging. It is difficult to justify weight selections to all stakeholders.

Data availability and quality is important, since poor quality and incomplete data can lead to inaccurate results and decisions, which finally can affect the reliability of MCA outcomes.

Furthermore, Scalability and Complexity can be noticed from Number of Criteria and Alternatives, and Interaction between Criteria.

## 5. Conclusions and recommendation

### 5.1. Conclusions

From analysis and discussion above, it can be concluded as the following:

1. The results showed that the highest weight value of criteria was 3.795 for geometric, 3.787 for accessibility, 3.521 for land use, and 3.157 for Pavement Structure, which means for geometric and accessibility criteria the level of significant is "very important", while for the land use and pavement structure criteria the level of significance is "important".
2. The calculation score performance of sub criteria results shows the highest number of 2570 in sub-criterion accessibility, criteria of connectivity on route C. While the highest number is found in sub-criterion road width 1638 on route D. This shows that accessibility and geometric criteria are the most influential parameters because they get a higher score than other criteria for route A and B, even though the difference is not too significant. Overall, the best route chosen was route B, which is the route of bordering Lampung–OKU–Prabumulih– Indralaya– Palembang with a score of 3565, which means this link is "very important"

### 5.2. Recommendation

This research is only in the scope of developing country, because there are still many transportation problems specifically in Indonesia. Global Road Management System has been found in this research and with the criteria derived from Indonesia condition. The criteria for MCA method must be developed with the criteria form US Indo Pacific Area.

To see more aspects of the application of this research, further research is needed to understand the characteristics of the US Indo Pacific Area. The importance of this research is for its wide application. The direction of the research is to build an application system that can be used by the Ministry of Public Works (PUPR), in the Global Road Management System (GRMS).

Application of multi-criteria elements as additional criteria for reading Pavement Management System, apart from the technical side in determining initial investment priorities for the construction of Public Private Partnership (KPBUP) road projects together with State Owned Enterprises (BUMN), Regional Owned Enterprises (BUMD) and private parties in the implementation of sustainable infrastructure.

## Declaration of Competing Interest

I hereby, state that this paper is far from Conflict of Interest, since the



authors of this paper are students and professors that guide the Research. The person's association with the organization do not interfere with the student's ability to carry out the research or paper. The results of the research paper are supportive to development of the region roads.

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