

Priorities for Road Infrastructure Maintenance in a Case Study of Kepanjen Regency Roads Using SWOT Analysis and the Analytical Hierarchy Process (AHP)

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ABSTRACT

Road pavement damage due to traffic loads can manifest in various forms, such as alligator cracking, longitudinal cracking, transverse cracking, potholes, rutting, and surface peeling. Therefore, prioritization is necessary for each road section within a single road maintenance program and activity. Addressing this challenge requires a comprehensive analytical approach to prioritize road infrastructure maintenance and improvement. The purpose of this study is to generate priority recommendations based on the analysis to support decision-making. The analysis found that the Blitar Regency-Kepanjen Highway Section is the first priority, followed by the Kepanjen-Gondanglegi Highway Section as the second priority, followed by the Wlingi City-Malang Regency Highway Section, and the Gondanglegi-Turen Highway Section as the last priority. It is also recommended that adjustments be made to the road maintenance priority criteria variables if this decision model is to be applied outside the Kepanjen Regency area and to deepen the comparative study regarding the reliability of the decision support system or software used in mapping the order of road preservation urgency

INTRODUCTION

Road infrastructure development is a key factor in supporting economic growth, public mobility, and the smooth distribution of goods and services. Roads serve as land transportation infrastructure connecting various centers of economic, social, and government activity. Therefore, good road pavement conditions are essential for optimal road service function. Premature pavement deterioration not only reduces the comfort and safety of road users but also has the potential to cause economic losses due to increased vehicle operating costs and road maintenance costs (Siahay et al., 2023).

Land transportation, particularly roads, plays a crucial role in supporting global economic activity and mobility (Kadarisman et al., 2016). Improving road stability continues to be a primary focus for many countries given its significant impact on economic growth and social development (Dewi, n.d.). According to the World Bank (2021), good road infrastructure can increase a country's GDP by 1-2% annually by facilitating access to markets, education, and healthcare (Septiani, 2020). However, constraints such as limited funding and resources often hamper road maintenance and improvement efforts, particularly in developing countries (Sahban & Se, 2018).

Increased economic activity and urban growth have led to a continuous increase in traffic volume, particularly for heavy vehicles and freight transport. This situation is often not matched by adequate vehicle load control, resulting in many vehicles traveling with excessive loads. This excessive load places significant pressure on the pavement structure, particularly on the surface and base layers, ultimately accelerating structural and functional damage (Yunus et al., 2025).

Pavement damage due to traffic loads can appear in various forms, such as alligator cracking, longitudinal cracks, transverse cracks, potholes, rutting, and surface peeling. This damage does not occur suddenly but is the result of the accumulation of repeated vehicle loads. The greater the load and the higher the frequency of heavy vehicle traffic, the greater the damage the pavement experiences (Yunus et al., 2025).

In addition to vehicle load, traffic density also plays a significant role in accelerating road pavement degradation. Roads with high traffic volumes tend to deteriorate more rapidly than those with low traffic volumes. This condition is exacerbated when traffic is dominated by heavy vehicles, such as trucks and trailers, which have a much greater destructive force than light vehicles (Ahmad, Azikin, Agustan, Nasrul, & Minmahddun, 2024).

Key factors influencing road maintenance include budget constraints, geographic location, usage intensity, and climate conditions, all of which impact the rate of road degradation (Ridwan & Saprudin, 2024). Limited funding availability, for example, means that not all roads requiring repairs can be addressed simultaneously, necessitating effective prioritization (Ghonniyu, 2024).

Under budget constraints, prioritizing activities aimed at maintaining existing assets is a reasonable step. If financial conditions permit, asset enhancement is a second option. Only if substantial funds are available can new

asset expansions be considered (Tamin, O.Z., 2002). This is a natural step in managing state assets, which constitute a significant amount of infrastructure, the performance of which will be the backbone of the national economy. Therefore, prioritization is necessary for each road section within a single program and road maintenance activity. If available funds only cover 25%, 50%, or 75% of the total road maintenance needs, it is necessary to determine which maintenance should be prioritized first.

