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Provincial Road Management under Fiscal Stress and Post-Disaster Conditions: A Multi-Criteria Approach

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ABSTRACT

This study aims to develop a multi-criteria prioritization framework for provincial road maintenance and rehabilitation under conditions of fiscal stress and post-disaster recovery needs in Aceh Province, Indonesia. A Multi-Criteria Decision Making (MCDM) approach was applied by integrating the Analytic Hierarchy Process (AHP) for criteria weighting and the Technique for Order of Preference by Similarity to Ideal Solution (TOPSIS) for ranking 84 provincial road segments across six main criteria: road technical condition, traffic volume, economic importance, accessibility and social aspects, development policy, and strategic area value, based on aggregated expert judgments from nine respondents representing three key agencies. The results indicate that development policy, road technical condition, and accessibility and social aspects emerged as the most influential criteria, with priority segments concentrated along corridors requiring recovery-oriented interventions. Validation against expert judgment yielded a high Spearman rank correlation (ρ = 0.9021), confirming the consistency and stability of the model. This study contributes by applying an AHP-TOPSIS framework to provincial road prioritization under fiscal constraints, while incorporating post-disaster damage and institutional priorities into the criteria structure.

INTRODUCTION

Transportation infrastructure plays a central role in regional development because it supports economic growth, facilitates the movement of goods and people, and strengthens interregional connectivity (Aschauer, 1989; Calderón & Servén, 2004; Donaldson, 2018). Global development agendas also emphasize inclusive and sustainable growth and recognize infrastructure quality and resilience as key enablers of these goals (United Nations Development Programme, 2025). In response, many countries have adopted performance-based approaches to road network management that rely on condition data, service indicators, and performance targets to guide maintenance and investment decisions (Broniewicz & Ogrodnik, 2021; Organisation for Economic Co-operation and Development, 2018). Such approaches are shown to improve maintenance efficiency and reduce life-cycle costs when they are implemented using transparent and data-driven procedures (Liu et al., 2024; Nautiyal & Sharma, 2022).

Multi-criteria decision-making (MCDM) methods have become an important component of these data-driven approaches. MCDM provides a structured way to combine quantitative indicators and expert judgments, thereby reducing the dominance of purely subjective considerations in preparing road intervention programs (Anastasiadou & Kehagia, 2025; Broniewicz & Ogrodnik, 2021). Integrated weighting and ranking procedures such as AHP and TOPSIS have been applied in transport and other sectors, and have been shown to generate consistent and traceable priority lists that can support decision makers under resource constraints (Ghaffar & Indrawati, 2024; Reffinda Melati & Indrawati, 2024; Sharma et al., 2025)

In Aceh Province, the need for such structured approaches has increased as fiscal capacity for road programs has declined. Intergovernmental transfer reductions and national fiscal policy adjustments have contributed to a sharp decrease in the provincial road management budget, from more than IDR 1.2 trillion in 2021-2022 to about IDR 116.76 billion in 2025 (Dinas PUPR Aceh, 2025; Kementerian Keuangan Republik Indonesia, 2025). This contraction is also consistent with the gradual reduction of special autonomy transfers under Law of the Republic of Indonesia No. 11 of 2006 on the Governance of Aceh, which reduces the share of nationally allocated funds available to Aceh over time (Dadek, 2022).

From a prioritization perspective, this tighter fiscal environment implies that each funding decision carries a greater opportunity cost. Under these conditions, structured multi-criteria approaches become increasingly important to help ensure that limited resources are allocated to road segments with the highest combined technical and socio-economic importance (Khan et al., 2023; Panwar & Sen, 2019).

This downward trend is illustrated in Figure 1, which shows the contraction of the provincial road management budget between 2021 and 2025. The reduction in financing capacity limits the number of road sections that can be handled each year and requires the provincial government to be more selective in allocating maintenance and rehabilitation funds, while reliance on routine practices or single-criterion considerations risks misaligning scarce budgets with the most urgent needs.

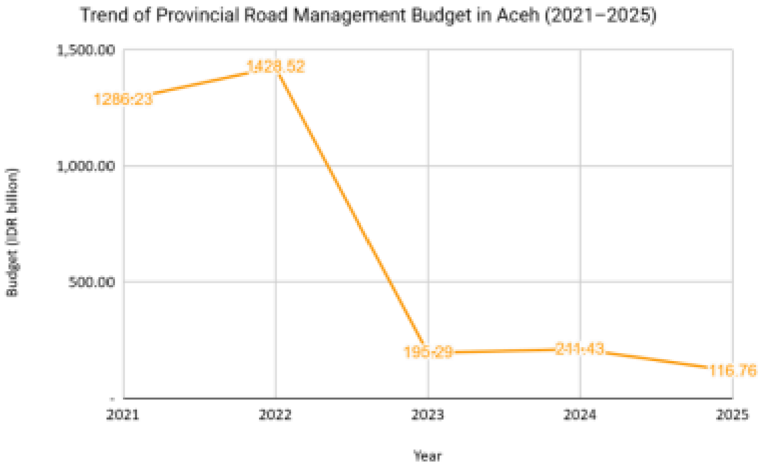

Figure 1. The downward trend of road management budget allocation in Aceh Province.
Source: Aceh Public Works and Spatial Planning Agency (2025)

At the same time, Aceh has recently experienced large-scale hydrometeorological events that have intensified pressure on the provincial road network. Floods and landslides at the end of 2025 caused extensive damage to roads and bridges and disrupted access to basic services, creating an urgent backlog of recovery-oriented interventions (Badan Nasional Penanggulangan Bencana, 2025; Pemerintah Aceh, 2025). Disaster-related disruptions increase recovery requirements and raise the risk of medium-term performance degradation when timely interventions are not implemented (Du et al., 2023). Under fiscal constraints, delays in post-disaster maintenance and rehabilitation have been associated with reduced service effectiveness and higher long-term economic and financial burdens in infrastructure programs

(Amin et al., 2022; Zheng et al., 2019). Recent statistics also indicate that inflationary pressures are somewhat higher in disaster-affected inland areas than at the provincial level, suggesting that disrupted road accessibility may contribute to higher distribution costs and localized price tensions, even though these relationships warrant further empirical investigation (Badan Pusat Statistik Kabupaten Aceh Tengah, 2026; Badan Pusat Statistik Provinsi Aceh, 2026).

In such a recovery-oriented context, accessibility and social service continuity may become more salient in the prioritization process than traffic-related or marginal service improvement indicators. This expectation is consistent with MCDM studies showing that road prioritization criteria are shaped by stakeholder objectives, local development needs, and the limitations of conventional traffic- or condition-based approaches, although the specific post-disaster weighting structure in Aceh is examined empirically in this study (Arifin et al., 2025; Bošnjak & Jajac, 2023; Chaipetch et al., 2025; Jumas et al., 2024).

Previous studies on MCDM-based road prioritization generally focus on methodological development and technical optimization under relatively stable budget conditions (Bafail & Abdulaal, 2022; Broniewicz & Ogrodnik, 2021; Chen & Zheng, 2021; Liu et al., 2024; Nautiyal & Sharma, 2022). Many previous MCDM-based road prioritization studies emphasize pavement or road condition, traffic-related indicators, and maintenance performance, with economic, accessibility, policy, safety, or land-use variables added to capture broader impacts (Arifin et al., 2025; Jumas et al., 2024; Kresnanto, 2022; Liu et al., 2024). However, they often give limited attention to provincial road prioritization under conditions of fiscal constraint and post-disaster recovery, particularly in developing-country contexts. Studies that examine road prioritization while jointly considering disaster-related recovery needs, fiscal limitations, and public-sector decision processes remain limited, particularly at the provincial government level in developing countries (Amin et al., 2022; Du et al., 2023). More recent applications of AHP-TOPSIS and related methods in road management show how multi-criteria tools can be adapted to incorporate stakeholder preferences and local policy objectives, but their treatment of disaster-related criteria and provincial-level fiscal conditions is still relatively limited (Bošnjak & Jajac, 2023; Chaipetch et al., 2025; Jumas et al., 2024).

