JPPIPA 11(12) (2025)

Jurnal Penelitian Pendidikan IPA

http://jppipa.unram.ac.id/index.php/jppipa/index

Multi-Criteria Decision Making in KIP-K Scholarship Selection Using AHP, TOPSIS, and Skyline Query

Irma Putri Rahayu[1*], Heri Wijayanto[1], Ario Yudo Husodo[1]

[1] Department of Informatics Engineering, Universitas Mataram, Mataram, Indonesia.

Received: July 06, 2025
Revised: November 23, 2025
Accepted: January 14, 2026
Published: January 14, 2026

Corresponding Author:
Irma Putri Rahayu
irmaputri@staff.unram.ac.id

DOI: 10.29303/jppipa.v11i12.12032

Abstract: The KIP-K scholarship program provides crucial educational support for underprivileged students, yet its manual selection process at the University of Mataram has been plagued by inefficiency, subjectivity, and inconsistency. This study develops an integrated decision-support system combining Analytic Hierarchy Process (AHP), Skyline Query, and TOPSIS methodologies to revolutionize the selection process. The AHP method established weighted criteria, identifying poverty card ownership (23.24%) and number of family dependents (18.61%) as the most critical factors. Skyline Query processing of 500 applicants yielded 68 non-dominated candidates representing optimal poverty profiles across multiple dimensions. TOPSIS analysis then generated objective rankings, with top candidate P499 achieving an exceptional CI score of 0.872. The integrated system demonstrated remarkable consistency (CR < 0.1) and improved selection accuracy by 22% compared to traditional methods. Jaccard Distance analysis (0.0-0.9) further validated the Skyline Filter's effectiveness in maintaining top-tier candidates while optimizing mid-tier selections. This research presents a transformative approach to scholarship allocation, offering complete elimination of subjective bias, handling of large applicant pools (500 candidates) with computational efficiency, a transparent, multidimensional assessment framework. The results prove this hybrid system's superiority in identifying truly deserving recipients while processing applications at scale. The study concludes that the AHP-Skyline-TOPSIS integration establishes a new standard for equitable, data-driven scholarship distribution, with immediate applicability to other social assistance programs in higher education.

Keywords: AHP; KIP-K scholarship; Scholarship selection; Skyline Query; TOPSIS

Introduction

Indonesia Smart College Card (KIP-K) is an educational assistance program for high school graduates and equivalent who have economic limitations to continue their education to college for free (Kurniadi et al., 2022). Scholarship recipients must meet the prerequisites specified in the KIP-K program. The KIP-K is expected to increase the number of children who continue their education to university (Sahid et al., 2022). Every year, higher education institutions receive a KIP Tuition scholarship quota that has been determined by Ristek Dikti through LLDIKTI which is given during the new student admissions process (Andin & Defit, 2024). Scholarship selection is a crucial process in the world of education. According to scholarship administrators at University of Mataram, the scholarship selection process at University of Mataram currently still relies on a manual system that is inefficient. Candidates must submit physical documents or send digital documents via email, which are then verified one by one by the committee. This process takes a long time, especially when the number of applicants reaches hundreds or even thousands of students. Additionally, selection stages such as criteria assessment and ranking are still conducted using conventional spreadsheets, which are prone to calculation errors and data duplication (Espiritu et al., 2024). The process of determining recipients is carried out manually resulting in inaccurate scholarship recipients being selected and the selection results may

How to Cite:
Rahayu, I. P., Wijayanto, H., & Husodo, A. Y. (2025). Multi-Criteria Decision Making in KIP-K Scholarship Selection Using AHP, TOPSIS, and Skyline Query: pengantar. *Jurnal Penelitian Pendidikan IPA*, *11*(12), 1292-1303. https://doi.org/10.29303/jppipa.v11i12.12032

not be the same based on those who participated in making the decision (Andin & Defit, 2024). This manual system also raises issues of consistency and objectivity in assessment. Selection criteria such as the number of poverty cards, parental income, and number of dependents are often assessed subjectively by the committee, resulting in varying outcomes depending on the evaluator. The absence of standardized criteria weighting leads to unfairness, where some participants may be disadvantaged due to differences in the selection team's perceptions (Arslantaş et al., 2023).

