DETERMINATION OF PRIORITY FOR ROAD INFRASTRUCTURE QUANTITY DEVELOPMENT IN SUPPORTING REGIONAL DEVELOPMENT IN KENDARI CITY WITH PROCESS HIERARCHY ANALYSIS METHOD

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Abstract

The high level of activity in Kendari city is due to its status as the provincial capital with functions as the center of government, education, and economic activity, resulting in limited road space, low accessibility and traffic congestion. The government's desire to make Kendari city a service city and attractive to investors and tourists, both domestic and foreign. In order to meet the needs of the community, with limited local government resources to meet them in a short period of time, it is necessary to do optimization. This research aims to: 1) analyze criteria and weights in determining road development priorities; 2) determine road development priorities in supporting regional development; 3) measure the impact of road development projects on relevant key performance indexes. The data analysis method is descriptive quantitative and qualitative with hierarchical analysis process (AHP). The results of the study concluded 1) The weighting analysis shows in order of the highest weight criteria accessibility, benefits, road network performance, regional development and costs. 2) Hierarchical process analysis shows that the most priority alternative chosen to meet the needs of the road network is a combination of Kendari ring road and inner ring road 3) Both combinations are useful for increasing accessibility, improving the performance of the existing road network, becoming a strategic road to support the industrial sector, trade and urban growth centers in order to improve the regional economy.

Keywords: AHP, Road, Development, Priority

INTRODUCTION

Kendari City is the capital of Southeast Sulawesi Province, as a city center and the main gateway for immigrants from outside. It has the status of a developing city with regional problems that tend to be the same as other urban areas. Kendari City is the area with the largest Human Development Index value of 84.51 making it the area with the largest number of population movements (urbanization) in Southeast Sulawesi Province with a population of 356,747 people or 13.20% of the total population of Southeast Sulawesi Province and an area of only 271.8 km2 or 0.71% of the total area of Southeast Sulawesi Province (BPS Southeast Sulawesi Province, 2023. In connection with this reality, the city of Kendari experiences a high level of activity, but with limited space to carry out responsibilities as a center of government, education, economic activities, services and industry, of course, it cannot be separated from traffic congestion. This illustrates that the city of Kendari with high production, consumption, and distribution activities results in an increasing need for movement, so that it requires the development of a sufficient quantity of road network, due to the lack of accessibility of the road network. As the results of research that have been conducted by Rianse, et al (2014) state that there are still some areas in Kendari City that still need a touch of infrastructure development, in this case the addition of the quantity of road infrastructure to be able to increase accessibility and encourage the area to continue to develop. This indicates that low accessibility which results in several movements having to rely on only one alternative, resulting in traffic congestion. For example, on MT. Haryono must accommodate the movement of various road networks in various regions, making it the most densely traveled road section in the city with lower road performance, so the costs incurred by road users will be higher and the travel time will be longer, and vice versa (Fidel Miro, 2005). This phenomenon is an obstacle for the city of Kendari to fulfill its function as the provincial capital. Kendari City is the gateway to Southeast Sulawesi which has various potentials such as attractive tourism, nickel mining, and ample fisheries and plantation industries. The

government has a great desire to meet the needs of road users by proposing a road development plan that is in accordance with the direction of the regional spatial plan through the construction of new roads and road widening However, in an effort to meet the complex needs of road users, there is often a problem of differences in interests between groups of road users, while the government must realize it in a short period of time. In determining the priority scale, it is proposed to use the process hierarchy analysis (AHP) method as the most appropriate method to solve multi-criteria problems to be simpler and in a hierarchy. The background description is the basis for the author to conduct research by formulating several research objectives as follows: 1) analyzing criteria and weights in determining road development priorities; 2) Determining the priorities of road development in supporting regional development; 3) Measure the impact of road development projects on relevant key performance indicators.