Therefore, this research intends to develop a multi-criteria-based model for prioritizing provincial road maintenance and rehabilitation in Aceh, where limited fiscal capacity coincides with post-disaster recovery demands. The study integrates the Analytic Hierarchy Process (AHP) to derive criteria weights from expert judgments and the Technique for Order Preference by Similarity to Ideal Solution (TOPSIS) to rank 84 provincial road segments requiring intervention (Broniewicz & Ogrodnik, 2021; Hwang & Yoon, 1981; Liu et al., 2024; Saaty & Vargas, 2012). Furthermore, the model's prioritization results are validated against expert assessments using Spearman's rank correlation to examine the consistency of the recommendations (Conover, 1999; Prion & Haerling, 2014).

By structuring criteria and sub-criteria so that post-disaster recovery needs and institutional priorities are represented alongside technical and economic indicators, the proposed framework seeks to extend existing AHP-TOPSIS applications within a provincial road management context characterized by tightening budgets and recent disaster impacts, without claiming to fully capture all dimensions of public-sector decision-making (Chaipetch et al., 2025; Jumas et al., 2024; Direktorat Jenderal Bina Marga, 2017).

The objectives of this study are: (1) to identify and structure relevant criteria and sub-criteria for provincial road intervention priorities; (2) to determine the relative importance of these criteria using AHP; (3) to generate a transparent ranking of provincial road segments using TOPSIS with AHP-derived weights; and (4) to assess the agreement between model-based rankings and expert judgments so that the proposed framework can support evidence-based planning in provincial road network management.

LITERATURE REVIEW

Operations Management

Operations management is a branch of management science that explains how organizations systematically manage resources so that processes produce outputs which create value for beneficiaries (Heizer et al., 2023). In the public sector, operations are oriented toward social value and equitable service distribution, requiring transparency, accountability, and public participation in decision-making (Radnor et al., 2015). Osborne (2021) stresses that public institutions must focus not only on completing outputs but also on outcomes and impacts experienced by communities, so that planning, implementation, and performance reporting remain aligned with regional development objectives.

Infrastructure Operations

Presidential Regulation No. 38 of 2015 defines infrastructure as technical facilities, physical systems, and related hardware-software needed to provide public services and support socio economic networks. Argue that effective infrastructure management depends on understanding asset conditions, setting priorities, and maintaining service continuity, using data on life-cycle costs and integrating social and environmental aspects into operational decisions (Schraven et al., 2011). Consistent with this view, the 2025-2029 National Medium-Term Development Plan identifies stronger infrastructure governance as a strategic priority to enhance connectivity, resource-use efficiency, and public service reliability (Kementerian PPN/Bappenas, 2025).

Road Infrastructure

Road infrastructure is a key component of the transport system and plays a vital role in supporting mobility, economic activity, and equitable regional development. The national road network functions as the backbone of connectivity between economic centers and public services, but effective management also requires systematic preservation of existing roads so that service levels can be maintained over the planned life cycle (Litman, 2025). Fitriani (2025) notes that preservation must be based on data and clear prioritization to control long-term rehabilitation costs and sustain infrastructure performance.

Strategic Decision-Making in Operations Management

Strategic decisions in operations management determine how resources are allocated across key areas such as location, capacity, and maintenance, so that organizational objectives can be achieved efficiently and effectively (Heizer et al., 2023). In road infrastructure, location decisions identify which corridors should be prioritized, while maintenance strategies aim to maintain asset condition before severe deterioration occurs, in line with the technical procedures outlined in Ministry of Public Works Regulation No. 13/PRT/M/2011. Together, these decisions provide a basis for analytical regional infrastructure management that requires objective weighting of multiple criteria rather than relying on a single indicator (Fitriani, 2025).

Multi-Criteria Decision Making

Multi-Criteria Decision Making (MCDM) is an analytical framework that allows decision-makers to evaluate alternatives using several criteria that reflect different dimensions of a decision problem (Belton & Stewart, 2002; Triantaphyllou, 2000). MCDM methods help integrate quantitative indicators and qualitative expert judgments, so that decisions become more rational and defensible, and form an important foundation for decision support systems in public management (Saaty, 2008). In road infrastructure, studies show that MCDM can combine technical, economic, and social indicators within a single model, and that careful selection of MCDM methods improves the efficiency of maintenance programs under sustainability and budget constraints (Broniewicz & Ogrodnik, 2021; France-Mensah et al., 2019; Nautiyal & Sharma, 2022).

Analytic Hierarchy Process

The Analytic Hierarchy Process (AHP) is a multi-criteria decision framework that breaks complex problems into a hierarchy of goals, criteria, sub-criteria, and alternatives, and then applies pairwise comparisons on a 1-9 scale to derive relative weights (Saaty, 2008). Priority vectors are obtained using eigenvalue-based calculations, and the Consistency Index and Consistency Ratio are used to ensure that expert judgments remain within an acceptable consistency threshold (Saaty & Vargas, 2012). For group decisions, AHP aggregates individual comparison matrices using the geometric mean so that multiple expert views can be combined into a single, coherent set of weights without losing the underlying hierarchical logic (Forman & Peniwati, 1998). In Indonesia, applications of AHP in the transport sector have shown that expert judgments from multiple stakeholders can be integrated into consistent and defensible criteria weights, providing a practical basis for infrastructure decision-making (Bhirowo et al., 2025).

Technique for Order Preference by Similarity to Ideal Solution

The Technique for Order Preference by Similarity to Ideal Solution (TOPSIS) is a multi-criteria decision method that ranks alternatives based on their distance to a positive ideal solution and a negative ideal solution (Hwang & Yoon, 1981). Its procedure involves building a decision matrix, normalizing and weighting criteria, determining ideal and anti-ideal points for benefit and cost criteria, and calculating a relative closeness coefficient between 0 and 1 for each alternative. In road infrastructure prioritization, TOPSIS has been shown to yield consistent ranking results and stable outcomes across different criteria sets, and is often combined with AHP weights to evaluate large numbers of road segments efficiently (Sayadinia & Beheshtinia, 2021; Sharma et al., 2025).

Research Criteria Aspects

The selection of criteria in multi-criteria road prioritization determines which dimensions influence how each road segment is evaluated (Saaty, 2008; Triantaphyllou, 2000). Drawing on previous studies and the Circular Letter of the Directorate General of Highways No. 12/SE/Db/2017, this research adopts six main criteria groups for provincial road management: road technical condition, traffic volume and vehicle load, economic importance, accessibility and social aspects, development policy, and strategic area value (Alam Sur et al., 2025; Jumas et al., 2024). Technical condition and policy-related indicators such as governor priorities, the development planning forum (musrenbang) proposals, and national strategic directives, together with post-disaster damage under the accessibility dimension, ensure that prioritization reflects both physical urgency and recovery-oriented, equity-based development objectives (Fauzi et al., 2023; Fitriani, 2025).

Research Propositions

Building on the literature reviewed above and the conceptual linkage from operations management to road infrastructure and MCDM based prioritization, this study formulates three research propositions to guide the empirical analysis. The first proposition states that determining provincial road intervention priorities requires a set of evaluation criteria that is aligned with the technical condition of the network, regional development objectives, and the recovery needs of affected areas, so that each road segment can be assessed in a manner that reflects its local context. The second proposition states that applying the Analytic Hierarchy Process (AHP) to expert judgments will generate differentiated importance weights across criteria, and that these weights can be used as structured inputs for the TOPSIS ranking of road segments. The third proposition states that the priority ranking produced by the combined AHP-TOPSIS model will exhibit a sufficiently high level of agreement with expert judgments to serve as a credible analytic basis for recommending provincial road intervention programs.