The development of a road maintenance program essentially involves two factors:

1. Physical, geometric, and traffic conditions that indicate the need for maintenance in a given year (fiscal need).
2. Availability of funds that can be allocated for road maintenance in a given year (fiscal capacity). The gap between fiscal need and fiscal capacity makes it impossible to implement all programs simultaneously. Therefore, a prioritization mechanism is needed to determine the maintenance needs for each road section according to its level of importance.

The Wlingi - Kepanjen - Turen road section (52,860 km) is a vital route connecting Malang Regency with Blitar Regency. Therefore, its performance must be maintained. The Wlingi - Kepanjen - Turen road section can be divided into four sections:

1. Link 057 (Wlingi City - Malang Regency) (19,690 km)
2. Link 058 (Wlingi City - Malang Regency) (19,690 km) Blitar - Kepanjen: 17,040 km long
3. Link 059: Kepanjen - Gondanglegi: 8,500 km long
4. Link 060: Gondanglegi - Turen: 7,630 km long

Therefore, a methodology is needed to prioritize road maintenance and improvements, which must be carried out evenly according to needs, as the government's funding capacity is very limited, ensuring that the objectives of the road service function are still met.

To address this challenge, a comprehensive analytical approach is required to prioritize road infrastructure maintenance and improvements. The Analytic Hierarchy Process (AHP) method (Thomas L. Saaty 1980) is used for multi-criteria decision-making by comparing alternatives based on hierarchical criteria such as road condition, traffic volume, and cost. Meanwhile, a SWOT (Strengths, Weaknesses, Opportunities, Threats) analysis provides a strategic perspective to identify internal strengths, weaknesses, external opportunities, and threats, thus supporting more holistic decision-making. The integration of AHP and SWOT allows for objective and strategic priority analysis.

Research Benefits

The following is a detailed description of the research benefits in two aspects: academic and practical.

Academic Benefits

Academically, this research is expected to contribute to the development of knowledge in the field of civil engineering, particularly in the field of road infrastructure analysis. The results of this study can enrich empirical references on determining road maintenance and improvement priorities. Theoretically, this research is expected to provide insight into the integration of the AHP and

SWOT methods in road infrastructure priority analysis, as well as contribute to the literature on multi-criteria decision-making at the local level.

Practical Benefits

1. For local governments, particularly the Kepanjen Regency Government, the results of this study can be used as a basis for prioritizing road maintenance programs. AHP and SWOT enable more objective, transparent, and efficient decision-making.
2. This research helps infrastructure practitioners optimize budget constraints. With a systematic prioritization model, maintenance budgets can be allocated more precisely to road sections that truly require urgent attention.
3. The research findings can be used as a reference by the Ministry of Public Works and Public Housing (PUPR) and Public Works and Public Housing Agencies in other regions to replicate similar models, thus creating more accountable and uniform road maintenance planning standards.
4. This research indirectly benefits the community, as its implementation has the potential to improve the quality of the road network, facilitate mobility, reduce transportation costs, and enhance road user safety.

THEORETICAL REVIEW

The research conducted is entitled "Determination of Road Management Priorities Based on Performance Analysis and Economic Feasibility (Case Study: Region I of Malang Road and Bridge Management Unit)". The purpose of this study is to determine the priority of road management in Region I of Malang Road and Bridge Management Unit using the AHP approach and Multicriteria Analysis. (Niken et al. 2024)

The research conducted is entitled "Analysis of Infrastructure Development Supporting Asol Water Tourism. Haruku Island Area, Maluku: Planning and Design Approach Using AHP Method". The purpose of the research is to analyze the priority of infrastructure development supporting Asol Water Tourism in Negeri Oma, Haruku Island using AHP method through three aspects: pre-construction, construction, and post-construction. (Rumihin.O. F, 2025).

The research was titled "Analysis of Road Maintenance Priorities in Karanganyar Regency Using the AHP Method." The purpose of this research was to determine the maintenance priority for 10 road sections in Karanganyar Regency using AHP with five criteria: road condition, road width, LHR (Land Use Area), maintenance costs, and land use. (Sushera, Rohman & Kartika, 2018).