THEORETICAL STUDIES
Network Analysis
Here are the stages of road development that can help in addressing traffic issues in network analysis:
1. Identify infrastructure needs: Through network analysis, traffic problems such as congestion, long travel times, or an imbalance between demand and capacity can be identified. Possible alternatives consider infrastructure development options, such as the construction of new roads, the expansion of existing roads, and improving network performance.
2. Transportation network optimization: Network Development Options involves analysis to evaluate various development options and select the most effective strategies to improve network performance.
3. Traffic forecasting: In Network Development Options, traffic forecasting is an important part of predicting future traffic demand and analyzing trends and travel patterns. Use historical data, to guide decision-making in network development options.
4. Infrastructure impact evaluation: development alternatives involve analyzing the impact of infrastructure on traffic. It can be evaluated how network development affects traffic flow, travel time, and network performance most effectively to reduce congestion and improve transportation quality.
5. The combination of Network Development Options and network analysis, better planning, informational decision-making, and effective solutions improve the performance of the transportation network.

Road Development and Its Development Criteria
In realizing road development, of course, there must be a determination of strategic roads to determine the highest priority in road development. The development of this road includes development programs, rehabilitation programs, road improvement programs, and new road construction programs. Through a priority program for road construction within the Directorate General of Highways with the aim of selecting early as well as selecting and determining road development plans at the most optimal cost with consideration of various more comprehensive criteria. In addition, this planning and priority is expected with an objective and proportional allocation of funds with consideration of the results of needs analysis (Circular Letter of the Ministry of Public Works and Culture Number 12/SE/Db/2017, 2017). Strategic roads must include main routes that serve various areas within the city or district. The criteria for road development with road sections that It usually accommodates high levels of traffic. However, in reality, this level is varied, for example, starting from 500 LHR for densely populated areas such as Java and > 50 LHR for less developed areas in islands outside Java with roads that serve sources of increased traffic other than urban, such as large material sources, factories, or plantations.

Prioritization
In determining priorities in general, using multiple criteria that are solved by process hierarchy analysis, as a method that is considered as a technical plan that is able to combine a number of criteria with different amounts also has the benefit of combining the perceptions of various related parties (Saaty, 1986). In general, criterion analysis has a more quantitative analysis characteristic. Quantitative because during the analysis and evaluation process by interpreting survey results data to assess the intensity of interests using the analytical hierarchy process approach analysis method. The decision-making in this method refers to three (3) main principles, namely (Saaty, 1986) the preparation of hierarchy, setting priorities, and

consistency.

Importance Rating Scale

To find out the comparison of interests between the criteria used to help make decisions in determining road development priorities, based on the level of importance, is the following table: If there are n criteria to be compared, then there is n (n-1)/2 comparisons between the two criteria that must be done. This number of comparisons is used as the entry of the triangle matrix above the main diagonal, while the entry of the triangle matrix below the main diagonal is the opposite of the corresponding triangle matrix above the main diagonal (Ataburan, 2013).

Weighting of Criteria

Comparison of pairs for matrix shapes is the most desirable form, as it is a simple tool and creates a framework for testing consistency, as well as obtaining additional information by making all possible comparisons and analyzing the sensitivity of the overall priority to changes in the comparison (Saaty, 1986). The column criteria on the left are always compared to the top row criteria, and the value is given to the left column criteria. If the criteria in the left column are considered unfavorable, then the judgment is a fraction, the inverse value is given to the row criteria when they appear as column criteria and the column criteria can appear as row criteria. The form of the paired comparison matrix is as follows: In this matrix, there is a comparison of the criteria itself on its main diagonal and is valued at 1. The paired comparison matrix can be seen in the following figure II.9 above. The value in the cell content is the comparative value W. The matrix above is a reciprocal matrix and it is assumed that there are n criteria, namely W1, W2, ..., Wn which are assessed comparatively. The value (judgment) of the comparison in pairs between (Wi, and Wj) can be presented like the matrix (Saaty, 1993).

$$W_i/W_j = A(I,J) = 1.2,....N \qquad (1)$$

The comparison matrix of opinions is then analyzed by calculating each row of the matrix:

$$W_i = {}^{N\sqrt{A_{i1} \times A_{i2} \times A_{i3} \times .....}} A_{Ij} \qquad (2)$$

