Analysis of Road Maintenance Priorities on Provincial Roads in the UPT PJJ Malang Region Using the Analytical Hierarchy Process Based on the Provincial/District Roads Management System

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ABSTRACT
The management of transportation infrastructure plays a vital role in supporting regional connectivity and sustainable development. However, limited government budgets often constrain the ability to maintain the entire road network, requiring a decision-making model that can objectively determine maintenance priorities. This research aims to analyze the prioritization of provincial road maintenance in the UPT PJJ Malang region using the *Analytical Hierarchy Process* (AHP) integrated with the *Provincial/District Roads Management System* (PKRMS). The study adopts a quantitative descriptive method that combines technical data from PKRMS with expert-based weighting analysis through AHP. The expected outcome is a decision-support model that can rank road segments according to their strategic, technical, and socio-economic importance. This approach not only supports transparent and efficient infrastructure management but also provides an applied learning framework for vocational engineering education, fostering smart and sustainable human resources in the field of transportation infrastructure management.

Keywords: *Analytical Hierarchy Process* (AHP), *Provincial/District Roads Management System* (PKRMS), *infrastructure management, transportation integration*

1. INTRODUCTION

Transportation networks are the backbone of regional and national development, serving as the foundation for economic activities, logistics, tourism, and social mobility. In developing regions such as East Java Province, Indonesia, road infrastructure plays a critical role in linking industrial centers, agricultural zones, and urban settlements. Efficient road management directly contributes to reducing logistics costs, supporting equitable economic growth, and enhancing public access to essential services. However, over the past decade, the condition of many provincial roads has declined due to a combination of aging infrastructure, increasing vehicle loads, and the delayed implementation of maintenance programs. Limited government budgets often result in uneven distribution of maintenance funding, where resources are concentrated on a few major corridors while secondary roads deteriorate rapidly. This imbalance leads to reduced accessibility, slower economic distribution, and increased transportation costs. Therefore, identifying which road segments should be prioritized for maintenance has become an urgent issue for regional infrastructure agencies.

The *Provincial/District Roads Management System* (PKRMS) has been adopted by the East Java Provincial Public Works Department as a key decision-support platform for road asset management. PKRMS collects and manages comprehensive data on road inventory, condition, traffic volume, and maintenance history. The system uses indicators such as the *Pavement Condition Index* (PCI) to categorize road quality from excellent to poor. Although PKRMS provides reliable technical data, its limitation lies in its inability to capture non-quantitative aspects — such as socio-economic function, policy priorities, and regional connectivity — that significantly influence the urgency of maintenance interventions.

To overcome these limitations, the *Analytical Hierarchy Process* (AHP) is integrated into the analysis framework. AHP, developed by Thomas L. Saaty in the 1970s, is a multi-criteria decision-making method that helps decision-makers structure complex problems into hierarchical levels of criteria and sub-criteria. By allowing experts to perform pairwise comparisons, AHP quantifies subjective judgments into objective priority scales. This capability is essential for infrastructure planning, where decisions often involve trade-offs between technical, financial, and socio-economic factors.

Integrating AHP with PKRMS offers several potential advantages. First, it allows the inclusion of qualitative judgment from experts, such as the importance of a road's connectivity to airports, ports, or economic centers, alongside quantitative PCI data. Second, it introduces a transparent and consistent weighting mechanism that improves decision accountability. Third, it creates a replicable framework that can be adapted by other regions or institutions to improve maintenance decision-making processes. From a broader perspective, this integration supports the vision of developing an *intelligent transportation management system* that promotes sustainability and resilience. As Indonesia transitions toward a more data-driven governance model, the combination of PKRMS and AHP aligns with the concept of *smart infrastructure management*, where digital tools and analytical methods are used to enhance service delivery and resource allocation.

Furthermore, this study also carries an educational dimension, particularly within the field of **vocational** engineering and applied sciences. The implementation of data-based decision-making models such as AHP-PKRMS can serve as an applied learning example in civil engineering education, fostering students' analytical thinking and technical problem-solving skills. By linking academic research with real-world infrastructure management practices, vocational institutions can better prepare graduates to address modern challenges in sustainable transportation systems.

In summary, this study seeks to develop a transparent, data-driven, and policy-sensitive model for determining road maintenance priorities in the UPT PJJ Malang region. The integration of PKRMS and AHP is expected to produce a practical framework that not only enhances infrastructure management efficiency but also contributes to Indonesia's broader agenda of integrating transportation networks — particularly between road and aviation systems — to promote human development and national competitiveness.