METHOD

Population, Sample, and Data

The population of this study consists of the entire provincial road network under the authority of the Aceh Provincial Government, comprising 84 road sections as stipulated in Governor of Aceh Decree No. 600.1.8/603/2024 concerning the designation of provincial roads. All 84 road sections were included as alternatives in the AHP-TOPSIS model. Accordingly, the study applied a total sampling approach by using the complete population of provincial road sections as the analytical sample.

Secondary data for the 84 road sections were compiled from several institutional sources, including the Aceh Public Works and Spatial Planning Agency, the Aceh Regional Development Planning Agency, the Transportation Agency, health and higher education databases, Statistics Indonesia, regional budget documents, and post-disaster assessment reports. Budget data for the provincial road program covered the 2021-2025 period to reflect changes in regional fiscal capacity, while post-disaster damage data were updated using field assessment reports finalized in early 2026 to represent recent recovery-related conditions. The TOPSIS decision matrix was constructed from the selected road performance, accessibility, policy, economic, and post-disaster indicators, while budget data were used to contextualize the fiscal constraints surrounding the prioritization process.

Expert Selection and Characteristics

This study involved nine experts who participated in the AHP weighting process. The experts were selected from institutions that, under Governor of Aceh Regulation No. 1/2024 concerning the organizational structure, duties, and functions of provincial government agencies, are involved in the planning, implementation, coordination, and oversight of provincial road infrastructure, namely the Aceh Public Works and Spatial Planning Agency, the Aceh Regional Development Planning Agency, and Commission IV of the Aceh Regional House of Representatives. For the legislative institution, Commission IV was included because, according to the Decision of the Leadership of the Aceh Regional House of Representatives No. 2/P-I/DPRA/2020 concerning the duties and working partners of the commissions, it is responsible for development and spatial-planning affairs, including transport and public works. The panel consisted of three representatives from each institution who occupy structural or functional positions related to road program management, development planning, infrastructure budgeting, and policy coordination. The equal composition of experts from each institution was intended to maintain balance among the institutional perspectives involved in provincial road governance. Although the technical institution had ten eligible officials who met the selection criteria, only three representatives were selected to align with the number of representatives from the planning and legislative institutions.

Experts were selected using purposive sampling based on their institutional roles, involvement in provincial road planning and budgeting processes, and experience related to road program formulation and oversight. The selection was intended to incorporate perspectives from technical, planning, and policy-budget institutions that are directly associated with provincial road management in Aceh. Each expert completed an individual AHP pairwise-comparison questionnaire, and responses that satisfied the accepted consistency threshold were retained for analysis. The individual judgments were subsequently aggregated using the geometric mean through the Aggregation of Individual Judgments (AIJ) approach to obtain collective weights for the criteria and sub-criteria. In the Spearman rank-correlation validation stage, the reference ranking of road segments was provided by the Head of the Aceh Public Works and Spatial Planning Agency, considering the institutional authority and direct involvement of the agency in the coordination and implementation of provincial road management programs.

Criteria Structure

The criteria and sub-criteria were developed from international and national literature on MCDM-based road prioritization and national technical guidelines, particularly the Circular Letter of the Directorate General of Highways No. 12/SE/Db/2017 (Abu Dabous et al., 2020; Amin et al., 2022; Nautiyal & Sharma, 2022; Sharma et al., 2025). Six main criteria are used in this study: road technical condition, traffic volume, economic importance, accessibility and social aspects, development policy, and strategic area value, each operationalized through one or more quantitative sub-criteria. The complete structure of criteria, sub-criteria, and indicators is summarized in Table 1.

Table 1. Structure of criteria, sub-criteria, and indicators

Criteria	Sub-criteria	Indicator
Road Technical Condition (C1)	Poor Road Condition (SC1)	Length of roads in poor condition
Traffic Volume (C2)	Average VCR (Volume Capacity Ratio) (SC2)	Ratio between traffic volume and road capacity to indicate congestion level
Economic Importance (C3)	Access to Seaport (SC3)	Proximity of road sections to seaports based on their classification
	Access to Airport (SC4)	Proximity of road sections to airports based on their classification
	Access to Terminal (SC5)	Proximity of road sections to bus terminals based on their classification
	GRDP (Gross Regional Domestic Product) per Capita (SC6)	Average regional income per capita in each district/city
Accessibility and Social Aspects (C4)	Access to Hospital (SC7)	Proximity of road sections to hospitals based on service class (A, B, C, and D).
	Access to University (SC8)	Road sections located near higher education institutions
	Connected to National Road Network (SC9)	Road sections connected to or located near the national road network
	Post-Disaster Damage (SC10)	Level of road damage caused by disasters that requires recovery actions
Development Policy (C5)	Governor's Priority (SC11)	Road sections included in the governor's priority programs
	Development Planning Forum (Musrenbang) (SC12)	Road sections proposed through the Musrenbang process
	National Strategic Direction (SC13)	Road sections supporting national development programs
Strategic Area Value (C6)	Strategic Area (SC14)	Number of strategic areas crossed by the road section
	Cultivation Area (SC15)	Number of cultivation areas crossed by the road section

As shown in Table 1, the criteria structure integrates road technical condition, traffic volume, economic importance, accessibility and social aspects, development policy, and strategic area value into a unified evaluation framework. The inclusion of post-disaster damage within the accessibility and social dimension highlights the need to incorporate recovery considerations into infrastructure prioritization. Meanwhile, policy-related indicators such as governor priorities and Musrenbang proposals ensure alignment with institutional planning processes. This structure enables the prioritization model to capture both network performance needs and governance-driven priorities within the provincial context.

AHP Weighting

Expert judgments on the relative importance of criteria and sub-criteria were obtained from nine experts representing technical implementation, planning, and policy institutions involved in provincial road management. The decision problem was structured into a hierarchy consisting of the overall goal, six main criteria, fifteen sub-criteria, and 84 alternative road segments. Pairwise comparisons were conducted using the standard 1-9 AHP scale to assess the relative importance of each criterion and sub-criterion, and individual comparison matrices were developed for both the main criteria and the sub-criteria under each criterion (Saaty & Vargas, 2012).

To obtain collective weights, the individual matrices were aggregated using the Aggregation of Individual Judgments (AIJ) approach based on the geometric mean, which is commonly recommended for ratio-scale judgments in group AHP applications (Forman & Peniwati, 1998). For each pairwise comparison, the group judgment was calculated as $GM = \sqrt[n]{(X_1)(X_2)\dots(X_n)}$ represent the judgments provided by the n experts for a given comparison. The geometric mean was used because it maintains the reciprocal properties of the pairwise comparison matrix and is consistent with the multiplicative structure of the AHP ratio scale. In addition, this approach helps reduce the influence of extreme individual judgments compared to the arithmetic mean. The aggregated matrices were subsequently processed to derive eigenvector-based priority weights for all criteria and sub-criteria.

The consistency of expert judgments was evaluated using the Consistency Ratio (CR), calculated as the ratio between the Consistency Index and the corresponding Random Index, with an acceptable threshold of CR≤0.10 (Saaty & Vargas, 2012). Individual matrices were first examined against this threshold, and only matrices that satisfied the consistency requirement were retained for aggregation. Experts whose comparisons exceeded the threshold were asked to revise their judgments in accordance with the research procedure.

AHP computations, including data entry, geometric mean aggregation, eigenvector extraction, and consistency testing, were performed using Analytic Hierarchy Process Software version 4.2.7 (SpiceLogic). In the initial stage, the pairwise comparison matrix from each expert was entered individually into the software. The Group Decision feature was then used by selecting the AIJ (Aggregation of Individual Judgments) option and setting the aggregation method to weighted geometric mean. In this configuration, each expert was assigned a relative priority value of 1, so that the final group judgment reflected equal weighting across experts while preserving the reciprocal structure of the pairwise comparison matrices. The resulting global sub-criteria weights, obtained by multiplying each sub-criterion's local weight by the weight of its parent criterion, were then used as inputs for the TOPSIS ranking procedure.