Calculation by entering the value of the Wi parameter, in the above calculation matrix into the following equation:

$$x_i = \frac{W_i}{\sum W_i} \qquad (3)$$

The matrix is further defined as the eigenvector which is the weight of the criterion. Eigenvector is characterized as an equation that has an alternative non-trivial solution, meaning that the solution x≠ 0. Eigen vevtor is also a matrix that equals the eigenvalue. The eigenvalue or characteristic value of a matrix that has a size n x n is a number λ. This value has a characteristic of being in the form of a matrix with the size n x n which is a number λ, so that the largest eigenvalue is λ_{max} which is the following value:

$$\lambda Max = . \ xj \tag{4}$$

Consistency

Matrix theory states that a small error in a coefficient will cause a small deviation also in the eigenvalue. By combining what has been described earlier, if the main diagonal of matrix A is worth one and also if the value A is consistent, then the small deviation from the aij will still show the greatest eigenvalue or λmax, the value will be close to n and the eigenvalue from its side will be close to zero. Consistency deviations are expressed as consistency indexes, with the following equations:

$$CI = \frac{(\lambda \ max - n)}{(n-1)}$$

Information:
CI   = Consistency Index
λ   = Eigenvalue maximum
N   = the size of the matrix

Consistency index (CI), a random matrix with a rating scale of 9 (1-9) along with its inverse as a random index (RI). Based on the calculation of the moment with 500 samples, if the numerical selection is taken at random from the scale of 1/9, 1/8, ...,1,2,.. 9 will get the average consistency for matrices of different sizes:

Analysis of Assessment (Scoring) of Proposed Road Development Plan

In addition to the weighting of criteria by stakeholders, the assessment or scoring of each criterion is decisive in decision-making and prioritization in the road development plan. This assessment is given using a scale between 0 to 10, where a score of 10 is given to a proposed road development that can meet the highest criteria, while a score of 0 is given to the lowest assessment (it has nothing to do with the criteria at all). This score is also carried out after an in-depth analysis of each criterion. After there has been a score of each road development plan adjusted to the criteria, then make a performance matrix that explains the level of fulfillment of the criteria of an altemalif road development plan. This value is the result of multiplying the alternative score of the road development plan to the weight of each criterion. The determination of priorities in each road development plan is determined by the amount of performance value, where the alternative value of the road development plan that shows the greatest performance value or Pi will be prioritized (Tamin, 2008).

METHODOLOGY
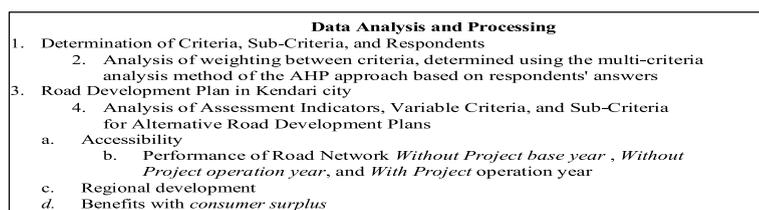Separately, the stages of research to achieve the goals are shown in the following flow chart:

Data Analysis and Processing
1. Determination of Criteria, Sub-Criteria, and Respondents
    2. Analysis of weighting between criteria, determined using the multi–criteria analysis method of the AHP approach based on respondents' answers
3. Road Development Plan in Kendari city
    4. Analysis of Assessment Indicators, Variable Criteria, and Sub-Criteria for Alternative Road Development Plans
    a. Accessibility
        b. Performance of Road Network *Without Project base year* , *Without Project operation year*, and *With Project* operation year
    c. Regional development
    d. Benefits with *consumer surplus*

Figure 1. Research Flow Diagram

RESULTS AND DISCUSSION
The results and discussion are presented in the order of the analysis as attached in the flowchart above

Determination of Criteria, Sub-Criteria, and Respondents
Prospective candidate criteria are determined based on literature review from previous research. In the selection, consideration is taken into account which is used to select criterion variables such as ease of data collection, dynamics of data changes from year to year, ease of quantification process and relevance to the

goals of road development both in terms of effectiveness and cost efficiency, aspects of equity, road operations and so on. Prospective candidates criteria are accessibility, road performance, regional development, benefits, costs, road conditions, and social environment. Of all the candidate candidates, not all of them will be further analyzed because it is necessary to select criteria that will pass for the next stage. The selection of these criteria is based on an analysis that meets its qualifications in terms of ease of data collection, relevance to the research, and consistency of the data. Below will be presented the selection process of criteria variables that have been analyzed by the author and meet the qualifications of the criteria selection requirements. There are 5 (five) criteria and 11 sub-criteria selected for further analysis and weighting. The selection of respondents is based on their requirements and qualifications. There are 3 (three) groups of respondents, namely, Regulators (respondents with the status of stakeholders who set policies, regional executive officials, chairman of the DPRD, BAPPEDA, and the highway office), Operators (respondents who have the authority to implement, operate, and be responsible for each road development plan), and Experts (respondents who are considered as expert experts, so that their views represent the needs of the community) (Sulistyorini, 2010)