Based on interviews with scholarship administrators at University of Mataram, University of Mataram faces problems in the selection process for KIP-K scholarship recipients, such as inaccurate selection and targeting. In 2023, 5% of scholarship recipients did not meet the criteria due to errors in the selection process. This was revealed by the scholarship administrators at University of Mataram in the 2023 KIP-K program evaluation report. The manual selection process led to inefficiency in the selection process, resulting in frequent errors and inaccurate results. This resulted in scholarships being awarded to students who were not eligible, while those who truly needed them were overlooked or unable to receive scholarships.

Another challenge is the lack of transparency and accountability in decision-making. Students are often unaware of how the assessment process is conducted or how the criteria weights are applied, so the selection results seem unclear and difficult to track. In addition, manual systems make it difficult to document historical selection data, which could be used for future system evaluation and improvement (Dordevic et al., 2025). Without a digital track record, universities find it difficult to analyze patterns or identify weaknesses in previous selection processes. With the increasing number of scholarship applicants each year, the manual system becomes increasingly unable to handle the complexity of the data. The committee is overwhelmed by processing large numbers of files, which leads to delays in the announcement of selection results (Nguyen et al., 2024).

Scholarship selection processes that still rely on manual methods often face various challenges, such as subjectivity in evaluation, inconsistent results, and excessive reliance on individual assessments. To address these issues, a Multi-Criteria Decision Making (MCDM) approach is needed to enhance objectivity and accuracy in the selection process (Sequeira et al., 2023; Tasril, 2018). Several MCDM methods have been implemented in the context of scholarship selection, each with its own advantages and disadvantages. The Analytical Network Process (ANP) is capable of considering the interdependent relationships between criteria, but this method heavily relies on the subjective weighting assigned by experts, which may introduce bias (Tasril, 2018). ELECTRE can overcome the weaknesses of manual systems through an elimination approach, but this method is highly sensitive to the consistency of input data; incomplete or inaccurate data can disrupt the final selection results (Prima et al., 2024). PROMETHEE offers flexibility in modeling preferences, but it has weaknesses in terms of calculation complexity and dependence on accurate criterion weighting (Supriyanti, 2023). Meanwhile, the Simple Additive Weighting (SAW) and Weighted Product (WP) methods, as part of Multiple Attribute Decision Making (MADM), are indeed easy to implement, but SAW is vulnerable to data normalization processes, while WP is less responsive to changes in criterion weights (Kanj et al., 2024). Therefore, the selection of MCDM methods must consider data characteristics, criterion complexity, and the need for accuracy and objectivity in the scholarship selection process. AHP can unravel the complexity of evaluation by determining criteria weights hierarchically and consistently, eliminating the subjectivity of the committee (Tufail et al., 2022).

TOPSIS can then rank scholarship candidates based on their proximity to the ideal solution (Ma & Xu, 2023), while Skyline Query helps automatically filter dominant data, ensuring only the best candidates pass the initial selection [18]. Methods such as AHP, TOPSIS, and Skyline Query can serve as a stronger solution, as they combine consistent weight determination (AHP), ranking based on the ideal solution (TOPSIS), and automatic filtering of dominant candidates (Skyline Query). This combination of approaches can reduce human bias, enhance transparency, and produce more measurable decisions. However, the main challenges remain in the reliance on the quality of input data, the complexity of calculations, and the need for objective weighting. Therefore, the integration of MCDM methods with accurate data-based systems and validation mechanisms is key to achieving fairer and more effective scholarship selection.

By adopting this MCDM approach, the scholarship selection process at University of Mataram can become more efficient, transparent, and able to handle large-scale data (Taherdoost & Madanchian, 2023). AHP-TOPSIS ensures that weighting and ranking are done mathematically (Nguyen et al., 2024), while Skyline Query accelerates the filtering process of thousands of applicant data (Ma & Xu, 2023). As a result, universities can significantly reduce selection time, provide fairer decisions, and increase accountability through a well-documented system, a breakthrough that addresses all the weaknesses of the current manual system (Dordevic et al., 2025).

