INSURE (Innovation in Sustainable Engineering)
Vol. 1, No. 1, 2026, pp. 30-37

# Systematic Comparative Analysis of the Application of Analytic Network Process (ANP) in Complex Decision-Making Environments : A Review

**Rio Embun Pratama [1*], Desta Atha Fahreza [1]**
[1]Master of Civil Engineering, Universitas Negeri Semarang
Correspondence: rioembunp@students.unnes.ac.id
rezafahreza@students.unnes.ac.id

**ABSTRACT**

This study conducts a comparative review of five scholarly articles applying the Analytic Network Process (ANP) across diverse fields to evaluate its effectiveness as a multi-criteria decision-making method. Using a qualitative comparative approach grounded in established methodological literature, the analysis examines differences in application contexts, data types, network structures, and decision outcomes. The results show that ANP consistently supports complex decision environments by modelling interdependent criteria and integrating quantitative, qualitative, and spatial data. Across the reviewed studies, ANP is applied both as a standalone tool and in combination with complementary methods such as Fuzzy Logic, DEMATEL, and statistical models, demonstrating its versatility and methodological scalability. The review concludes that ANP remains a robust and adaptable framework for addressing diverse decision-making challenges, while future research should explore hybrid models, enhanced empirical validation, and broader applications in infrastructure, environmental planning, and policy analysis.

**Keywords:** Analytic Network Process; Multi-Criteria Decision Making; Decision Support; Fuzzy Integration; Comparative Analysis.

**Article History:**
Received. : 12-01-2026
Revised : 13-01-2026
Accepted.: 13-01-2026
Online : 22-01-2026



## A. BACKGROUND

Many problems in the modern industrial world require the assistance of Decision Support Systems (DSS) to solve complex problems with multiple decision alternatives. Decision Support Systems play an important role when decision makers are faced with multi-criteria decision making (MCDM), where each alternative must be evaluated against various criteria that are often interdependent. One method that is particularly relevant in this context is the Analytic Network Process (ANP), which is an extension of the Analytic Hierarchy Process (AHP) that takes into account the reciprocal relationships between criteria and alternatives.

In industry and research, ANP is used to solve problems involving the interdependence of factors, whether economic, social, technical, or environmental. This method enables researchers and practitioners to make more comprehensive, data-driven, and rational decisions. The ANP approach is often applied in various fields, ranging from infrastructure development, construction

project risk management, natural disaster mapping, to human resource management.

In addition to assigning priority weights to each alternative, ANP is also capable of integrating various data sources, both qualitative and quantitative, so that the resulting decisions are holistic. For example, in infrastructure projects, ANP can help determine the best road paving technology based on technical and environmental sustainability criteria. In the field of construction work safety, ANP serves to determine risk priorities based on the level of danger and frequency of occurrence.

Thus, ANP is a very important method in Decision Support Systems in Multi-Criteria Decision Making (MCDM) situations. Through a network of relationships between elements, ANP takes into account feedback loops and interrelationships between factors, so that the decision results are more accurate and in line with complex real-world conditions.

## B. METHODS AND IMPLEMENTATION

The research method used in this review is qualitative comparison. This approach was chosen to compare the application of the ANP method in various fields in depth and narratively, rather than based solely on statistical testing. The qualitative approach in scientific research aims to understand phenomena contextually, highlighting processes, reasons for choosing methods, and the relevance of results to applied fields.

As explained by Creswell (2009), qualitative research is exploratory and interpretive, in which researchers play an active role in identifying patterns, relationships, and meanings that emerge from the data. In the context of this review, each article analyzed is used as a unit of analysis to assess how ANP is used in solving multi-criteria decision problems.

Additional reference sources such as the ebook "Qualitative Research Methods for the Social Sciences" (Berg B & Lune H, 2012) confirm that qualitative comparisons between studies are very useful in assessing the effectiveness of methodologies applied in various disciplines. This approach allows researchers to evaluate the suitability of ANP application in specific contexts, such as construction, risk management, human resources, and disaster mitigation.

In this study, each article was reviewed based on the following aspects:

1. Research objectives and context of ANP application.
2. Types of data and variables used.
3. The network model that was built.
4. Decision result validation techniques.
5. Advantages and limitations of the ANP approach in each field.

## C. RESULT AND DISCUSSION

In this article, we will review five articles that use the ANP method to solve problems in various fields. The articles discussed in this article consist of :

1. Project-Level Sustainable Asphalt Roadway Treatment Selection Framework Featuring a Flowchart and Analytic Network Process (Salman et al., 2020).
2. Construction Project Safety Performance Management Using Analytic Network Process (ANP) as a Multicriteria Decision-Making (MCDM) Tool (Gunduz & Khader, 2020).
3. Clustering and reference value for assessing influence in analytic network process without pairwise comparison matrices: Study of 17 real cases (Schulze-González et al., 2023).
4. Conforming work teams within SMEs using Fuzzy Logic and Analytic Network Process (ANP) (Olmedo-Navarro et al., 2023).
5. Flood susceptibility mapping using an improved analytic network process with statistical models (Yariyan et al., 2020).