Table 1. Selected Respondents

Yes	Linkages to Network Development Southeast Sulawesi Province Road	Code	Condition 1	Condition 2	Condition 3	Condition 4	Decision	Weight Influence Respondents (%)
1	Stakeholder (Regulator)	R1	Yes	Yes	Yes	Yes	Escape	25
2	Stakeholder (Regulator)	R2	Yes	Yes	Yes	Yes	Escape	21
3	Stakeholder(Regulator)	R3	Yes	Yes	Yes	Yes	Escape	6
4	Stakeholder	R4	Yes	Yes	Yes	Yes	Escape	12
5	Stakeholder	R5	Yes	Yes	Yes	Yes	Escape	5
6	Stakeholder	R6	Yes	Yes	Yes	Yes	Escape	5
7	Stakeholder	R7	Yes	Yes	Yes	Yes	Escape	10
8	Stakeholder	R8	Yes	Yes	Yes	Yes	Escape	5
9	Stakeholder	R9	Yes	Yes	Yes	Yes	Escape	5
10	User&Expert	R10	Yes	Yes	Yes	Yes	Escape	3
11	User&Expert	R11	Yes	Yes	Yes	Yes	Escape	3
12	User&Expert	R11	Yes	Yes	Yes	Yes	Escape	3

Weighting of Criteria

Based on the respondents' answers using the importance scale (Time. 1980) The results of weighting criteria are obtained with the calculation stages as in chapter 2, as follows:
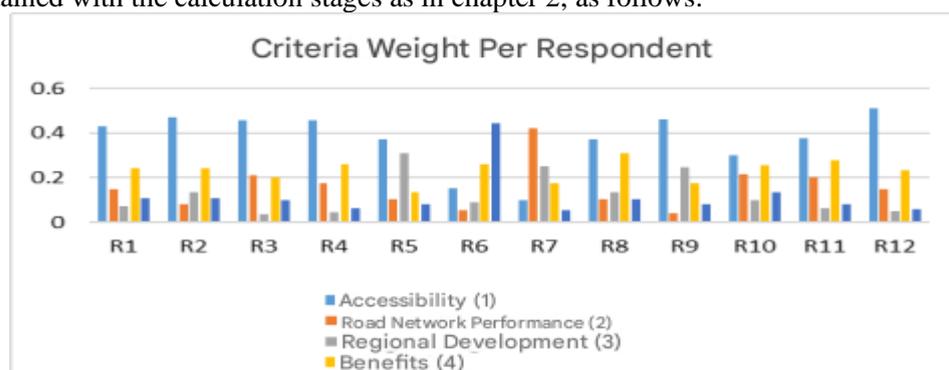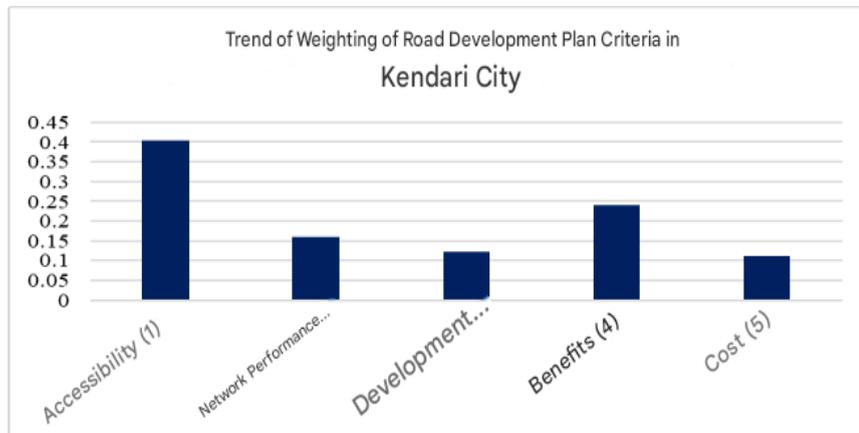