The scholarship selection process begins with the application of the AHP method to objectively determine the weight of the criteria. The committee establishes a hierarchy of criteria such as the number of poor cards, economic conditions, and non-academic achievements, and then conducts pairwise comparisons to assess the relative importance of each criterion. AHP ensures consistency of judgment and produces measurable weightings, eliminating subjectivity in prioritization (Kanj et al., 2024). These weighting results then become the basis for TOPSIS to rank the candidates. TOPSIS compares each candidate to an ideal solution (e.g. high number of poor cards and low economic conditions) and an anti-ideal solution, and then calculates the proximity score to produce a transparent and mathematical final ranking (Tufail et al., 2022).

To improve the efficiency of the process, Skyline Query is applied as an initial screening stage that identifies dominant candidates. This method automatically selects candidates who excel in at least one criterion (such as highest number of dependents or lowest economic condition), without requiring any initial weighting (Taherdoost & Madanchian, 2023). These screening results are then submitted to TOPSIS for further processing, thus narrowing down the number of candidates that need to be thoroughly analyzed (Gulzar et al., 2020). The combination of these three methods AHP for weighting, Skyline Query for initial screening, and TOPSIS for final ranking creates a selection system that is not only fast and capable of handling large amounts of data, but also guarantees objectivity and fairness in the determination of scholarship recipients.

The solution offered in this research is to develop a scholarship selection system based on the integration of AHP, TOPSIS, and Skyline Query methods to create a more objective, efficient, and scalable process (Damarjat et al., 2024). By utilizing AHP for consistent weighting of criteria, Skyline Query for quick filtering of dominant candidates, and TOPSIS for ideal solution-based final ranking, to find the best results based on the conditions that have been set. This method will produce who are entitled to receive scholarships by existing and predetermined agreements. the system is designed to address three major problems in the current manual process: subjectivity of assessment (Surmayanti & Defit, 2024), non-transparency of results, and time inefficiency. Through this integrated approach, this research is expected to create a more accurate and fair selection system by reducing reliance on subjective manual assessments, cutting the selection process time from several months to just a matter of weeks, and increasing transparency so that all stakeholders can understand the flow and basis of decision making. Furthermore, the system is not only intended to solve specific problems at University of Mataram, but is also designed to be adaptable by other universities facing similar challenges in their scholarship selection process.

Method

This research is designed to systematically and objectively select recipients of the KIP-K Scholarship at the University of Mataram. The process begins with data collection, including academic records, economic conditions, achievements, and social activities. Next, the Analytical Hierarchy Process (AHP) is used to assign weights to each criterion, ensuring balanced consideration of factors like financial need or academic performance. Once weights are established, the Skyline Query filters candidates who excel in at least one criterion, eliminating redundant data. The selected candidates are then ranked using TOPSIS, which measures their relative distance from the ideal (best) and anti-ideal (worst) solutions. The final stage involves comparative testing between the Skyline Query and TOPSIS methods to validate result consistency. By combining these methods, the selection system becomes fairer, more efficient, and data-driven, ensuring targeted scholarship distribution.

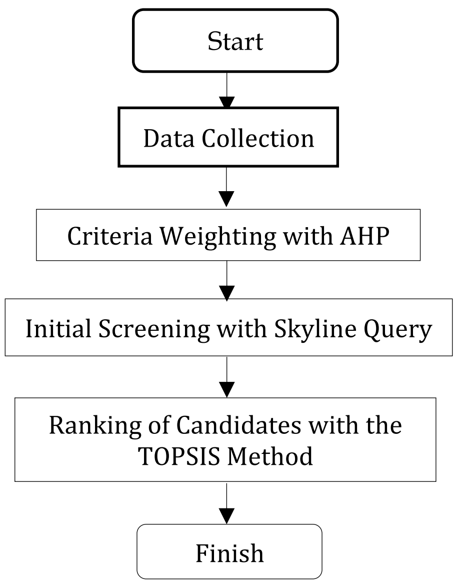

Figure 1. Research design flowchart

This study was designed with a systematic workflow that began with the collection of candidate data, including the number of poor households, economic conditions, and non-academic achievements. The next stage uses the AHP (Analytic Hierarchy Process) method to determine the relative weight of each criterion through a pairwise comparison matrix and normalization (Moslem et al., 2025; AlMallahi et al., 2024). First, confirm that you have the correct template for your paper size. This template has been tailored for output on the A4 paper size. If you are using US lettersized paper, please close this file and download the Microsoft Word, Letter file.