Table 1. Resume comparison of the articles reviewed

| No | Title | Research Question | Research Objectives | Research Tools And Methods | Research Results |
|---|---|---|---|---|---|
| 1 | Project-Level Sustainable Asphalt Roadway Treatment Selection Framework Featuring a Flowchart and Analytic Network Process | Many project decision-making tools for roads do not consider the complex interrelationships between economic, social, and environmental aspects of sustainability. | The objective is to develop a flowchart-based decision framework and Analytic Network Process (ANP) for selecting sustainable asphalt pavement treatments at the project level. | A survey of State DOTs was conducted to obtain data on technical, economic, social, and environmental factors. The ANP model was used to compare 12 factors, and validation was performed through interviews and case studies of real projects at NYSDOT. | The proposed framework produces rational and effective recommendations for selecting sustainable asphalt treatments and supports rapid and consistent decision-making. |

| No | Title | Research Question | Research Objectives | Research Tools And Methods | Research Results |
|---|---|---|---|---|---|
| 2 | Construction Project Safety Performance Management Using Analytic Network Process (ANP) as a Multicriteria Decision-Making (MCDM) Tool | Construction Project Safety Performance Management Using Analytic Network Process (ANP) as a Multicriteria Decision-Making (MCDM) Tool | To identify and prioritize construction safety risks by considering the interrelationships and frequency of occurrences between hazards using ANP. | A survey of 106 construction professionals identified 42 hazards in 14 categories, analyzed using a frequency-adjusted importance index and ANP for pairwise assessment between hazards. | The study successfully mapped and ranked the main safety hazards. The integration of ANP with the frequency index resulted in a more realistic risk assessment model. |
| 3 | Clustering and reference value for assessing influence in analytic network process without pairwise comparison matrices: Study of 17 real cases | The conventional ANP process requires many complex and time-consuming paired comparison matrices, and the impact of clustering on the results is unclear. | To assess whether the use of influence scales (without comparison matrices) and single or multiple clustering provides results similar to traditional ANP. | An experimental study of 17 real cases compared four models (with/without clusters, with/without comparison matrices). Spearman's correlation, Kendall's correlation, and compatibility index were used. | Hasil The results show that clustering affects ANP results. The use of a single cluster can simplify the process with little difference in results, thereby reducing the time and number of questions for decision makers. |

| No | Title | Research Question | Research Objectives | Research Tools And Methods | Research Results |
|---|---|---|---|---|---|
| 4 | Conforming work teams within SMEs using Fuzzy Logic and Analytic Network Process (ANP) | Many SMEs do not yet have quantitative methods to manage and assess work team performance objectively. | Proposing a quantitative methodology for work team management using fuzzy logic and ANP in managerial decision-making. | Descriptive-experimental method. Identification of key variables (trust, collaboration, leadership, communication, evaluation) through literature study, qualitative→quantitative with fuzzy logic, relationships between variables analyzed with ANP. | The fuzzy-ANP combination produces a model that can identify the strengths and weaknesses of teams, as well as assist in the formation of high-performance teams in SMEs. |
| 5 | Flood susceptibility mapping using an improved analytic network process with statistical models | The city of Saqqez is prone to flooding, while existing flood susceptibility mapping methods are inaccurate because they do not integrate statistical methods and ANP in an integrated manner. | To develop a flood susceptibility mapping model by combining Improved ANP and statistical models (FR, EBF, OWA). | Spatial quantitative approach. 42 flood points were analyzed, 10 physical-environmental factors were evaluated, factor weighting was done using frequency ratio, and model validation was done with ROC curves. | The combined ANP-EBF model produced the highest accuracy (AUC 95.1%) compared to ANP-FR (91%) and ANP-OWA (89.6%), proving the effectiveness of integrating statistics with ANP for flood prediction. |

A review of five journals shows that the application of the Analytic Network Process (ANP) method has different characteristics depending on the context of needs, data types, and decision-making objectives. Although they come from various disciplines, all of these studies show a common pattern that ANP is used

to address multi-criteria problems that have interdependent relationships, but the approach varies according to the complexity of the problem.

The first comparison can be seen in the purpose of applying ANP. Salman et al. (2020) and Yariyan et al. (2020) used ANP for the selection of technical alternatives in the context of infrastructure and the environment. Both sought to decide on the best option based on a combination of technical, environmental, and social criteria. However, Salman et al. focused on determining sustainable road pavement technology, while Yariyan et al. applied ANP to map flood vulnerability by combining it with a spatial statistical model. This difference demonstrates the flexibility of ANP, which is capable of handling both performance-based technical decisions and geospatial data-based decisions.

Meanwhile, Gunduz & Khader (2020) directed ANP towards occupational safety risk management, which requires the analysis of non-linear relationships between risks. In this study, ANP was used to reveal the interrelationships between 42 safety risk factors, thus serving as a tool for identifying interdependent priorities. This contrasts with Olmedo-Navarro et al. (2023), who applied ANP to human resources through the selection of work team members. The study emphasized the use of ANP to assess subjective personal characteristics, with the help of Fuzzy Logic so that qualitative data could be converted into numerical values that could be processed systematically. Both show that ANP is effective not only for technical decisions but also for human behavior-based decisions.