Figure 2. Graph of Criteria Weighting Results Based on Respondents

The figure above shows that 10 (ten) out of 12 (twelve) respondents chose accessibility as the highest

weight in setting road development priorities This is in line with the mission of the regional head, which is to increase connectivity in order to increase regional competitiveness through infrastructure development and improvement. As in line that accessibility is directly proportional to connectivity, the higher the accessibility, the higher the connectivity. 8 (eight) out of 12 (twelve) respondents chose benefits as the second highest weight. This is in line with the purpose of the road development plan to increase accessibility in order to improve the performance of the road network and provide benefits as needed by the community. Respondent 6 has the highest criterion weight on costs, as his position as the head of the highway planning section which plans the implementation of roads is adjusted to the existing budget or costs. The weight of the respondent's criteria as a whole was then carried out a weighted average with the cumulative results of the multiplication of the weight of the criteria and the weight of the influence of the respondents as follows:

Figure 3. Graph of Results of Weighting Criteria Thoroughly

The figure above shows that the weight that has the highest priority is accessibility with a weight of 40.25%, followed by the benefit of the second rank with a weight of 23.96%, then the performance of the road network has a weight of 16.05%, then regional development of 12.35%, and finally cost with a weight of 11.17%. The weight of this criterion is a consideration in determining the priority of road development that suits the needs of the community in the city of Kendari.
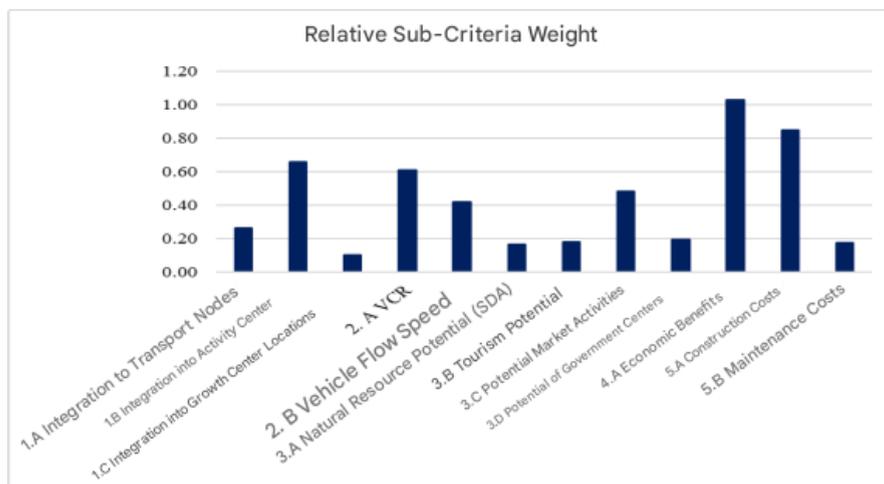
Figure 4. Graph of Weighting Results of Sub Criteria

From the results of the weighting of the sub-criteria, the one that has the highest importance is the economic benefit. Economic benefits. Increased Productivity: Good and connected roads can improve economic productivity. Increased travel speed and efficiency help reduce time spent on transportation, save operational costs, and improve logistics efficiency. This can increase the company's productivity, reduce production costs, and increase competitiveness.

Road Development Plan

1. Kendari-Toronipa Tourist Road

Kendari as the capital of the province of Southeast Sulawesi which of course must be developed in its territory. The city of Kendari is part of the national activity center (PKN), one of the reviews is based on the regional spatial plan (RTRW) that Kendari and its surroundings become a national tourism development area (KPPN). As its potential as an area with tourism advantages that must be developed, with the construction of the Kendari-Toronipa road, it is hoped that people who pass along the Kendari-Toronipa road can easily go to the tourism areas of Toronipa Beach, Saponda Island, Bokori Island, Hari Island, and Tanjung Taipa Beach. Kendari-Toronipa is located on the coast around the outskirts of the island of Sulawesi. In addition, the Kendari-Toronipa tourist road also aims to support the realization of strategic areas from the point of view of economic interests, namely Kendari Bay whose area is indicated to include the Kendari Bay area and its surroundings (Kendari-Konawe-South Konawe). The Kendari-Toronipa tourist road is one of the development plans that have been stipulated in the RPJMD document (2020-2025). In terms of design criteria, this road was built with a 4/2 D road type using a road body width of 14 m, a road shoulder of 2 m, a median width of 2 m, a width of 5 m of sidewalks and green paths, a bicycle lane width of 4 m, and a road length of 11.14 km.

