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Priority Sequence Analysis of Local Primary Road Bridge Infrastructure Handling Using AHP and TOPSIS Methods in Bojonegoro Regency

Arik Nur Cahyo, Esti Wulandari, Andi Patriadi
Universitas 17 Agustus 1945 Surabaya, Indonesia
Email: arik.nur.cahyo.st.86@gmail.com, wulandariesti@untag-sby.ac.id, andipatriadi@untag-sby.ac.id

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Abstract

Optimal management of bridge infrastructure requires effective planning and implementation. Currently, bridge maintenance prioritization in Bojonegoro Regency faces challenges due to budget limitations resulting from central government efficiency policies. Therefore, selecting priority bridges from the list proposed in the budget implementation document is essential to ensure that bridge maintenance programs managed by the Public Works and Spatial Planning Office are implemented efficiently and appropriately. This study aimed to analyze the priority sequence for handling primary local road bridge infrastructure in Bojonegoro Regency by considering various aspects and criteria objectively. Among various decision-making methods, the Analytical Hierarchy Process (AHP) and the Technique for Order Preference by Similarity to Ideal Solution (TOPSIS) were considered suitable approaches because they assist in solving complex decision-making problems by organizing criteria and alternatives into a hierarchical structure. The results of the AHP and TOPSIS analyses showed different priority rankings for bridge handling. Based on the AHP method, the priority order was Bridge *Sambeng–Kedewan* 19, Bridge *Sambeng–Besah 5,* Bridge *Sumberrejo–Kepohkidul 2,* Bridge *Watujago–Bobol 3,* Bridge *Sidobandung–Sepat 6, and* Bridge *Kapas–Sampang 1. Meanwhile, the TOPSIS method produced the priority order of* Bridge *Sambeng–Kedewan 19,* Bridge *Watujago–Bobol* 3, Bridge *Sambeng–Besah 5,* Bridge *Sumberrejo–Kepohkidul 2, Bridge Sidobandung–Sepat 6, and* Bridge *Kapas–Sampang* 1.

INTRODUCTION

Roads and bridges are essential infrastructure components that support economic development and public welfare (Bhattacharyya et al., 2023; EZEUDU & FADEYI, 2024; Foster et al., 2023; Fosu & Twumasi, 2022; Ibanga & AKPAN, 2024; Mahmood et al., 2025; Muhammad et al., 2023). A bridge is a structural construction that enables transportation routes to cross rivers, lakes, streams, highways, railways, and other physical obstacles (Shintike et al., 2015). According to Shintike et al. (2015), “Bridges play a significant role as they, along with roads, form the backbone of the transportation system.” In major cities, many roads and bridges are generally maintained in good condition. However, because roads and bridges naturally deteriorate over time, whether they are actively used or not, continuous and routine maintenance is required to preserve their quality or slow the rate of degradation. Limited government funding for maintenance often results in some road and bridge infrastructure experiencing poor conditions (Bonilla et al., 2023; Foster et al., 2022; Mazele & Amoah, 2022; Mbiyana et al., 2023; Musah et al., 2022).

The road and bridge network is an important component of transportation infrastructure that contributes to economic growth, sociocultural development, environmental sustainability, political stability, and national security (Law No. 38 of 2004). As economic conditions continue to improve, public demand for better transportation infrastructure will inevitably increase. Furthermore, an adequate road network is necessary to support the smooth movement of economic activities, information exchange, and technological development within a region (Alkatheeri et al., 2025; Peng et al., 2025; Salvo et al., 2025; Tzonevska, 2023).

Effective bridge infrastructure management requires proper planning and administration from the initial planning stage through the construction and maintenance phases. One of the current challenges in determining bridge maintenance priorities in Bojonegoro Regency is budget limitations resulting from central government efficiency policies, particularly for Jalan Lokal Primer (JLP) or primary local roads. Prioritizing bridge maintenance is essential because efficient budget utilization requires the selection of priority bridges among those already listed in the Budget Implementation Document (DPA) under the 2025 Bridge Widening Sub-Activity. Therefore, bridge maintenance programs planned by the Bojonegoro Department of Public Works and Spatial Planning must be implemented effectively and aligned with priority needs.

The main challenge in infrastructure prioritization is determining the most appropriate alternative among several options, as various stakeholders may have different interests and considerations in the decision-making process. Each aspect and criterion has a different level of importance; therefore, the weighting of aspects and criteria should reflect stakeholder priorities, where stakeholders refer to all parties involved in or affected by the decision-making process. All criteria should be evaluated objectively based on their relevance. The Analytical Hierarchy Process (AHP) and the Technique for Order Preference by Similarity to Ideal Solution (TOPSIS) are appropriate methods for addressing such problems because they facilitate complex decision-making by structuring alternatives, aspects, and criteria into a systematic hierarchy.

Research on determining priorities for bridge infrastructure management has been conducted by several researchers. Marsono (2020) found that AHP is effective for solving complex multi-criteria decision-making problems, Suryadi (1998) emphasized the importance of consistency in AHP assessments, and Syahputra et al. (2021) demonstrated the capability of TOPSIS in generating objective rankings. Although the application of AHP and TOPSIS has been widely studied, several research gaps remain.