The research was titled "Analysis of the SWOT-Fuzzy AHP Integration Method for Developing Strategies to Increase Air Transportation Utilization at Trunojoyo Airport, Sumenep." The purpose of this research was to determine the best strategy to increase the number of air transportation users at Trunojoyo Airport, Sumenep, which has been declining since 2019, through a combination of SWOT analysis and Fuzzy AHP. (Hidayat, Sudarso, 2024)

METHODOLOGY

The research was conducted on the Wlingi – Kepanjen – Turen road section in Kepanjen Regency, East Java Province, which was selected as a case study due to its diverse road network (district and village) with hilly geographical challenges and high traffic volumes.

Data analysis was conducted in two main stages: road condition analysis and the application of the AHP and SWOT methods.

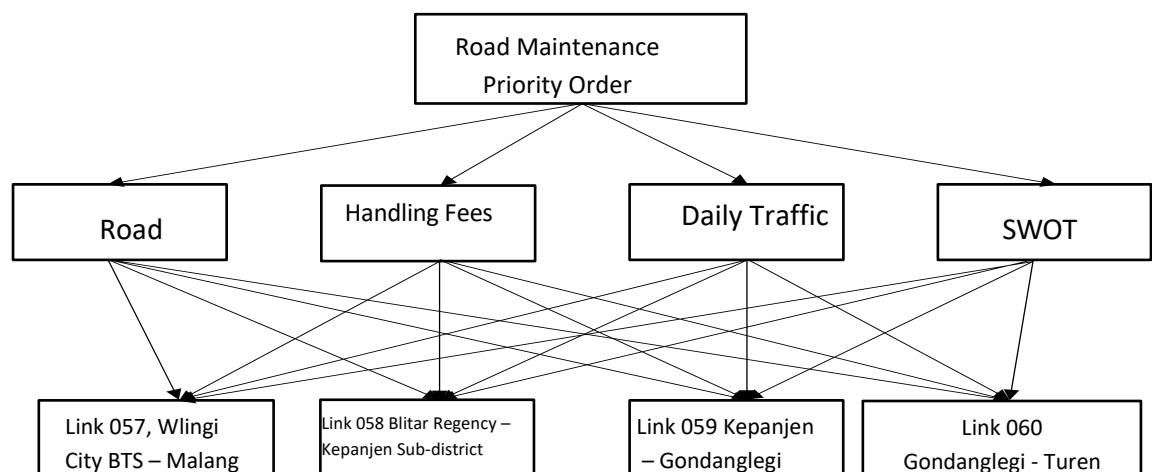
- Road Condition Analysis: Using IKJ data and parameters such as surface damage, structural strength, and drainage to describe road conditions in Kepanjen Regency.

SWOT Identification

- Strengths Identification: Positive internal aspects such as human resources or available technology.
- Weaknesses Identification: Negative internal aspects such as budget constraints.
- Opportunities Identification: Positive external factors such as government support or investment.
- Threats Identification: Negative external factors such as natural disasters or climate change.
- Using SWOT analysis to identify influential internal and external factors.
- Integration of AHP and SWOT: The SWOT identification results are used as the basis for prioritization in the AHP hierarchy formation. The analysis is performed using software such as Expert Choice for AHP and manual analysis for SWOT.

AHP Analysis

1. Hierarchy formation: Objectives (maintenance priorities), criteria (SWOT), sub-criteria (most influential factors in SWOT).
2. Pairwise comparison: Using the Saaty scale (1-9) through an expert questionnaire to create a comparison matrix.
3. Weight calculation: Using the eigenvector method to calculate priority weights and check consistency with a consistency ratio ($CR < 0.1$).
4. Priority synthesis: Combining weights to determine the best alternative.



AHP Analysis Diagram

RESULTS AND DISCUSSION

Analysis of Existing Conditions of Road Network

The Wlingi-Kepanjen-Turen road section is a strategic component of the road network, connecting Blitar Regency and Malang Regency. This section serves as the main distribution route for economic activities, particularly in the trade, agriculture, and inter-regional transportation sectors.