2. Kendari Ring Road

The distribution of strategic growth areas (WPS) as the basis for integrated PUPR infrastructure planning and programming is carried out with the aim of reducing the gap between regions and increasing their competitiveness. With this background foundation, it is appropriate that the Kendari ring road be realized to reduce the regional gap. The areas outside the study area (Kendari city) have difficulty in achieving accessibility. To reach the area, it needs a fairly long journey and has to go through the city center, the impact of traffic in the city becomes congested. So that the Kendari ring road, in addition to being a strategic growth area program, also aims to unravel traffic from outside the city. It is said to be a strategic road that will increase high accessibility to halu oleo airport, bungkutoko port as a national activity center (PKN), and also toronipa tourist attractions as a national tourism strategic area (KSPN). In terms of design criteria. It is a 2/2 UD type road, the width of the road body is 7 m, the shoulder of the road is 2 m.

3. Ring Road of the Department House (RUJAB)

The center of government is one of the important parts of a region to be able to develop. The ring road of the governor's office of the governor of Southeast Sulawesi province is an accessibility support road to the Kendari city government complex. In addition to supporting the government center in the city of Kendari, the ring road of the office house is one of the strategic routes to the center of regional activities, including the city hall road, the laute road, and the suropati garden road. This road is an existing road that has been reconstructed both in terms of design which was originally 2/2 UD with a road body width of 6 m to a 4/2 D road type, using flexible pavement with a road body width of 14 m, a road median of 2 m, a road shoulder of 2 m, and a length of 1.4 km.

4. Inner Ring Road

The Inner Ringroad is part of the road network system in the city of Kendari which is within the city of Kendari. This road network was built to connect 4 road sections, namely Z.A Sugianto road, H.E.A Mokodompit (T-junction of the Halu Oleo University campus), Malaka road (RS. Abunawas), and Brigadier General M. Jonoes road (kali kadia). The four road sections are based on existing historical data as the main congestion points in the city of Kendari. This congestion will hinder the movement of traffic to regional economic generating areas such as the Kendari Bay bridge, Bungkutoko port, and Konawe industrial area. Therefore, it is necessary to have an inner ring road network, in order to be able to decompose the existing traffic on the existing road network and shorten travel time. It is also hoped that this inner ringroad, with its affordability with tourist centers and so on, can be its own advantage to open MSME locations there.

Table 2. Alternative Road Development Plan

Yes	Code	Alternative Road Development Plan		
1	1	Kendari-Toronipa Road		
2	2	Kendari Ring Road		
3	3	Governor's Office House Ring Road		
4	4	Inner Ringroad		
5	1-2	Kendari-Toronipa	-	Kendari Ring Road
6	1-3	Kendari-Toronipa	-	Rujab Circle
7	1-4	Kendari-Toronipa	-	Inner Ringroad
8	2-3	Kendari Ring Road	-	Rujab Circle
9	2-4	Kendari Ring Road	-	Inner Ringroad
10	3-4	Rujab Circle	-	Inner Ringroad
11	1-2-3	Kendari-Toronipa	Kendari Ring Road	RUJAB Circle
12	1-2-4	Kendari-Toronipa	Kendari Ring Road	Inner Ringroad
13	1-3-4	Kendari-Toronipa	RUJAB Circle	Inner Ringroad
14	2-3-4	Kendari Ring Road	RUJAB Circle	Inner Ringroad
15	1-2-3-4-5	Kendari-Toronipa, Kendari Ring, RUJAB Ring and Inner Ringroad		

