



Analysis of Provincial Road Priorities and Costs in the Malang PJJ UPT Area Using the Analytical Data-Based Hierarchy Process Method of the Provincial/District Roads Management System

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ABSTRACT

Provincial road infrastructure is a key element in accelerating local economic growth and reducing development disparities between regions. In line with East Java's development vision of becoming a "highly competitive province by 2045," the Governor has established a number of priority programs that emphasize the importance of connectivity and infrastructure strengthening as part of the strategic agenda. The criteria weights using the Analytic Hierarchy Process (AHP) method are: Road condition with a weight of 28.6%, connectivity with a weight of 19.9%, road service level with a weight of 18.7%, priority areas with a weight of 18.3%, and policy with a weight of 14.5%. The total cost required for addressing provincial road sections in the UPT PJJ Malang area, based on the analysis of the PKRMS application combined with the AHP method, is Rp. 357,814,927,151,-

INTRODUCTION

Roads are essential land transportation infrastructure that play a critical role in supporting economic growth, equitable development, and public mobility. A well-planned road network improves standards of living and supports sustainable regional development by providing accessibility and connectivity between regions, which encourages the efficient distribution of goods and services. Population growth further demands the development of strategic road infrastructure to facilitate movement and strengthen economic growth. Consequently, road management and maintenance are key priorities, particularly for provincial roads that connect centers of activity between districts and cities.

East Java Province, one of Indonesia's largest and most populous provinces, plays a strategic role in national development. Its location at the eastern tip of Java Island positions it as a gateway for transportation and trade, both interprovincially and across eastern Indonesia. The province contributes significantly to the national economy through industry, trade, agriculture, and tourism. Land transportation infrastructure, particularly the provincial road network spanning approximately 1,666.96 km across 38 regencies/cities, is vital for maintaining smooth mobility of goods and people.

In recent years, the quality of East Java's provincial roads has declined. Data from the East Java Provincial Public Works and Highways Agency indicate that while "stable" roads accounted for 89.61% of the network in 2021, this figure dropped to 83.14% by 2024. This deterioration is closely linked to budget reallocations during the COVID-19 pandemic, which diverted road maintenance funds to emergency health and socio-economic recovery programs. If left unaddressed, minor damage may evolve into severe structural damage, requiring costly reconstruction. Budget constraints remain the main challenge for road management, requiring the government to prioritize maintenance projects based on criticality and contribution to regional economic growth (Irawan & Suprpto, 2020; Andre, 2023).

To improve decision-making, the East Java Provincial Public Works and Highways Agency has implemented the Provincial/District Roads Management System (PKRMS). This system records road conditions, classifies road functions, and processes traffic data to produce road condition indices categorized as good, moderate, light damage, or heavy damage. While PKRMS supports inventory and maintenance planning, it struggles to account for non-technical variables such as connectivity, priority areas, and policy alignment, limiting its capacity for comprehensive decision-making.

THEORETICAL REVIEW

Multi-criteria decision-making methods have been widely applied to enhance road maintenance prioritization. The Analytical Hierarchy Process (AHP), developed by Thomas L. Saaty (2000), is one such approach, allowing decision-makers to systematically compare technical and non-technical criteria in a hierarchical structure. Each criterion can be weighted according to its relative importance, and alternatives—such as road sections—can be ranked for maintenance priority. This approach increases transparency, logic, and

accountability in decision-making, addressing limitations of conventional systems like PKRMS.

Studies highlight the importance of considering multiple factors in road prioritization, including traffic volume, road connectivity, economic significance, and current physical condition. Effective prioritization allows limited budgets to be allocated efficiently, ensuring that the most critical roads are maintained first. Research also emphasizes that incorporating spatial, functional, and economic data improves the objectivity of prioritization and enhances the alignment of maintenance activities with broader regional development goals.

In practice, multi-criteria approaches have been applied successfully in regional road management. For example, decision-making units such as the Technical Implementation Unit (UPT) for Road and Bridge Management in Malang utilize priority ranking to allocate resources across provincial roads in Malang City, Malang Regency, and Batu City. The methodology supports strategic development areas, such as trade and tourism corridors and the Greater Malang metropolitan area, ensuring that road maintenance aligns with socio-economic, tourism, and inter-regional integration priorities.