Administratively, this road section is divided into several segments: Link 057, Link 058, Link 059, and Link 060. Each segment has distinct characteristics, including length, road condition, and traffic density.

These differences in characteristics result in varying maintenance requirements for each section. Therefore, a comprehensive analysis is required to prioritize road maintenance appropriately, effectively, and efficiently.

There are technical, logical, and managerial reasons why Road Condition is the highest priority, while the SWOT aspect is ranked lowest:

a. Urgency of Direct Physical Impact

The physical condition of the road (such as the level of potholes, sinkholes, and alligator skin cracks) has a direct impact on road user safety and vehicle operating costs (VOK). Unaddressed physical damage will accelerate the rate of pavement structural degradation due to repeated vehicle loads, particularly from the phenomenon of overloaded vehicles (Over Dimension Over Loading/ODOL) on the Wlingi-Kepanjen-Turen corridor. Therefore, experts and practitioners logically place the highest weight on existing road conditions to maintain optimal road service function and prevent greater economic losses.

b. Priority Scale in Conditions of Budget Constraints

According to the asset management theory by Tamin (2002), under conditions of limited funding (budget constraints), infrastructure management policies must prioritize activities aimed at preserving existing assets over other aspects. Road physical condition assessments provide objective, quantitative data on which sections are in critical condition or experiencing inadequate service. This physical data serves as a critical indicator of urgent needs that must be prioritized in the allocation of the regional annual budget over external considerations.

c. Macro Characteristics and Subjectivity of SWOT Criteria

The SWOT criterion's fourth (lowest) ranking does not indicate that strategic aspects are unimportant, but rather due to the macro, long-term, and qualitative nature of the instrument. A SWOT analysis comprehensively maps an institution's internal (strengths-weaknesses) and external (opportunities-threats) factors. In determining operational road management priorities, these long-term management or policy factors were considered by expert respondents to be more sensitive and subjective. Therefore, the strategic weight of the SWOT serves as a policy direction supporting program distribution, but its hierarchical importance remains subordinate to actual technical parameters in the field, such as road physical conditions and traffic volume.

Therefore, the integration of the AHP and SWOT methods in this study aims to generate priorities that are not only technical but also consider strategic aspects of road infrastructure development.

Based on the results of the AHP and SWOT calculations, a priority order for management was obtained for each study road section. Priority determination was based on the total weight of all analyzed criteria.

The road section with the highest score indicates a greater level of urgency for management compared to other sections. The main factors influencing these priorities are road damage conditions, traffic volume, and urgent handling needs.

Table 1. Priority Sequence for Handling Road Sections with AHP Analysis

Section Name	Road Section Data Weight				AHP Questionnaire Weight				Bobot Priority	Order
	K1	K2	K3	K4	K1	K2	K3	K4		
Wlingi City BTS – Malang Regency BTS	0.33	0.22	0.22	0.25	0.14	0.25	0.24	0.09	0.180	3
Blitar Regency – Kepanjen Highway Section	0.33	0.22	0.33	0.13	0.14	0.25	0.24	0.09	0.195	1
Kepanjen – Gondanglegi Section	0.17	0.44	0.22	0.50	0.14	0.25	0.24	0.09	0.234	2
Gondanglegi – Turen Section	0.17	0.11	0.22	0.13	0.14	0.25	0.24	0.09	0.117	4

Based on the calculations and analysis above, the priority order of road sections based on the AHP method is as follows:

- Blitar Regency – Kepanjen Highway
- Kepanjen – Gondanglegi Highway
- Wlingi City – Malang Regency Highway
- Gondanglegi – Turen Highway

CONCLUSION AND RECOMMENDATION

The analysis found that the Blitar Regency – Kepanjen Highway section was the first priority, followed by the Kepanjen – Gondanglegi Highway section as the second priority, followed by the Wlingi City – Malang Regency Highway section, and the Gondanglegi – Turen Highway section as the last priority.

The recommendation is the need to make adjustments to the road maintenance priority criteria variables if this decision model is to be applied outside the Kepanjen Regency area and to develop and deepen comparative studies related to the reliability of the decision support system or software used in mapping the order of road preservation urgency.

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