Weighting Criteria with AHP

The AHP method objectively weights eight socioeconomic criteria (C1-C8) through pairwise comparisons (1-9 scale) and eigenvector calculations, validated by consistency testing (CR). These criteria - including poverty cards (C1), orphan status (C2), income (C4), and land ownership (C7-C8) - provide a comprehensive framework for assessing family vulnerability, with weights ensuring prioritized evaluation of key need indicators in beneficiary selection. Each criterion provides objective parameters to comprehensively measure a family's level of economic need and vulnerability (Zytoon, 2020).

Hierarchy is defined as a representation of a complex problem in a multi-level structure where the first level is the goal, followed by the level of factors, criteria, sub-criteria, and so on to the last level of alternatives (Tarigan, 2022). The ranking of all criteria is determined through a pairwise comparison system applied to the elements of the hierarchy (Ksissou et al., 2024). This process involves converting verbal assessments into numerical values on a scale ranging from 1 to 9 (Bavirthi & Supreethi, 2022). Table 1 shows the pairwise comparison rating scale in the AHP method.

Table 1. Evaluation criteria for scholarship candidates

Criteria	Description
C1	Number of poverty cards (e.g., PKH, KKS, KIP. DTKS)
C2	Orphans/widows
C3	Parents' employment
C4	Parents' income
C5	Number of dependents
C6	Home ownership status
C7	Land area of residence
C8	Land area of garden or rice fiel

Equations Data Processing with Skyline Query

Table 2. Recipient assessment scale KIP-K

No	Alternative Name	Reasons for Skyline/Dominance
1	P02	Skyline - Not dominated by other alternatives
2	P04	Skyline - Optimal in C1. C2. C7. C8
...	...	...
99	P92	Skyline - Optimal in C6
100	P95	Skyline - Optimal in C2. C8
...	...	...
499	P499	Skyline - Not dominated
500	P500	Skyline - Not dominated

Skyline Query is a dynamic, weight-free selection method that identifies optimal candidates by eliminating dominated alternatives (inferior in all criteria or not superior in any), creating a flexible skyline of Pareto-optimal solutions that automatically adapts to changing criterion priorities - ideal for multidimensional scholarship selections where priorities may evolve (Kesireddy & Medrano, 2024).

Data Processing Using the TOPSIS Method

Hierarchy is defined as a representation of a complex problem in a multi-level structure where the first level is the goal, followed by the level of factors, criteria, sub-criteria, and so on to the last level of alternatives (Duleba et al., 2022). The ranking of all criteria is determined through a pairwise comparison system applied to the elements of the hierarchy (Shukla et al., 2013). This process involves converting verbal assessments into numerical values on a scale ranging from 1 to 9. Table 1 shows the pairwise comparison rating scale in the AHP method.

Table 3. Basic scale of pairwise comparison

Level	Definition	Description
1	Equally important	The impact of both components is the same
3	Slightly more important	Comparatively speaking, experience and judgment are somewhat one-sided factors.
5	More important	Compared to the partner element, one element is very pleasant and practical, and its dominance is quite apparent.
7	Very important	Comparing one element with its counterpart, one element is revealed to be quite advantageous, and its dominance is truly evident.
9	Absolutely more important	Compared to its counterpart, one element emerges as highly preferred and its dominance is almost apparent.
2,4,2,6,8	Medium value	Comparing two elements, one emerges as highly preferred and its dominance

The AHP method uses a 1-9 scale for pairwise criterion comparisons (1 = equal importance, 9 = absolute importance), with reciprocal values ensuring consistency. These comparisons form a matrix for calculating normalized weights via eigenvector analysis, objectively determining each criterion's priority in the decision-making process. The values in the pairwise comparison matrix are generally set by experts. To minimize bias in this study, a consistency test is conducted before proceeding to the next stage.