Overall, the literature demonstrates that integrating multi-criteria decision-making methods, such as AHP, with conventional road management systems improves resource allocation, supports sustainable road maintenance, and strengthens regional connectivity in line with development objectives.

METHODOLOGY

The population in this study included all provincial road segments within the working area of the Malang Road and Road Transportation Technical Implementation Unit (UPT PJJ) and registered in the Provincial/District Roads Management System (PKRMS) database. Each road segment containing information related to pavement condition, section length, road classification, level of damage, and recommended treatment was considered part of the study population. This population was the primary focus because data from the PKRMS was used as the basis for determining road treatment priorities using the Analytical Hierarchy Process (AHP) method.

The population was determined based on the selection of respondents with relevant expertise and experience in the field being studied. This approach was used because the Analytical Hierarchy Process (AHP) method requires assessment by individuals with a deep understanding of the technical and policy aspects related to road treatment. According to Saaty (1990), AHP relies on expert judgment to produce valid weightings that reflect actual priorities in complex decision-making. Therefore, the research population focused on experts and practitioners directly involved in provincial road management.

The expert population in this study included employees of the East Java Provincial Public Works and Highways Department who work in the Malang UPT PJJ work area and the Maintenance Division. The expert population in this study consisted of structural officials, functional officials, data managers, and road and bridge supervisors who understand the technical and administrative conditions of the road network. Therefore, this population is expected to provide

an accurate assessment of road management priorities within the Malang UPT PJJ area.

The research sample is a subset of the population selected for more in-depth analysis to obtain results that are representative of the entire population. In this study, the sample was taken from provincial road segments within the working area of the Malang Distance Learning Unit (UPT PJJ) and recorded in the Provincial/Regency Roads Management System (PKRMS). Sample selection was carried out by considering data completeness, relevance to the research objectives, and representativeness of road conditions in each district or administrative area covered by the UPT PJJ Malang.

In this study, the population used was 53 employees working within the Public Works and Highways Agency of East Java Province, specifically within the working area of the UPT PJJ Malang and the Maintenance Division. The sample size was determined using the Slovin formula, as described in 2.15, with a tolerance of 10%. Questionnaires were distributed to employees of the East Java Provincial Public Works and Highways Agency.

This research focuses on provincial roads under the authority of the East Java Provincial Public Works and Highways Agency, specifically within the working area of the Malang Road and Bridge Management Unit (UPT PJJ).

The road sections selected for this research are as follows:

Located in Malang Regency

1. Batu City Highway - Kediri Regency Highway (Link 018)
2. Malang City Highway - Batu City (Sengkaling) Highway (Link 019)
3. Malang City Highway - Turen Highway (Link 020)
4. Karanglo Highway - Batu City (Karang Ploso) (Link 021)
5. Talok - Druju - Sendangbiru (Link 022)
6. Mangliawan (Malang City Main Road) - Tumpang (Link 023)
7. Tumpang - Wonomulyo (SP3 Tulus Besar) (Link 024)
8. Wonomulyo (SP3 Tulus Besar) - Gubuk Klakah Poncokusumo Rest Area (Link 025)

Located in Malang City

1. Jln. Tlogo Mas (Link 128.11K)
2. Jln. Mayjen. Hariyono (Link 128.12K)
3. Jln. Soekarno-Hatta (Link 128.13K)
4. Jln. Borobudur (Link 128.14K)
5. Jln. A. Yani (Link 128.15K)
6. Jln. Kol. Sugiono (Link 129.11K)
7. Jln. Laksda Adisucipto (Link 130.11K)

Located in Batu City

1. Cangar Raya Street (Link 134.11K)
2. Tulungrejo Raya Street (Link 134.12K)
3. Punten Raya Street (Link 134.13K)
4. Bukit Berbunga Street (Link 134.14K)
5. Brantas Street (Link 134.15K)
6. Trunojoyo Street (Link 135.11K)

7. Sudirman Street (Link 135.12K)
8. Gajah Mada Street (Link 135.13K)
9. Diponegoro Street (Link 135.14K)
10. Patimura Street (Link 135.15K)
11. Ir. Soekarno (Link 135.16K)
12. Jln. Dr. M. Hatta (Link 136.11K)

The research implementation period was four (4) weeks, including data collection surveys, interviews, and data analysis.