TOPSIS Ranking

Before applying TOPSIS, a decision matrix was constructed for 84 provincial road segments across fifteen sub-criteria, combining quantitative indicators with accessibility and policy-related variables. In this study, all sub-criteria were treated as benefit criteria, meaning that higher values indicate greater importance or urgency for intervention, except GRDP per capita, which was modeled as a cost criterion because roads located in lower-income regions were considered to require greater development attention. This categorization reflects the principle of equitable development, where infrastructure intervention is directed toward areas with relatively lower economic capacity. The approach is also consistent with Mission 4 of the Aceh Government concerning equitable basic infrastructure development and the sixth Asta Cita agenda, which emphasizes development from underdeveloped regions to support more balanced economic growth (Kementerian PPN/Bappenas, 2025; Qanun Aceh Nomor 10 Tahun 2025 Tentang Rencana Pembangunan Jangka Menengah Aceh Tahun 2025 - 2029, 2025).

The TOPSIS procedure in this study consisted of the following stages (Triantaphyllou, 2000):

1. **Constructing the decision matrix**. A decision matrix $X = \left[x_{ij}\right]$ was developed, where each element represents the performance value of alternative i under criterion j.
2. **Normalizing the decision matrix**. Because the criteria were measured using different units and scales, the decision matrix was normalized using vector normalization to ensure comparability among criteria, expressed as $r_{ij} = \frac{x_{ij}}{\sqrt{\sum_{i=1}^{m} x_{ij}^2}}$.
3. **Obtaining the weighted normalized matrix**. The normalized values were multiplied by the AHP weights to produce the weighted normalized matrix, formulated as $v_{ij} = w_j \cdot r_{ij}$. This stage incorporates both the performance value of each alternative and the relative importance of each criterion.

4. **Defining benefit and cost criteria and determining ideal solutions**. Each criterion was classified either as a benefit criterion, where higher values indicate better performance, or as a cost criterion, where lower values are preferred. Based on this classification, the positive ideal solution $A_j^+ = \begin{cases} \max_i(v_{ij}), & Benefit \\ \min_i(v_{ij}), & Cost \end{cases}$ and negative ideal solution $A_j^- = \begin{cases} \min_i(v_{ij}), & Benefit \\ \max_i(v_{ij}), & Cost \end{cases}$. The positive ideal solution represents the most desirable condition, whereas the negative ideal solution reflects the least desirable condition for each criterion
5. **Calculating the separation distances**. The Euclidean distance of each alternative to the positive and negative ideal solutions was calculated using $D_i^+ = \sqrt{\sum_{j=1}^{n}(v_{ij} - A_j^+)^2}$ and $D_i^- = \sqrt{\sum_{j=1}^{n}(v_{ij} - A_j^-)^2}$.
6. **Computing the preference value**. The relative closeness coefficient was then calculated as $C_i = \frac{D_i^-}{D_i^+ + D_i^-}$. Alternatives with higher coefficient values are considered closer to the positive ideal solution and farther from the negative ideal solution, indicating higher priority in the final ranking.

Categorical indicators were first transformed into quantitative scores before the normalization stage. Accessibility-related variables were coded using ordinal scales that reflect increasing levels of access or service quality, where higher scores indicate greater strategic importance. The scoring ranges followed the classifications established in the relevant national regulations, including Government Regulation No. 31 of 2021 on ports, Government Regulation No. 32 of 2021 on airports, Minister of Transportation Regulation No. 24 of 2021 on road transport terminals, and hospital classifications reported in the national hospital information system during the transition between Government Regulation No. 47 of 2021 and Government Regulation No. 28 of 2024. Binary variables related to accessibility and policy alignment were coded as 1 when the attribute was present and 0 otherwise. Meanwhile, strategic and cultivation area variables were measured based on the number of designated areas crossed by each road segment according to the draft Aceh Spatial Plan (RTRW). After the transformation process, all variables were integrated into a single decision matrix and processed using the same normalization and weighting procedures within the TOPSIS analysis.

Validation

To assess the consistency of the model outputs, Spearman's rank correlation was used to compare the AHP-TOPSIS ranking with expert judgments and with the standalone AHP ranking (Conover, 1999; Prion & Haerling, 2014). The test was applied to all 84 road segments, and tied ranks were handled using average ranks, providing evidence on how closely the multi-criteria model reflects expert perceptions and whether the combined AHP-TOPSIS approach shows closer alignment with expert judgment than the standalone AHP approach.

RESULT AND DISCUSSION

RESULTS

Criteria Weights

After conducting the calculations using the AHP software developed by SpiceLogic, the criteria weighting results were obtained as presented in Table 2. The development policy criterion received the highest weight, followed by road technical condition and accessibility and social aspects, while traffic volume had the lowest weight. This pattern suggests that strategic and policy-driven considerations were prioritized over purely operational traffic indicators in the weighting structure. These results served as the basis for calculating the global weights of the sub-criteria in the TOPSIS analysis.

Table 2. Criteria weights based on AIJ method

Rank	Criteria	AIJ weight
1	Development Policy (C5)	0.3003

Rank	Criteria	AIJ weight
2	Road Technical Condition (C1)	0.2300
3	Accessibility and Social Aspects (C4)	0.1879
4	Economic Importance (C3)	0.1736
5	Strategic Area Value (C6)	0.0693
6	Traffic Volume (C2)	0.0387

The weighting results, as presented in Table 2, indicate that policy-related considerations play a dominant role in the prioritization framework, followed by physical road condition and accessibility factors. This suggests that infrastructure planning decisions in the study context are influenced not only by technical performance but also by broader development direction and service needs. Meanwhile, the relatively low weight assigned to traffic volume reflects that operational flow alone was not considered sufficient to represent urgency in road handling.

Sub-criteria Weights

The global weights of each sub-criterion, which were used as inputs for the TOPSIS calculation, are presented in Table 3. The sub-criteria poor road condition, governor's priority, development planning forum (musrenbang), and post-disaster damage ranked among the highest-weighted sub-criteria, indicating the prominence of technical urgency and policy-driven considerations related to post-disaster damage within the prioritization framework.

Table 3. Sub-criteria weights and global ranking results

Criteria	Sub-criteria	Local weight	Global weight	Global rank
Road Technical Condition (C1)	Poor Road Condition (SC1)	1,0000	0,2300	1
Traffic Volume (C2)	Average VCR (SC2)	1,0000	0,0387	9
Economic Importance (C3)	Access to Seaport (SC3)	0,2750	0,0477	7
	Access to Airport (SC4)	0,1665	0,0289	12
	Access to Terminal (SC5)	0,4670	0,0810	5
	GRDP per Capita (SC6)	0,0913	0,0158	14
Accessibility and Social Aspects (C4)	Access to Hospital (SC7)	0,1587	0,0298	11
	Access to University (SC8)	0,0793	0,0149	15
	Connected to National Road Network (SC9)	0,1978	0,0371	10
	Post-Disaster Damage (SC10)	0,5640	0,1060	4
Development Policy (C5)	Governor's Priority (SC11)	0,4326	0,1299	2
	Development Planning Forum (Musrenbang) (SC12)	0,4223	0,1268	3
	National Strategic Direction (SC13)	0,1450	0,0435	8
Strategic Area Value (C6)	Strategic Area (SC14)	0,6944	0,0481	6
	Cultivation Area (SC15)	0,3055	0,0211	13

The global ranking results, as presented in Table 3, show that sub-criteria related to physical road condition and development policy play a dominant role in shaping the prioritization structure. Poor road condition (SC1), governor's priority (SC11), and musrenbang proposals (SC12) consistently rank among the most influential factors, indicating that both technical urgency and policy direction strongly influence the determination of intervention priorities. In addition, post-disaster damage (SC10) also emerges as a key consideration, underscoring the significance of recovery needs within the overall decision-making framework.