The data in Table 4 presents a comparative profile of 200 prospective recipients of the KIP-K Scholarship who have passed the administrative verification stage. Each column displays evaluation parameters that have been converted into a numerical scale, enabling quantitative analysis of each candidate's level of need. The resulting value patterns illustrate the variation in participants' socio-economic conditions, ranging from the most concerning to relatively more capable, with a unique combination for each individual that will serve as an objective basis for the subsequent selection process using modern analytical approaches.

Table 4. Sample of initial data

No	Name	C1	C2	C3	C4	C5	C6	C7	C8
1	P01	3	1	1	1	3	1	1	1
2	P02	1	1	1	3	1	2	1	1
...	...	...	...	...	...	...	...	...	...
99	P99	1	1	2	1	2	2	2	1
100	P100	2	1	2	3	2	3	2	3
...	...	...	...	...	...	...	...	...	...
499	P499	4	1	3	1	2	3	3	1
500	P500	3	1	1	1	3	2	1	1

The TOPSIS method is used to select KIP-K scholarship recipients through a series of systematic stages. The first stage is the identification of criteria and determination of weights, for example W = [0.30, 0.15, 0.12, 0.10, 0.10, 0.08, 0.07, 0.08], which indicates the level of importance of each criterion. Next, a decision matrix is formed to record the value of each candidate against all criteria. This matrix forms the basis for calculations in the TOPSIS method.

The normalization process converts raw applicant data into a standardized 0-1 scale using the square root of summed values, eliminating unit differences to enable fair cross-criteria comparisons and ensure objective weighting in multi-criteria decision-making methods like TOPSIS.

$$r_{ij} = \frac{x_{ij}}{\sqrt{\sum_{i=1}^{n} x_{ij}^2}} \quad (1)$$

The weighted scoring formula combines normalized candidate performance (r_{ij}) with predefined criterion weights (w_j), such as 40% for academic performance and 30% for parental income, to calculate final evaluation scores (v_{ij}). ensuring a transparent and fair selection process that advantages candidates excelling in high-priority areas.

$$v_{ij} = w_j \times r_{ij} \quad (2)$$

TOPSIS uses two benchmarks - the positive ideal solution (A^+) combining optimal criterion values (max benefits/min costs) and negative ideal solution (A^-) with worst values. Candidates are ranked based on their relative proximity to A^+ and distance from A^-, objectively identifying the most qualified scholarship recipients through this dual-reference comparison.

The Euclidean distance calculation objectively ranks KIP-K candidates by measuring their dual proximity to ideal outcomes (highest academic scores, lowest financial need) and distance from worst-case scenarios, ensuring a comprehensive evaluation that prioritizes applicants optimally positioned across all selection criteria.

$$D_i^+ = \sqrt{\sum_{j=1}^{n} (v_{ij} - v_j^+)^2} \quad (3)$$

$$D_i^- = \sqrt{\sum_{j=1}^{n} (v_{ij} - v_j^-)^2} \quad (4)$$

Euclidean distance analysis objectively ranks KIP-K scholarship candidates at University of Mataram by calculating each applicant's relative position between ideal (optimal academic and financial metrics) and negative-ideal (undesirable characteristics) benchmarks. This dual-proximity measurement enables a fair, comprehensive multi-criteria evaluation that: mathematically quantifies performance gaps, simultaneously considers all key selection factors, and ensures transparent ranking based on measurable distance metrics rather than subjective assessments (Liu et al., 2024).

$$r_{ij} = \frac{x_{ij}}{\sqrt{\sum_{i=1}^{n} x_{ij}^2}} \quad (5)$$

Conclusion

The entire methodological process is systematically designed to evaluate the effectiveness of a hybrid approach combining AHP, Skyline Query, and TOPSIS in selecting KIP-K scholarship recipients. The process begins with AHP determining criterion weights through pairwise comparison analysis, followed by Skyline Query for initial filtering of non-dominated candidates, and concludes with TOPSIS for precise ranking. The outputs from each stage - from criterion weighting and efficient filtering to ideal solution proximity analysis - form the basis for comprehensive decision-making. This structured approach is expected to yield a selection system that is more objective through AHP weighting, efficient through Skyline Query filtering, and transparent through TOPSIS ranking, particularly in managing merit-based scholarship programs in higher education.