Data collection in this study was conducted using:

1. Primary data is data obtained directly from respondents through a questionnaire as a data collection tool related to road sections at the Malang Distance Learning and Development Technical Implementation Unit (UPT PJJ). In this study, the author asked respondents questions to obtain data from the research subjects.
2. Secondary data is data obtained directly from the East Java Provincial Public Works and Highways Office (PU Bina Marga), including East Java Provincial Road Space Decree (SK Jalan Ruang Jalan) data, a summary of road condition results, unit price data for work used in calculating maintenance needs, and the East Java Provincial PU Bina Marga Office's Medium-Term Development Plan (RPJMD). This secondary data serves as a source of quantitative information that strengthens the analysis results.

The AHP method is used to determine priority weights based on criteria that influence road management decisions. The hierarchical structure is structured into three levels: the first level is objectives, the second level is criteria, and the third level is sub-criteria.

1. Level I (Objectives)

Determining the priority of provincial road sections to be addressed within the Malang UPT PJJ area.

2. Level II (Criteria)

Factors determining priority

- a. Road Condition (PKRMS Data)
- b. Priority Area
- c. Connectivity
- d. Road Service Level
- e. Policy

3. Level III (Alternatives)

Road sections within the Malang UPT PJJ.

This hierarchical structure serves as the basis for developing a pairwise comparison questionnaire to obtain criteria weights from experts or relevant stakeholders at the East Java Provincial Public Works and Highways Department.

The questionnaire instrument in this study was designed based on the paired comparison structure between criteria used in the AHP method. Each pair of criteria was structured as a question that asked respondents to determine their relative importance. This questionnaire aimed to systematically capture the

preferences and assessments of experts so that they could be translated into quantitative values in a comparison matrix.

The respondents involved were individuals with technical competence in road and bridge construction, including technical officials from the Malang Distance and Bridge Development Technical Implementation Unit (UPT PJJ), staff from the Maintenance Division, and the Regulation and Control Division of the East Java Provincial Public Works and Highways Agency. Respondents were selected based on their experience, technical understanding, and involvement in the road infrastructure management process. Each respondent provided an assessment using the Saaty scale (1-9), with higher scores indicating greater importance compared to other criteria.

After all questionnaires were collected, the assessment data from each respondent was processed using the geometric mean method to combine the experts' opinions into a single composite matrix.

This technique was chosen because it maintains proportionality in assessment scores among respondents and aligns with the basic principles of ratio comparison in the AHP method. The combined scores were then used as the final pairwise comparison matrix, which served as the basis for calculating priority weights in the next analysis stage.

Performing a pairwise comparison process between criteria, by constructing a comparison matrix containing numeric values representing the relative importance of one element to another. Through this matrix, each criterion is evaluated based on its influence or priority compared to other criteria. The general form of the comparison matrix between criteria.

The next step is to perform a matrix normalization process, where each element in the comparison matrix is divided by the total number of columns corresponding to it. This step aims to obtain proportional comparison values between criteria. This process can be calculated using formula 2.10 and can be displayed in table 2.14. After the normalization process is completed, the next step is to determine the priority weights, which are obtained by summing the values in each row of the normalized results for each criterion and dividing by the number of criteria. These values are called eigenvectors. The sum of the average values of these weights must equal 1.

The next stage is the Consistency Test, which aims to ensure that the pairwise comparisons between the criteria provided by respondents are logical and not contradictory. If the assessments are too contradictory, the resulting weights will be unreliable. First, calculate λ (Maximum Eigenvalue) using formula 2.12, which is the sum of the results of each row of the comparison matrix divided by its criterion weight (W_i). Next, calculate the Consistency Index (CI) obtained from formula 2.13, then calculate the Consistency Ratio (CR) obtained from formula 2.14. If the CR value is ≤ 0.1 , the assessment is considered to have acceptable consistency. If the CR value is > 0.1 , improvements to the comparison matrix are necessary.

RESULTS AND DISCUSSION

Based on the criteria weighting and final priority weighting of road sections obtained using the Analytical Hierarchy Process (AHP) method, these weighting values are then used as input data in the analysis process using the Provincial/District Roads Management System (PKRMS) application. The input data entered into PKRMS includes the criteria weighting values from the AHP results, road condition data, and other supporting parameters relevant to the road management priority assessment.

This process aims to integrate the stakeholder assessment results with the technical road condition data available in the system.