TOPSIS-Based Ranking Results

The TOPSIS analysis generated preference values for each road segment, which were used to establish the priority order for road maintenance and rehabilitation. The ten road segments with the highest preference values are presented in Table 4.

Table 4. Top ten priority road segments based on the AHP-TOPSIS model

Priority rank	Road segment code	Road segment name	D^+ (distance to A^+)	D^- (distance to A^-)	Preference score (C)
1	P. 035.11	Jl. Peureulak - Lokop - Batas Gayo Lues	0.0426	0.1356	0.7607
2	P. 038.11	Jl. Blangkejeren - Tongra-Batas Aceh Barat Daya	0.0589	0.0962	0.6202
3	P. 035.12	Jl. Batas Aceh Timur - Pining - Blangkejeren	0.0652	0.0897	0.5792
4	P. 056.12	Jl. Nasreuhe - Lewak -Sibigo	0.0858	0.0820	0.4886
5	P. 029.12	Jl. Batas Aceh Utara - Bandara Rembele	0.0937	0.0625	0.4000
6	P. 029.11	Jl. Krueng Geukueh - Batas Bener Meriah	0.0962	0.0629	0.3955
7	P. 041	Jl. Isaq - Jagong Jeget - Simpang Gelelungi	0.0923	0.0595	0.3920
8	P. 042.11	Jl. Simpang Lawe Deski - Muara Situlen - Batas Kota Subulussalam	0.0946	0.0582	0.3810
9	P. 029.16	Jl. Bintang - Simpang Kraft	0.1005	0.0508	0.3358
10	P. 045.13	Jl. Batas Aceh Selatan - Kuala Baru - Singkil - Telaga Bakti	0.1043	0.0527	0.3357

As shown in Table 4, the five highest-ranked road segments based on the TOPSIS preference values are Peureulak-Lokop-Batas Gayo Lues (P.035.11), Blangkejeren-Tongra-Batas Aceh Barat Daya (P.038.11), Batas Aceh Timur-Pining-Blangkejeren (P.035.12), Nasreuhe-Lewak-Sibigo (P.056.12), and Batas Aceh Utara-Bandara Rembele (P.029.12). These segments recorded the highest closeness coefficients, indicating stronger proximity to the ideal solution compared to other alternatives.

AHP Ranking Results

In addition to TOPSIS, priority assessment was also conducted using the standalone AHP method through weighted summation. The ten highest-ranked road segments based on the AHP model are presented in Table 5.

Table 5. Top ten priority road segments based on the AHP model

Priority rank	Road segment code	Road segment name	AHP score
1	P. 035.11	Jl. Peureulak - Lokop - Batas Gayo Lues	0.7405
2	P. 038.11	Jl. Blangkejeren - Tongra-Batas Aceh Barat Daya	0.6247
3	P. 029.11	Jl. Krueng Geukueh - Batas Bener Meriah	0.6053

Priority rank	Road segment code	Road segment name	AHP score
4	P. 035.12	Jl. Batas Aceh Timur - Pining - Blangkejeren	0.5993
5	P. 056.12	Jl. Nasreuhe - Lewak - Sibigo	0.5206
6	P. 024.12	Jl. Batas Pidie - Meulaboh	0.4815
7	P. 045.13	Jl. Batas Aceh Selatan - Kuala Baru - Singkil - Telaga Bakti	0.4749
8	P. 029.12	Jl. Batas Aceh Utara - Bandara Rembele	0.4723
9	P. 036	Jl. Batas Aceh Timur - Kota Karang Baru	0.3854
10	P. 029.13	Jl. Bandara Rembele - Batas Aceh Tengah	0.3835

Table 5 indicates that the five highest-ranked road segments based on the AHP scores are Peureulak-Lokop-Batas Gayo Lues (P.035.11), Blangkejeren-Tongra-Batas Aceh Barat Daya (P.038.11), Krueng Geukueh-Batas Bener Meriah (P.029.11), Batas Aceh Timur-Pining-Blangkejeren (P.035.12), and Nasreuhe-Lewak-Sibigo (P.056.12). While several segments are consistent with the TOPSIS results, the AHP ranking highlights a slightly different ordering, reflecting its reliance on aggregated weighting rather than distance-based evaluation.

Validation Results Using Spearman's Rank Correlation

Validation of ranking consistency was performed by comparing the prioritization results generated by the AHP-TOPSIS model, the standalone AHP method, and expert judgment using Spearman's rank correlation coefficient. The analysis was conducted for $n = 84$ road segments. A summary of the consistency test results is presented in Table 6.

Table 6. Results of spearman's rank correlation analysis

Comparison	Spearman's ρ	p-value
AHP-TOPSIS vs. Expert Judgment	0.9021	< 0.001
AHP vs. Expert Judgment	0.8505	< 0.001
AHP-TOPSIS vs. AHP	0.9206	< 0.001

The results of the Spearman correlation analysis, as presented in Table 6, indicate a very strong relationship between the AHP-TOPSIS results and expert judgment ($\rho = 0.9021$, $p < 0.001$). The correlation between the standalone AHP results and expert judgment also demonstrates a strong relationship ($\rho = 0.8505$, $p < 0.001$). In addition, the correlation between AHP-TOPSIS and AHP reaches $\rho = 0.9206$ ($p < 0.001$), indicating a very high level of consistency between the two methods. These findings suggest that the proposed AHP-TOPSIS model produces ranking outcomes that are closely aligned with expert assessments and alternative weighting approaches.

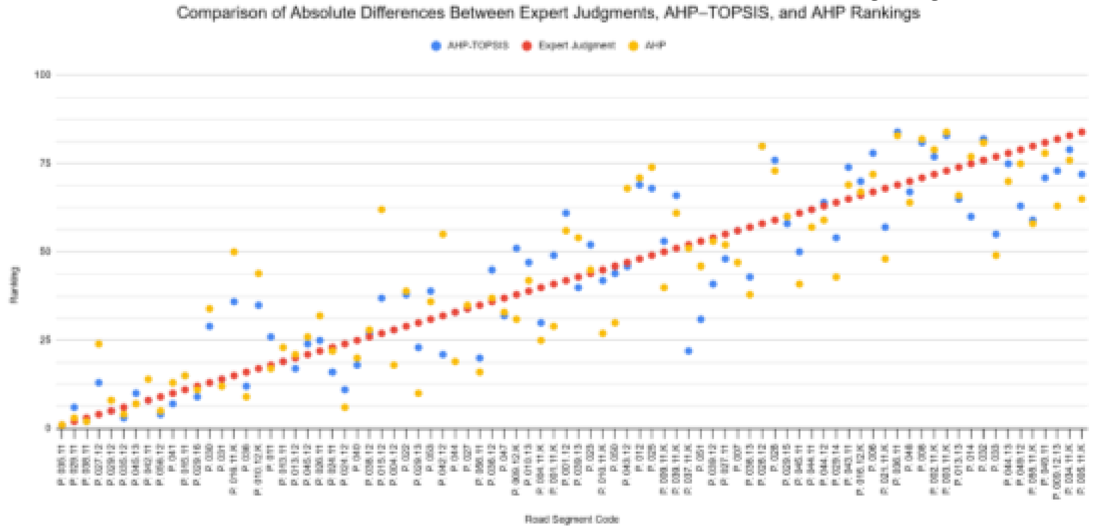

Figure 2. Comparison of absolute ranking differences between AHP-TOPSIS, Expert Judgment, and AHP methods across road segment codes

The relationships among the rankings obtained from AHP-TOPSIS, AHP, and expert judgment are visualized in Figure 2. The scatter plots show a strong positive association, with most data points clustered around the regression line. This pattern indicates a high level of consistency among the proposed model, practitioner assessments, and the standalone AHP approach. The visualization reinforces the spearman correlation results and demonstrates that the developed prioritization framework is consistent with expert assessments.