2. LITERATURE REVIEW

2.1. Analytical Hierarchy Process (AHP) in Infrastructure Decision-Making

The *Analytical Hierarchy Process* (AHP), developed by Saaty (2000), is a structured technique designed to assist complex decision-making processes involving multiple and often conflicting criteria. It decomposes a decision problem into a hierarchy, allowing comparisons between elements based on their relative importance. AHP uses a scale of 1 to 9 to measure preferences, where 1 indicates equal importance and 9 indicates extreme importance of one element over another.

In infrastructure planning, AHP is particularly useful for prioritizing maintenance projects, evaluating investment options, and assessing risk. Several studies have successfully implemented AHP in transportation management. For example, Irawan and Suprapto (2020) applied AHP to optimize the allocation of limited road maintenance budgets by incorporating both technical and socio-economic considerations. Their study demonstrated that roads connecting public service facilities and economic centers tend to receive the highest priority scores. Similarly, Halich et al. (2023) confirmed that AHP's hierarchical structure enhances transparency and reproducibility in infrastructure-related decision-making, providing a more objective foundation compared to subjective administrative judgment.

AHP's strength lies in its ability to convert qualitative assessments into quantitative values through a systematic consistency check using the *Consistency Ratio (CR)*. A CR value less than or equal to 0.1 indicates that expert judgments are consistent enough to be considered valid. This makes AHP highly suitable for problems involving multidisciplinary evaluation criteria, such as transportation infrastructure, where decisions depend on engineering conditions, socio-economic impacts, and government policies.

2.2. Provincial/District Roads Management System (PKRMS)

The *Provincial/District Roads Management System* (PKRMS) is an integrated platform designed to manage road asset data for both provincial and district levels in Indonesia. It was developed to standardize data collection and analysis related to road networks, conditions, and maintenance activities under the Directorate General of Highways (*Direktorat Jenderal Bina Marga*). PKRMS includes several key components: road inventory data, pavement condition assessment (typically using PCI values), traffic volume data, and maintenance history. According to Bappenas (2023), the system plays a central role in supporting evidence-based decision-making in infrastructure planning. By providing a digital platform for monitoring and evaluating road conditions, PKRMS helps local governments identify road segments requiring urgent repair, rehabilitation, or preservation.

Despite its benefits, PKRMS's limitation lies in its analytical scope. The system primarily relies on numerical condition data and does not include qualitative parameters, such as strategic economic connectivity or regional policy priorities. Consequently, while PKRMS can provide a technical diagnosis, it lacks the capacity to deliver a holistic prioritization framework that considers broader development objectives.

2.3. Integration of AHP and PKRMS

Integrating AHP with PKRMS offers a comprehensive solution for improving road maintenance decision-making. The synergy between these two systems allows technical condition data (from PKRMS) to be evaluated alongside qualitative and policy-driven factors (through AHP). The resulting hybrid model provides decision-makers with a multi-dimensional perspective on infrastructure priorities. According to research by Halich et al. (2023), the integration of data-based management systems and multi-criteria decision-making methods improves accuracy and fairness in resource allocation. Roads that serve multiple strategic functions — such as connecting airports, ports, or industrial zones — can be identified and prioritized using a combination of PCI scores and expert judgment weights. This integration reduces the risk of bias and ensures that infrastructure investment decisions align with both technical needs and socio-economic goals.

Moreover, the combined PKRMS-AHP framework contributes to sustainable transportation planning. As noted by Bappenas (2023), sustainability in infrastructure not only refers to physical longevity but also includes economic efficiency, social inclusivity, and environmental responsibility. Through AHP-PKRMS integration, decision-makers can incorporate sustainability indicators, such as accessibility to rural areas, reduction in vehicle emissions, and enhancement of mobility equity.

3. RESEARCH METHODOLOGY

3.1. Research Approach and Design

This study adopts a quantitative-descriptive approach to develop a decision-support framework for determining provincial road maintenance priorities in East Java Province. The research focuses on the UPT PJJ Malang region, which manages several key provincial road segments that connect urban centers, industrial areas, and public service facilities. The methodology combines secondary data analysis from the Provincial/District Roads Management System (PKRMS) with expert-based pairwise comparison using the Analytical Hierarchy Process (AHP). The overall goal is to formulate a transparent and data-driven model capable of ranking road segments based on their strategic and functional importance.

The study is structured into four main phases:

1. Problem Identification and Data Collection – reviewing PKRMS datasets, identifying research variables, and collecting supporting policy documents.
2. Model Development (AHP Framework) – designing a hierarchical model that represents the decision structure, consisting of the main goal, criteria, and sub-criteria.
3. Data Analysis and Weight Calculation – performing pairwise comparisons to generate weight values for each criterion and validating consistency using the Consistency Ratio (CR) test.
4. Integration and Priority Ranking – combining weighted AHP results with PKRMS road condition data to produce a ranked list of road maintenance priorities.