The combined application of AHP and TOPSIS for bridge maintenance prioritization at the regency level remains limited. Previous studies have predominantly focused on technical aspects while providing less attention to strategic, economic, and social considerations. In addition, studies examining bridge prioritization in Bojonegoro Regency under central government budget efficiency policies are still limited, and comparative analyses between AHP and TOPSIS results in bridge infrastructure decision-making contexts are rarely conducted. The novelty of this research lies in applying an integrated AHP and TOPSIS approach to determine bridge maintenance priorities in Bojonegoro Regency by incorporating technical, strategic, economic, and social aspects. This study also compares the ranking results produced by both methods to contribute to the development of multi-criteria decision-making applications in public infrastructure management and provide empirical evidence regarding the influence of budget efficiency policies on regional infrastructure prioritization.

Based on the identified background and research gaps, this study aimed to analyze the priority sequence for handling primary local road bridge infrastructure in Bojonegoro Regency by considering various aspects and criteria using the AHP and TOPSIS methods. This study also aimed to compare the priority rankings generated by both methods and provide recommendations for bridge maintenance priorities to the Bojonegoro Department of Public Works and Spatial Planning. Theoretically, this research contributes to infrastructure management and decision support system studies by applying AHP and TOPSIS for bridge maintenance prioritization and enriching the literature on multi-criteria decision-making in the public sector. Practically, this research provides benefits for the Bojonegoro Department of Public Works and Spatial Planning in determining systematic and targeted bridge maintenance priorities, supports local governments in allocating infrastructure budgets efficiently, assists academics and researchers in developing decision-making approaches for infrastructure management, and contributes to improving bridge infrastructure quality for the community.

METHOD

The Analytical Hierarchy Process (AHP) is a structured multi-criteria decision-making method developed by Thomas L. Saaty to support complex decision-making processes (Saaty, 1993). The AHP method organizes decision problems into a hierarchical structure consisting of objectives, criteria, and alternatives. After establishing the hierarchy, pairwise comparisons are conducted to determine the relative importance of each criterion and alternative based on decision-maker judgments. The results of these comparisons are then used to calculate priority weights and determine the ranking of alternatives that best meet the research objectives (Saaty, 1993). The AHP weighting process consisted of the following steps:

a. Constructing the hierarchy in an AHP structural diagram
b. Creating a pairwise comparison matrix
c. Calculating the geometric mean to obtain a single matrix using the following equation:

GM =

$\sqrt{nX1'X2'} \ldots Xn$ ……...……………………………………………………...(1)

Where :

GM : Geometric Mean

X,X 2…, Xn : weight 1st, 2nd, 3rd,…n assessment

n : number n (order)

d. Determining the priority weights using eigenvector determination

e. Measuring logical consistency by testing the Consistency Index (CI) and the Consistency Ratio (CR) using the following formulas :

$$CI = \frac{\lambda_{\max} - n}{n-1} \quad \ldots$$

……...(2)

Where :

λ_{max} : Maximum Eigenvalue (sum of all evaluations)

n : number of elements

To calculate λ_{max} follow these steps (Marsono , 2020) :

a) Determine Vector [A] using :
   Vector [A] = Initial Matrix x Priority Weights (Eigenvector)………………..…(3)

b) Determine Vector [B] using :
   Vector [B] $= \frac{\text{Vector [A]}}{\text{Weights Priority}}$…………………………………………………………(4)

c) Compute λ_{max} (Maximum Eigenvalue)
   $\lambda_{max} = \frac{\text{Number of Elements in Matrix B}}{\text{n}}$
   ……………………………………………..….(5)
   Where :
   n : amount element

A randomly generated comparison matrix is absolutely inconsistent. From such a matrix, the Consistency Index value known as the Random Consistency Index (RI) can be determined (Saaty, 1993). The RI values are shown in Table 1:

Table 1. Values Random Consistency Index (RI)

n	1	2	3	4	5	6	7	8	9	10
RI	0	0	0.52	0.89	1.11	1.25	1.35	1.4	1.45	1.49

Source : Saaty, 1993

By comparing CI to RI, the level of consistency of a matrix can be assessed. The reference is the Consistency Ratio (CR), formulated as (Saaty, 1993):

$$CR = \frac{CI}{RI}$$

……………………………………………………………………………………(6)

Element comparisons are considered consistent if the CR value does not exceed 10% (CR ≤ 0.1). If CR > 10%, it indicates possible random or inconsistent judgments, and revisions may be needed (Suryadi, 1998).

f. Create a global priority

g. Make a decision

TOPSIS is a multi-criteria decision-making method first introduced by Yoon and Hwang (1981). It operates on the principle that the best alternative is the one closest to the positive ideal solution and farthest from the negative ideal solution, using Euclidean distance as the measurement (Syahputra et al., 2021)