To obtain analysis results from the PKRMS, the first step is to enter basic data on the road sections to be analyzed, such as provincial data, island data, district data, road network data, such as road section length, road inventory data, and road condition data obtained from a survey conducted by the Malang Distance Learning and Education Unit (UPT PJJ). The PKRMS data input for this study is provided in Appendix 4.

The next step is to add Multi-Criteria Analysis (MCA) parameters to the PKRMS application based on the analysis results using the AHP method, as shown in Table 4.15. The MCA values for road sections used in PKRMS refer to Criteria 2 (Priority Areas), Criteria 3 (Connectivity), Criteria 4 (Road Service Level), and Criteria 5 (Policy), in addition to the road condition criteria already fundamentally calculated in PKRMS. The MCA values are input according to the parameters in the PKRM application. These categories are divided into three categories: Low = 1, Medium = 2, and High = 3.

The results of the analysis of the cost requirements for provincial road maintenance in the Malang Regional Public Works and Transportation Technical Implementation Unit (UPT PJJ), which have been compiled based on the level of need for maintenance. The cost calculations in this table are compiled using the unit prices for the work listed in Table 2.17, so that the resulting costs reflect applicable cost standards and can be justified technically and administratively. The use of uniform unit prices aims to maintain consistency in cost calculations between road sections, ensuring that any differences in cost are solely influenced by the level of road damage and the type of maintenance required.

The road maintenance costs presented in Table 4.21 show significant variation between road sections. This variation reflects differences in the physical condition of the road, the length of the section being maintained, and the level of damage. Road sections with severe damage tend to require more complex maintenance, resulting in higher costs. Conversely, road sections with light to moderate damage require relatively lower costs because the recommended maintenance is routine or periodic.

This study demonstrates that a priority-based road management approach can provide a basis for more efficient decision-making under budget constraints. By understanding the cost requirements for each road section, stakeholders can determine the most optimal management scenario, either by focusing the budget on the highest-priority road sections or by adjusting the scope of management according to budget availability. This demonstrates that the results of the road

management cost analysis serve not only as technical information but also as a tool in formulating budget policies.

Overall, the results of the road management cost analysis demonstrate that the integration of multi-criteria-based priority determination and unit price-based cost calculations can produce more targeted and measurable road management planning.

CONCLUSION

The conclusions from the data analysis are as follows:

1. The criteria weights using the Analytic Hierarchy Process (AHP) method are: Road condition with a weight of 28.6%, connectivity with a weight of 19.9%, road service level with a weight of 18.7%, priority areas with a weight of 18.3%, and policy with a weight of 14.5%.
2. The priority order of provincial road sections to be addressed using the PKRMS combined with the AHP method is as follows: X, E, P, Q, O, AA, U, C, D, G, A, H, F, Z, J, B, I, K, L, N, R, S, T, V, W, Y, M
3. The total cost required for addressing provincial road sections in the UPT PJJ Malang area, based on the analysis of the PKRMS application combined with the AHP method, is Rp. 357,814,927,151,-

RECOMMENDATION

The recommendations are as follows:

1. Coordination between Distance Learning (PJJ) Technical Implementation Units (UPTs) is needed to ensure that the process of collecting and verifying road condition data is more consistent, accurate, and reflects actual field conditions. With better data quality, priority analysis results will be more targeted and can support more effective management decisions.
2. The AHP criteria used in this study are expected to be reviewed periodically to remain relevant to the dynamics of road network developments.
3. The PKRMS system needs to be updated regularly to reflect current conditions and can be used optimally in priority analysis.
4. The combination of PKRMS and the AHP method also needs to be continuously developed to produce more comprehensive and precise road management priority determination.
5. Human resource capacity building for survey and technical analysis personnel is needed through regular training on the use of PKRMS, road condition survey techniques, and an understanding of the AHP method.

FURTHER STUDY

Future research is recommended to further evaluate the integration of the Analytic Hierarchy Process (AHP) with the Provincial Road Management System (PKRMS) by including additional criteria such as environmental impact, traffic volume, and socio-economic benefits. Subsequent studies could explore the sensitivity of priority rankings to changes in criteria weights and assess the

robustness of decision-making under varying scenarios. In addition, applying the combined AHP-PKRMS method to other regions or larger networks of provincial roads may provide comparative insights into its scalability and effectiveness. Longitudinal research tracking the implementation outcomes of prioritized road sections could also provide practical evidence on cost efficiency, service level improvements, and connectivity enhancements over time.

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