3.2. Hierarchical Model Development

The AHP framework for this research consists of three hierarchical levels:

a. Level 1: Goal — Determining the priority of provincial road maintenance in the UPT PJJ Malang region.
b. Level 2: Criteria — Road Condition, Connectivity, Accessibility, Economic Importance, Public Service, and Policy Relevance.
c. Level 3: Alternatives — Specific road segments identified within the PKRMS database (e.g., Malang–Blitar Road, Kepanjen–Turen Road, Lawang–Singosari Road, etc.).

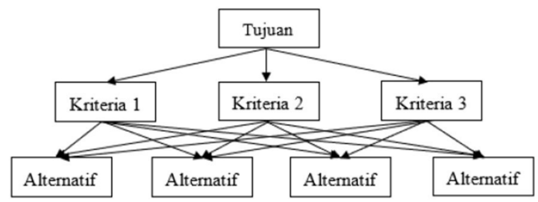

Figure 1. AHP Framework

3.3. Hierarchical Model Development

The AHP process follows the standard methodology established by Saaty (2000):

a. Pairwise Comparison: Each criterion is compared to every other criterion using Saaty's 1–9 scale, where 1 denotes equal importance and 9 denotes extreme importance of one factor over another.

b. Matrix Normalization: Each column of the pairwise comparison matrix is divided by its total to normalize the values.

c. Priority Vector Calculation: The average of each row in the normalized matrix represents the relative weight of the criterion.

d. Consistency Check: The Consistency Index (CI) and Consistency Ratio (CR) are calculated to ensure logical coherence in the expert judgments.

   The acceptable limit is $CR \leq 0.1$.

e. Integration with PKRMS: The final AHP weights are applied to PKRMS quantitative data (e.g., PCI, traffic volume, and strategic function) to compute the final composite score for each road segment.

3.4. Research Flowchart

The overall research methodology can be visualized in the flowchart below:

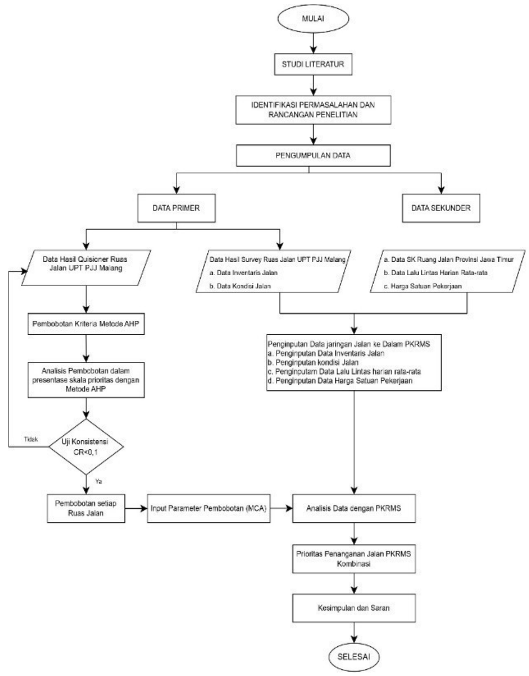

Figure 1. Research Flow Diagram

4. EXPECTED ANALYTICAL OUTCOMES

At the current stage, the research has developed a comprehensive model for integrating the Analytical Hierarchy Process (AHP) with the Provincial/District Roads Management System (PKRMS) to determine provincial road maintenance priorities in the UPT PJJ Malang region. However, the implementation and validation process have not yet been completed; therefore, this section presents the expected analytical outcomes that will likely emerge once the analysis is finalized. In alignment with the objectives stated in Chapter 1, the study aims to:

1. Establish a transparent and data-driven model for road maintenance prioritization.
2. Produce consistent and measurable weights for the six selected criteria.
3. Integrate these criteria with PKRMS road condition data to generate a ranking of maintenance priorities.
4. Provide a framework that can be replicated by other regions or adopted as a decision-support tool by public works agencies.

The following subsections describe the expected results for each criterion based on literature review, preliminary PKRMS data, and expert opinions gathered during the methodological design phase.

5. CONCLUSION

This research shows that the AHP method integrated with PKRMS has the potential to be an effective model in determining priorities for handling provincial roads objectively and efficiently. This approach not only helps local governments in proper budget allocation, but also strengthens public transparency and accountability. In addition, the results of this research are expected to make a real contribution to civil engineering vocational education through the application of data-based analytical methods in infrastructure planning.

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