DISCUSSION

This study is based on provincial road budget data and related planning documents covering the 2021-2025 period. Meanwhile, data for the selected AHP-TOPSIS sub-criteria were compiled using January 2026 data obtained from various sectoral institutions, including the Aceh Public Works and Spatial Planning Agency, the Aceh Transportation Agency, the Aceh Regional Development Planning Agency, the Ministry of Health of the Republic of Indonesia, the Higher Education Database (PDDikti) under the Ministry of Higher Education, Science, and Technology, and Statistics Indonesia for Aceh Province. Consumer Price Index (CPI) data for January 2026 were obtained separately from Statistics Indonesia for Aceh Province and Central Aceh Regency. Accordingly, the analysis is intended to examine prioritization patterns under the fiscal and post-disaster conditions observed during the study period, rather than to predict future budgetary or economic developments.

Interpretation of Main Findings

The AHP-TOPSIS ranking results indicate a concentration of priority road segments along corridors leading to central Aceh. Eight of the top ten prioritized segments are directed toward the central region of the province, while the remaining two are located in the southwestern sector, namely Jl. Nasreuhe-Lewak-Sibigo and Jl. Batas Aceh Selatan-Kuala Baru-Singkil-Telaga Bakti. In addition, only one road segment among the top ten, Jl. Nasreuhe-Lewak-Sibigo, was not affected by hydrometeorological disasters. This segment appears in the top-ten list largely in association with the extensive length of damaged sections, suggesting that damage extent remains a significant factor influencing ranking outcomes in the proposed model.

The dominance of policy-related sub-criteria, such as governor's priority and the development planning forum (musrenbang), together with the high weight assigned to post-disaster damage, is reflected in the concentration of priority corridors toward central Aceh. The combination of post-disaster socio-economic recovery needs and strong regional policy support is associated with the higher rankings of these road segments within the recovery-oriented budgeting context. These findings suggest that technical considerations alone may be insufficient, as the urgency of accelerating post-disaster recovery appears to play an important role in shaping prioritization outcomes in the Aceh context.

Linkage between the Results and the Consumer Price Index (CPI)

The latest data released by Badan Pusat Statistik Provinsi Aceh (2026) indicate that the Consumer Price Index (CPI) of Aceh Province in January 2026 reached 6.69%, with the food group identified as the main contributor to inflation. Meanwhile, data from Badan Pusat Statistik Kabupaten Aceh Tengah (2026) show that the CPI in the central Aceh region reached 8.60% during the same period, with a substantially higher contribution from the food group, estimated at approximately 7.65%. In contrast, the contribution of the food group at the provincial level was recorded at around 2.46%.

This disparity is consistent with the assumption that disrupted accessibility and damaged road networks may increase distribution costs and constrain the supply of essential goods to affected areas. Such conditions may indicate pressure on local price levels. Accordingly, prioritizing the rehabilitation of road segments connecting the central region may help support more stable distribution conditions and reduce the risk of sharp increases in staple food prices. Although the relationship between accessibility, supply chains, and inflation requires further verification through quantitative logistics data analysis, the observed CPI differentials provide relevant indications regarding the urgency of infrastructure policy interventions.

Comparison with Previous Studies

Many MCDM studies on road maintenance prioritization generally identify technical indicators and traffic volume as the primary determinants of priority setting (Liu et al., 2024; Majstorović & Jajac, 2022; Nautiyal & Sharma, 2022). While the findings of this study reaffirm the importance of technical aspects, they also demonstrate that, in the context of Aceh Province, institutional factors and post-disaster recovery needs play a substantial role in shaping prioritization outcomes. This indicates that priority determination is influenced not only by the level of physical damage but also by socio-economic recovery requirements following disasters.

These findings are consistent with studies advocating the integration of stakeholder preferences and local contexts into prioritization models (Anastasiadou & Kehagia, 2025; Kresnanto, 2022). However, the results differ from studies focusing on high-traffic road networks in metropolitan areas, which tend to place greater emphasis on technical conditions and traffic volume. Accordingly, this study contributes empirical evidence showing that in disaster-prone regions such as Aceh, regional policy contexts and recovery needs can alter priority rankings that are typically generated by purely technical-based models.

Practical Implications for Regional Infrastructure Planning

From a practical perspective, the outputs of the AHP-TOPSIS model can serve as a technical reference for the formulation of annual programs and recovery-oriented budgeting at the provincial level. The resulting priority list may be used as a basis for budget allocation, particularly for strategic corridors such as those leading to central Aceh. However, physical road rehabilitation may be complemented by measures to secure supply chains, including the provision of alternative routes, emergency distribution management, and the preparation of essential goods reserves at local logistics centers, in order to support improvements in goods distribution and market accessibility.

n addition, field verification mechanisms should be strengthened to ensure implementation readiness, including land acquisition processes and the availability of Detailed Engineering Designs (DED). Strengthening these preparatory aspects may help reduce implementation delays and support more stable distribution access and the continuity of basic public services in affected areas. Accordingly, the model outputs may serve as one of the technical references for practical policy implementation.

CONCLUSION

This study developed a multi-criteria model for prioritizing provincial road maintenance and rehabilitation in Aceh under concurrent fiscal pressure and post-disaster recovery demands. The key contribution lies in applying an AHP-TOPSIS framework to provincial road decision-making under fiscal constraints, while incorporating post-disaster damage and institutional priorities into the criteria structure (Direktorat Jenderal Bina Marga, 2017). The criteria structure shows that development policy, road technical condition, and accessibility and social aspects are the most influential dimensions, while economic importance, strategic area value, and traffic volume play supporting roles.

At the sub-criteria level, poor road condition, governor's priority, development planning forum (musrenbang) proposals, and post-disaster damage emerge as the most dominant factors influencing the ranking of road segments. The highest-priority corridors are concentrated in areas that combine significant physical damage with strong policy support and critical accessibility functions, particularly toward the central region of Aceh. These patterns indicate that, in a recovery-oriented budgeting context, prioritization is shaped not only by technical urgency, but also by the alignment between infrastructure interventions, service provision, and regional development directions.

Theoretically, the findings suggest that prioritization outcomes in disaster-affected and fiscally constrained settings may differ from conventional models that emphasize technical condition and traffic volume alone. The prominence of post-disaster damage and policy-related sub-criteria indicates that multi-criteria road prioritization in such contexts is influenced by the interaction between physical urgency, socio-economic recovery needs, and formal planning instruments, rather than by engineering indicators in isolation. The strong agreement between AHP-TOPSIS rankings and expert judgments, as reflected in the Spearman correlation analysis, provides empirical support that combining expert-based weights with quantitative indicators can produce prioritization patterns that are broadly consistent with practitioner assessments.

Overall, this study shows that integrating fiscal stress, post-disaster recovery needs, and institutional priorities into a multi-criteria framework can support more coherent and data-informed decision-making in provincial road network management. However, the proposed framework is not intended to fully capture all dimensions of public-sector decision-making, particularly those related to political negotiation, implementation readiness, and institutional dynamics beyond the analytical model.

Recommendations

From a policy perspective, the prioritization results can serve as one of the technical inputs for structuring annual provincial road programs, especially when recovery-oriented interventions must be implemented under tight budget constraints. Using the model outputs alongside existing planning mechanisms and participatory processes may help strengthen transparency and consistency in setting priorities, while field verification remains essential to ensure implementation readiness, including land acquisition, availability of Detailed Engineering Designs, and alignment with local service needs.

In disaster-affected regions such as central Aceh, prioritizing corridors that combine severe damage, critical accessibility functions, and strong policy support may also contribute to improving distribution access and potentially reducing localized price pressures, although these relationships require further quantitative investigation. Therefore, the model should be viewed as a decision-support tool rather than a substitute for field assessment, stakeholder deliberation, and formal government planning procedures.