Steps in the TOPSIS method include :

a. Normalization Decision Matrix

TOPSIS requires performance ranking every Ai alternative on every criteria Normalized Cj , namely :

$$r_{ij} = \frac{xij}{\sqrt{\sum_{i-1}^{m} x_{ij}^{2}}}$$

…...……………………………………………………………….......(7)

with i = 1,2,... .m; and j=1,2,......n;

b. Normalized weighted decision matrix

Normalized weighted decision matrix counted with equality as following :

$$y_{ij} = W_{i} r_{ij}$$

…………………………………………………………………….........(8)

with i = 1,2,... ,m and j=1,2,...,n

c. Positive and Negative Ideal Solutions

Positive ideal solution A+ and the negative ideal solution A- can be determined based on weight ranking normalized (yij) as follows:

$$A^{+} = (y_{1}^{+}, y_{2}^{+}, \dots, y_{n}^{+});$$

...………...……………………………………………………….…(9)

$$A^{-} = (y_{1}^{-}, y_{2}^{-}, \dots, y_{n}^{-});$$

………………...………………………………………………….…(10)

Where :

y+j is max yij , if j is benefit criteria.

y+j is min yij , if j is cost criteria.

yj is min yij , if j is benefit criteria.

yj is max yij , if j is cost criteria.

d. Distance To Ideal Solution

The distance is Ai alternative with positive ideal solution formulated as :

$$D_{i}^{+} = \sqrt{\sum_{j-1}^{x} (y_{i}^{+} - y_{ij})}$$

……………..…………………………………………………...(11)

$$D_i^- = \sqrt{\sum_{j-1}^{x}(y_{ij} - y_i^-)}$$
……………..……………………………………………………….(12)

Where :

i =1, 2, . . .m

e. Preference Value for Each Alternative

Preference Value for Each Alternative (Vi) is given as :

$$V_i = \frac{D_i^-}{D_i^- + D_i^+}$$
………………………………………………………………………….(13)

Where :

i =1, 2, . . .m

Higher Vi value indicates a more preferred alternative.

RESULTS AND DISCUSSION

The data used in this study were obtained from questionnaires distributed to 30 respondents. After data collection, an analysis was conducted to determine the priority handling of bridge infrastructure on Primary Local Roads in Bojonegoro Regency. The respondents were selected using a purposive sampling method, meaning they were chosen based on specific criteria: holding leadership positions, having knowledge, and possessing competence in the field of bridge infrastructure and related matters.

The results of the analysis using both the AHP and TOPSIS methods produced a priority ranking for bridge maintenance, where each bridge is ordered based on its calculated weight from each method. The results of the AHP method can be seen in Table 2, and the results of the TOPSIS method can be seen in Table 3

Table 2. Priority Results for Bridge Handling Using AHP Method

No	Bridge	Alternative	Weight
1	Bridge Sambeng - Kedewan 19	E3	0.506
2	Bridge Sambeng - Besah 5	E2	0.157
3	Bridge Sumberrejo - Kepohkidul 2	E5	0.115
4	Bridge Watujago - Bobol 3	E6	0.106
5	Bridge Sidobandung - Sepat 6	E4	0.094
6	Bridge Kapas - Sampang 1	E1	0.023

Source : Analysis Results , 2025

From Table 2 above obtained priority handling AHP method bridge according to order is Bridge Sambeng - Kedewan 19 (0.506), Bridge Sambeng - Besah 5 (0.157), Bridge Sumberrejo - Kepohkidul 2 (0.115), Bridge Watujago – Bobol 3 (0.106), Bridge Sidobandung - Sepat 6 (0.094) and Bridge Kapas - Sampang 1 (0.023).

Table 3. Priority Results for Bridge Handling Using TOPSIS Method

No	Bridge	Alternative	Weight
1	Bridge Sambeng - Kedewan 19	E3	1,000
2	Bridge Watujago - Bobol 3	E6	0.280
3	Bridge Sambeng - Besah 5	E2	0.116
4	Bridge Sumberrejo - Kepohkidul 2	E5	0.098
5	Bridge Sidobandung - Sepat 6	E4	0.069
6	Bridge Kapas - Sampang 1	E1	0,000

Source : Analysis Results , 2025

From Table 3 above obtained priority handling TOPSIS method bridge according to order is Bridge Sambeng - Kedewan 19 (1,000), Bridge Watujago – Bobol 3 (0.280), Bridge Sambeng - Besah 5 (0.116), Bridge Sumberrejo - Kepohkidul 2 (0.098), Bridge Sidobandung - Sepat 6 (0.069) and Bridge Kapas - Sampang 1 (0.000).

CONCLUSION

The priority sequence for bridge maintenance based on the AHP method analysis was Bridge Sambeng–Kedewan 19, Bridge Sambeng–Besah 5, Bridge Sumberrejo–Kepohkidul 2, Bridge Watujago–Bobol 3, Bridge Sidobandung–Sepat 6, and Bridge Kapas–Sampang 1. Meanwhile, the priority sequence based on the TOPSIS method analysis was Bridge Sambeng–Kedewan 19, Bridge Watujago–Bobol 3, Bridge Sambeng–Besah 5, Bridge Sumberrejo–Kepohkidul 2, Bridge Sidobandung–Sepat 6, and Bridge Kapas–Sampang 1. Future research should consider comparing additional decision support methods to improve the evaluation framework and provide more comprehensive infrastructure prioritization analyses.

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