Analysis of Criteria Variable Assessment Indicators
        Each alternative road development is assessed on the indicator variables in the measurement criteria**:**
1.   **Accessibility**
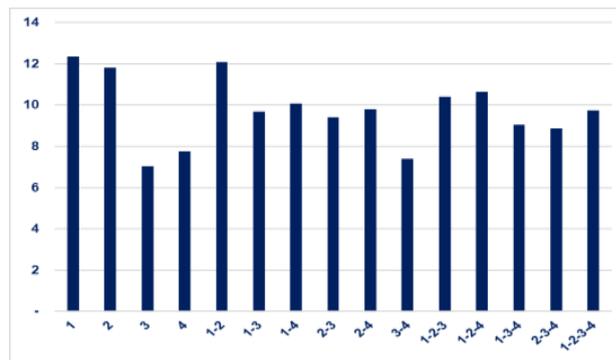
Figure 5. Results of Alternative Assessment of Accessibility Criteria Variables (km)
        The results of the assessment show that those with the best accessibility are those with the smallest distance in km. From alternatives 1-15, the one that has high accessibility for the three sub-criteria is the RUJAB Ring Road and the combination of the RUJAB Ring Road and the Inner Ringroad because, this road has access close to the center of Kendari.

Analysis of Priority Selection of Road Development Plans in the city of Kendari Supports the Development of Its Region

        The results of the alternative assessment in subchapter 4.5 are multiplied by the weight of the criteria so that the results of the calculation of the performance of each alternative are obtained, which are as follows:

Figure 6. Results of Alternative Performance Assessment of Road Development Plan
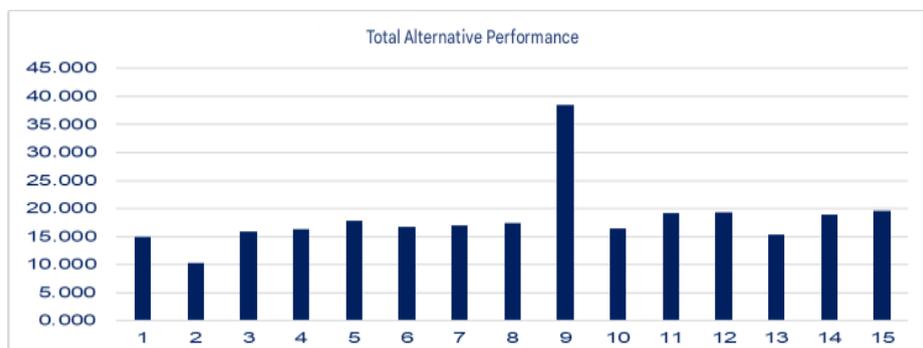
The results of the calculation of the total performance value of each alternative are as shown in the table above, with the highest score in alternative number 9 (nine), namely the combination of the Kendari Ring Road and the Inner Ringroad which indicates it as the first priority in the road development plan from the results of the study of the process hierarchy analysis method (AHP).

Key Performance Index (KPI) Measurement Analysis
KPIs (Key Performance Indicators) of road and traffic networks change after the project:
1. Increased accessibility and mobility are seen from increasing road lengths, connectivity between regions, or increasing access to economic and social activity centers.
2. Increased capacity, reduced congestion, as seen from the improving value of the VCR
3. Reduced Travel Time, seen from reduced travel time and high time value savings.
4. Strategic roads, after withproject, the industrial, tourism, and trade sectors are affordable.

CONCLUSION

After the selection is carried out in determining the priorities of road development and determining priorities from accessibility criteria, road network performance, regional development, benefits and cost criteria. Based on the respondents' answers and the results of the weighting analysis, it showed that the criteria with the highest weight value or influence in the first rank were accessibility with a weight of 40.25%, followed by the benefit of the second place with a weight of 23.96%, then the performance of the road network had a weight of 16.05%, then regional development 12.35%, and finally cost with a weight of 11.17%. The weight of this criterion is a consideration in determining the priority of road development in the city of Kendari. The alternative is a combination of the Kendari Ring Road development plan and the Inner Ringroad. The impact of road development projects on the key performance index (KPI) has been proven that the condition of the project has a considerable influence to be able to improve accessibility and mobility, save time value and improve the performance of the existing road network and density in the city of Kendari, as well as become a strategic road that will be developed to support the tourism industry sector, trade, and urban growth centers in an effort to improve the community's economy and dynamic regional development, as well as providing benefits for road users.

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