For future research, the framework could be extended by incorporating longer time-series data, spatial analysis, or logistics performance indicators to capture dynamic interactions between accessibility, supply chains, and regional resilience. Subsequent studies may also consider integrating climate risk exposure and socio-economic vulnerability into the criteria structure, so that multi-criteria prioritization models can better support adaptive infrastructure planning in disaster-prone regions and provide a stronger evidence base for long-term investment decisions.

References

Abu Dabous, S., Zeiada, W., Zayed, T., & Al-Ruzouq, R. (2020). Sustainability-informed multi-criteria decision support framework for ranking and prioritization of pavement sections. *Journal of Cleaner Production*, *244*. https://doi.org/10.1016/j.jclepro.2019.118755

Alam Sur, W. A., Adriana, M., Machfiroh, I. S., Dewi, N., Kurniawan, B., & Safitri, I. (2025). Comparative Study of Integrated Multicriteria Decision Making: Ahp-Topsis Vs Entropy-Topsis for Prioritizing Road Damage Repair. *Jurnal Jalan Jembatan*, *42*(1). https://doi.org/10.58499/jatan.v42i1.1331

Amin, M. Al, Pan, S., & Zhang, Z. (2022). Pavement maintenance and rehabilitation budget allocation considering multiple objectives and multiple stakeholders. *International Journal of Pavement Engineering*, *24*(2). https://doi.org/10.1080/10298436.2022.2027941

Anastasiadou, K., & Kehagia, F. (2025). Road Safety Improvement and Sustainable Urban Mobility: Identification and Prioritization of Factors and Policies Through a Multi-Criteria Approach. *Urban Science*, *9*(4). https://doi.org/10.3390/urbansci9040093

Arifin, M., Marleno, R., & Oetomo, W. (2025). Criteria Analysis and Application of Analytical Hierarchy Process (AHP) In Determining Road Maintenance Priorities on Cokroaminoto Bojonegoro Road Section Attribution-ShareAlike 4.0 International (CC BY-SA 4.0). *Asian Journal of Social and Humanities*. https://doi.org/10.59888/ajosh.v3i6.529

Aschauer, D. A. (1989). Is public expenditure productive? *Journal of Monetary Economics*, *23*(2), 177-200. https://doi.org/10.1016/0304-3932(89)90047-0

Badan Nasional Penanggulangan Bencana. (2025). *Dashboard Penanganan Darurat Banjir dan Longsor Provinsi Aceh, Sumatera Utara, dan Sumatera Barat Tahun 2025*. https://gis.bnpb.go.id/bansorsumatera2025/

Badan Pusat Statistik Kabupaten Aceh Tengah. (2026). *Pada Januari 2026 terjadi inflasi year on year (yoy) di Kabupaten Aceh Tengah sebesar 8,60 persen; IHK pada Januari 2025 yaitu 108,47 mengalami kenaikan pada Januari 2026 menjadi 117,80*. https://acehtengahkab.bps.go.id/id/pressrelease/2026/02/02/137/pada-januari-2026-terjadi-inflasi-year-on-year--yoy--di-kabupaten-aceh-tengah-sebesar--8-60-persen--ihk-pada-januari-2025-yaitu-108-47-mengalami-kenaikan-pada-januari--2026-menjadi-117-80-.htm

Badan Pusat Statistik Provinsi Aceh. (2026). *Januari 2026 inflasi year on year (y-on-y) Provinsi Aceh sebesar 6,69 persen; inflasi tertinggi terjadi di Kabupaten Aceh Tengah sebesar 8,60 persen*. https://aceh.bps.go.id/id/pressrelease/2026/02/02/1190/januari-2026-inflasi-year-on-year--y-on-y--provinsi-aceh-sebesar-6-69-persen--inflasi-tertinggi-terjadi-di-kabupaten-aceh-tengah-sebesar-8-60-persen.html

Bafail, O. A., & Abdulaal, R. M. S. (2022). A Combined BWM-TOPSIS Approach Versus AHP-TOPSIS Approach: An Application to Solid Waste Management. *ACM International Conference Proceeding Series*. https://doi.org/10.1145/3524338.3524343

Belton, V., & Stewart, T. J. (2002). Multiple Criteria Decision Analysis. Dalam *Multiple Criteria Decision Analysis*. https://doi.org/10.1007/978-1-4615-1495-4

Bhirowo, H., Indrawati, Tambunan, H. B., Aditya, I. A., Windya Giri, R. R., Hakim, F. M., & Pakutandang, F. N. (2025). Analyzing the adoption of hybrid electric and hydrogen vehicles in Indonesia: A multi-criteria and total cost of ownership approach. *Cleaner Engineering and Technology*, *24*. https://doi.org/10.1016/j.clet.2025.100893

Bošnjak, A., & Jajac, N. (2023). Determining Priorities in Infrastructure Management Using Multicriteria Decision Analysis. *Sustainability*, *15*(20), 14953. https://doi.org/10.3390/su152014953

Broniewicz, E., & Ogrodnik, K. (2021). A comparative evaluation of multi-criteria analysis methods for sustainable transport. *Energies*, *14*(16). https://doi.org/10.3390/en14165100

Calderón, C., & Servén, L. (2004). The Effects of Infrastructure Development on Growth and Income Distribution. Dalam *The Effects of Infrastructure Development on Growth and Income Distribution*.

https://doi.org/10.1596/1813-9450-3400

Chaipetch, P., Amprayn, C., Pawan, P., & Ratanavaraha, V. (2025). A Multi-Criteria Decision Support System for Prioritizing Road Maintenance: Integrating AHP and TOPSIS with a Focus on Low-Volume Roads. *IOP Conference Series: Earth and Environmental Science*, *1450*(1). https://doi.org/10.1088/1755-1315/1450/1/012004

Chen, W., & Zheng, M. (2021). Multi-objective optimization for pavement maintenance and rehabilitation decision-making: A critical review and future directions. Dalam *Automation in Construction* (Vol. 130). https://doi.org/10.1016/j.autcon.2021.103840

Conover, W. J. (1999). Practical nonparametric statistics Third Edition. Dalam *John Wiley and Sons. Inc. New York*.

Dadek, T. A. (2022). Otonomi Khusus Aceh dan Kemiskinan (Sebab dan Upaya). Dalam *Pemerintah Aceh Badan Perencanaan Pembangunan Aceh (BAPPEDA) Aceh Tahun 2022*. https://bappeda.acehprov.go.id/media/2022.11/otonomi_khusus_aceh_dan_kemiskinan1.pdf

Dinas PUPR Aceh. (2025). *Ringkasan Anggaran Dinas PUPR Aceh 2022-2025*. https://pupr.acehprov.go.id/halaman/ringkasan-anggaran

Donaldson, D. (2018). Railroads of the Raj: Estimating the impact of transportation infrastructure. *American Economic Review*, *108*(4-5). https://doi.org/10.1257/aer.20101199

Du, J., Wang, W., Lou, T., & Zhou, H. (2023). Resilience and sustainability-informed probabilistic multi-criteria decision-making framework for design solutions selection. *Journal of Building Engineering*, *71*. https://doi.org/10.1016/j.jobe.2023.106421

Fauzi, A. F., Rachmat, A., & Chalid, A. (2023). Analisis Penentuan Prioritas Penanganan Jalan Kabupaten Di Kabupaten Majalengka Provinsi Jawa Barat. *Techno-Socio Ekonomika*, *16*(2), 130. https://doi.org/10.32897/techno.2023.16.2.1580

Fitriani, H. (2025). *Manajemen Infrastruktur Strategi dan Pemeliharaan*. PT Media Penerbit Indonesia.