A more fundamental difference emerges in the journal by Schulze-González et al. (2023), which does not focus on the application of ANP to a case but on method development. This study reduces ANP's dependence on pairwise comparison matrices by integrating DEMATEL. Thus, ANP becomes more efficient and easier to apply to systems with many elements. Compared to other journals that are oriented towards practical problem solving, this study highlights methodological innovations that expand the potential use of ANP in the future.

In terms of data type, the journals by Salman et al. and Yariyan et al. utilize quantitative data sourced from technical surveys and geospatial data. In contrast, the research by Olmedo-Navarro et al. uses qualitative data on work behavior, while Gunduz & Khader use mixed data in the form of risk frequency and hazard impact. These differences in data characteristics show that ANP can be adapted to various forms of information, both numerical and linguistic.

In terms of method integration, the characteristics of each journal are even more diverse. Yariyan et al. added a statistical model to improve spatial prediction accuracy, while Olmedo-Navarro et al. combined ANP with Fuzzy

Logic to overcome human subjectivity. Schulze-González et al. integrated DEMATEL to simplify the ANP structure. On the other hand, Salman et al. and Gunduz & Khader continued to use ANP conventionally without heavy method integration, as their focus was on practical application in the field. These differences show that ANP can stand alone or be combined with other computational methods to improve the sharpness of the analysis.

Based on the overall comparison, it appears that ANP functions differently according to the challenges faced by each study, such as a tool for selecting the best option, a tool for modeling the interdependence of risk factors, a framework for evaluating human performance, a support for spatial mapping, and a new methodological concept. Despite differences in scope and data types, ANP consistently demonstrates its superiority in capturing relationships between variables and generating more realistic decision priorities compared to traditional hierarchical approaches.

## D. CONCLUSION AND RECOMMENDATIONS

A review of five studies shows that the Analytic Network Process (ANP) is a highly adaptive multi-criteria decision-making method that excels at handling interdependencies between variables in technical, managerial, social, and environmental contexts. ANP has been proven to produce more realistic decision priorities through the integration of various types of data, ranging from quantitative technical data and spatial data to behavior-based qualitative assessments, while remaining effective when combined with other approaches such as Fuzzy Logic, DEMATEL, and statistical models. Cross-study comparisons confirm that ANP functions not only as a weighting tool but also as a comprehensive analytical framework that can adjust the structure of decision networks according to problem characteristics, making it a relevant and reliable method for complex systems across various disciplines.

Based on these findings, further research needs to develop a hybrid ANP approach with modern analytical technologies such as machine learning and big data to produce more dynamic and predictive decision models, while simplifying the analysis structure through methods such as DEMATEL to make the evaluation process more efficient. ANP is also recommended for application in large-scale decision systems, such as infrastructure planning, disaster risk management, or public policy evaluation, by strengthening empirical validity through the use of spatial and longitudinal data. In addition, cross-sector best practice-based technical guidelines are needed so that ANP can be implemented

consistently by practitioners, thereby optimizing the benefits of this method in complex and multidimensional decision making.

## REFERENCES

Berg B, & Lune H. (2012). *Berg-B.-Lune-H.-2012.-Qualitative-Research-Methods-for-the-Social-Sciences*.

Creswell. (2009). *Research design: Qualitative, quantitative, and mixed methods approaches*.

Gunduz, M., & Khader, B. K. (2020). Construction Project Safety Performance Management Using Analytic Network Process (ANP) as a Multicriteria Decision-Making (MCDM) Tool. *Computational Intelligence and Neuroscience*, *2020*, 2610306. https://doi.org/10.1155/2020/2610306

Olmedo-Navarro, A., Fuentes, C. K., Vasquez, L. A., Utreras, J. J., Arrieta-Barrios, T., & Corrales-Paternina, A. (2023). Conforming work teams within SMEs using Fuzzy Logic and Analytic Network Process (ANP). *Procedia Computer Science*, *220*, 952–957. https://doi.org/10.1016/j.procs.2023.03.131

Salman, B., Salem, O., & He, S. (2020). Project-Level Sustainable Asphalt Roadway Treatment Selection Framework Featuring a Flowchart and Analytic Network Process. *Journal of Transportation Engineering, Part B: Pavements*, *146*(3), 04020041. https://doi.org/10.1061/jpeodx.0000202

Schulze-González, E., Pastor-Ferrando, J. P., & Aragonés-Beltrán, P. (2023). Clustering and reference value for assessing influence in analytic network process without pairwise comparison matrices: Study of 17 real cases. *Operations Research Perspectives*, *10*. https://doi.org/10.1016/j.orp.2023.100275

Yariyan, P., Avand, M., Abbaspour, R. A., Torabi Haghighi, A., Costache, R., Ghorbanzadeh, O., Janizadeh, S., & Blaschke, T. (2020). Flood susceptibility mapping using an improved analytic network process with statistical models. *Geomatics, Natural Hazards and Risk*, *11*(1), 2282–2314. https://doi.org/10.1080/19475705.2020.1836036