Forman, E., & Peniwati, K. (1998). Aggregating individual judgments and priorities with the Analytic Hierarchy Process. *European Journal of Operational Research*, *108*(1), 165-169. https://doi.org/10.1016/S0377-2217(97)00244-0

France-Mensah, J., Kothari, C., O'Brien, W. J., & Jiao, J. (2019). Integrating social equity in highway maintenance and rehabilitation programming: A quantitative approach. *Sustainable Cities and Society*, *48*. https://doi.org/10.1016/j.scs.2019.101526

Ghaffar, A. A., & Indrawati. (2024). The Assessment of Usability and Service Quality in E-Commerce Using the Integration of Analytical Hierarchy Process (AHP) and Technique for Order Performance by Similarity to Ideal Solution (TOPSIS). *Asian Journal of Business and Accounting*, *17*(1), 201-224. https://doi.org/10.22452/ajba.vol17no1.7

Heizer, Jay Render, B., & Munson, Ummah, C. (2023). Operations Management: Sustainability and Supply Chain Management. Dalam *Sustainability (Switzerland)* (Vol. 11, Nomor 1).

Hwang, C.-L., & Yoon, K. (1981). Multiple Attributes Decision Making Methods and Applications. *Multiple Attribute Decision Making*.

Jumas, D., Ariani, V., Rita, E., Sesmiwati, S., & Rozaan, A. (2024). Optimasi Pemeliharaan Jalan: Model Pengambilan Keputusan Multi-Kriteria untuk Prioritas di Kabupaten Pasaman, Sumatera Barat. *Jurnal Teknik Sipil*, *31*(3), 327-334. https://doi.org/10.5614/jts.2024.31.3.10

Kementerian Keuangan Republik Indonesia. (2025). *Keputusan Menteri Keuangan Nomor 29 Tahun 2025 tentang Penyesuaian Rincian Alokasi Transfer ke Daerah menurut Provinsi/Kabupaten/Kota Tahun Anggaran 2025*. https://djpk.kemenkeu.go.id/?p=60831

Kementerian PPN/Bappenas. (2025). *Rencana Pembangunan Jangka Menengah Nasional Tahun 2025-2029*. https://perpustakaan.bappenas.go.id/e-library/file_upload/koleksi/dokumenbappenas/konten/Dokumen 2025/Konten/Relayout Narasi RPJMN Tahun 2025-2029 (2).pdf

Khan, M. T. I., Anwar, S., Sarkodie, S. A., Yaseen, M. R., & Nadeem, A. M. (2023). Do natural disasters affect economic growth? The role of human capital, foreign direct investment, and infrastructure dynamics. *Heliyon*, *9*(1). https://doi.org/10.1016/j.heliyon.2023.e12911

Kresnanto, N. C. (2022). Prioritizing District Road Maintenance Using AHP Method. *Lecture Notes in Civil Engineering*, *216*(February), 363-371. https://doi.org/10.1007/978-981-16-7949-0_32

Litman, T. (2025). Evaluating Transportation Equity: Guidance for Incorporating Distributional Impacts in

Transport Planning. *Victoria Transport Policy Institute*.
Liu, Y., Yu, C., Guo, F., Zhao, X., Shan, J., Lu, T., Peng, H., & Yuan, D. (2024). Multi-Criteria Decision-Making Framework (AHP-TOPSIS): Pavement Preventive Maintenance Case Study for Ordinary National Trunk Highways. *Buildings*, *14*(10), 3048. https://doi.org/10.3390/buildings14103048
Majstorović, A., & Jajac, N. (2022). Maintenance Management Model for Nonurban Road Network. *Infrastructures*, *7*(6), 1-21. https://doi.org/10.3390/infrastructures7060080
Nautiyal, A., & Sharma, S. (2022). Methods and factors of prioritizing roads for maintenance: a review for sustainable flexible pavement maintenance program. *Innovative Infrastructure Solutions*, *7*(3), 190. https://doi.org/10.1007/s41062-022-00771-6
Organisation for Economic Co-operation and Development. (2018). Road and Rail Infrastructure in Asia: Investing in Quality. *The Development Dimension*.
Osborne, S. P. . (2021). *Public service logic : creating value for public service users, citizens, and society through public service delivery*.
Panwar, V., & Sen, S. (2019). Economic Impact of Natural Disasters: An Empirical Re-examination. *Margin*, *13*(1). https://doi.org/10.1177/0973801018800087
Pemerintah Aceh. (2025). *Laporan pantauan data penanggulangan bencana alam hidrometeorologi di Posko Terpadu Pemerintah Aceh*. https://bencana.acehprov.go.id/dashboard
Peraturan Menteri Pekerjaan Umum dan Perumahan Rakyat Nomor 13/PRT/M/2011 Tahun 2011 Tata Cara Pemeliharaan dan Penilikan Jalan (2011).
Prion, S., & Haerling, K. A. (2014). Making Sense of Methods and Measurement: Spearman-Rho Ranked-Order Correlation Coefficient. *Clinical Simulation in Nursing*, *10*(10), 535-536. https://doi.org/10.1016/j.ecns.2014.07.005
Qanun Aceh Nomor 10 Tahun 2025 Tentang Rencana Pembangunan Jangka Menengah Aceh Tahun 2025 - 2029 (2025). https://bappeda.acehprov.go.id/halaman/rpjma
Radnor, Z., Bateman, N., Esain, A., Kumar, M., Williams, S., & Upton, D. (2015). *Public Service Operations Management* (Z. Radnor, N. Bateman, A. Esain, M. Kumar, S. Williams, & D. Upton (ed.)). Routledge. https://doi.org/10.4324/9781315747972
Reffinda Melati, A., & Indrawati, I. (2024). Analysis of Key Indicators for Reach, Act, Convert, and Engage (RACE) in Social Media Platforms for B2B Companies in Indonesia Using the AHP Method. *International Journal of Current Science Research and Review*, *07*(08). https://doi.org/10.47191/ijcsrr/v7-i8-70
Saaty, T. L. (2008). Decision making with the analytic hierarchy process. *International Journal of Services Sciences*, *1*(1), 83. https://doi.org/10.1504/IJSSCI.2008.017590
Saaty, T. L., & Vargas, L. G. (2012). *Models, Methods, Concepts & Applications of the Analytic Hierarchy Process* (Vol. 175). Springer US. https://doi.org/10.1007/978-1-4614-3597-6
Sayadinia, S., & Beheshtinia, M. A. (2021). Proposing a new hybrid multi-criteria decision-making approach for road maintenance prioritization. *International Journal of Quality & Reliability Management*, *38*(8), 1661-1679. https://doi.org/10.1108/IJQRM-01-2020-0020
Schraven, D., Hartmann, A., & Dewulf, G. (2011). Effectiveness of infrastructure asset management: challenges for public agencies. *Built Environment Project and Asset Management*, *1*(1), 61-74. https://doi.org/10.1108/20441241111143786
Sharma, A., Aggarwal, P., & Sachdeva, S. N. (2025). Prioritization Comparison of TOPSIS and AHP to IRC: A Case Study of Kurukshetra Roads. *Journal of Rehabilitation in Civil Engineering*, *13*(3), 22-42. https://doi.org/10.22075/jrce.2024.33664.2032
Surat Edaran Direktorat Jenderal Bina Marga Nomor 12/SE/Db/2017 tentang Petunjuk Teknis Penyusunan Program Prioritas Pembangunan Jalan (2017).

Triantaphyllou, E. (2000). *Multi-Criteria Decision Making Methods: A Comparative Study*.
United Nations Development Programme. (2025). *Sustainable Development Goals*. https://www.undp.org/sustainable-development-goals
Zheng, X., Easa, S. M., Yang, Z., Ji, T., & Jiang, Z. (2019). Life-cycle sustainability assessment of pavement maintenance alternatives: Methodology and case study. *Journal of Cleaner Production*, *213*. https://doi.org/10.1016/j.jclepro.2018.12.227