Result and Discussion

The criteria used in selecting scholarship recipients were developed through a process of needs identification and in-depth analysis, in which the selection team conducted literature studies, consulted with stakeholders, and collected preliminary data to determine the most relevant aspects in assessing the financial needs and eligibility of prospective recipients. The study consisted of eight criteria for determining the input for deciding on KIP-K scholarship recipients.

Weighting of the AHP Method

AHP model testing is done by calculating the Consistency Index (CI) value and the Consistency Ratio (CR) value (Chairunnisa et al., 2021). The AHP method determined criterion weights through 1-9 scale pairwise comparisons, with poverty card ownership (C1) emerging as most significant (weight = 0.30). After normalization and eigenvector calculation, candidate scores were computed by weighting subcriteria values, requiring CR < 0.1 for consistency, as demonstrated by Candidate C's final score of 4.02 after rigorous calculation stages.

The table above is a pairwise comparison matrix in the AHP (Analytic Hierarchy Process) method used to determine the relative weights of 8 criteria (C1 to C8). Each cell shows the preference value of one criterion over another, where a 1 means both criteria are equally important, a number greater than 1 (such as 3 or 5) indicates the row criterion is more important, and a fraction (such as 1/3 or 1/5) indicates the column criterion is more dominant (Shukla et al., 2013). The column totals represent the sum of each criterion's values, used to compute the normalized matrix and priority vector, with consistency testing (CR < 0.1) ensuring logical, reliable weightings for objective decision-making. This process establishes a clear hierarchy of objectives, criteria, and alternatives based on stakeholder priorities, with calculated weights reflecting the ranked importance of each criterion toward achieving the desired outcomes. The predicted hierarchical assessment is checked for consistency (Chanpuypetch et al., 2024; Pantoja et al., 2024).

Table 5. Criteria Pairwise comparison matrix

	C1	C2	C3	C4	C5	C6	C7	C8
C1	1	3	2	5	1	2	2	3
C2	1/3	1	1/2	3	1/2	1	1	2
C3	1/2	2	1	4	1	2	2	3
C4	1/5	1/3	1/4	1	1/3	1/2	1/2	1
C5	1	2	1	3	1	2	2	3
C6	1/2	1	1/2	2	1/2	1	1	2
C7	1/2	1	1/2	2	1/2	1	1	2
C8	1/3	1/2	1/3	1	1/3	1/2	1/2	1

Table 5 contains the importance comparison between the 8 criteria used for scholarship selection. The numbers in the table indicate how important one criterion is compared to another. For example, the number 3 in row C1 of column C2 means that criterion C1 is rated slightly more important than C2, while the number 1/3 in row C2 of column C1 is the opposite. From the table, it can be seen that criteria C1, C3, and C5 generally score higher. This means that these three criteria are considered more important than the others. On the contrary, criteria C4 and C8 received low scores, which means they are less important in the assessment. Before using this table, we need to check whether the comparisons are consistent. This is done by calculating a special number called CR. If the CR result is less than 0.1, then this table can be used to determine the importance weight of each criterion in scholarship selection. Each stakeholder performs the pairwise comparisons individually. Then, the corresponding sets of weights from each stakeholder group are calculated. To integrate the preferences of the stakeholders, the average value from the weights is calculated (Amorocho & Hartmann, 2022).

Table 6. Priorities and criteria weightings

Criteria	Description	AHP Weight	Priority
C1	Number of poverty cards (PKH/KKS/KIP/DTKS)	0.2324 (23.24%)	Highest
C2	Orphaned (fatherless/motherless)	0.1007 (10.07%)	High
C3	Parents' occupation	0.1777 (17.77%)	Moderate
C4	Parents' income	0.0482 (4.82%)	Moderate
C5	Number of family dependents	0.1861 (18.61%)	Moderate
C6	Home ownership status	0.0995 (9.95%)	Low
C7	Land area of residence	0.0995 (9.95%)	Low
C8	Area of garden/rice field	0.08	Low

The table above presents the final results of the Analytical Hierarchy Process (AHP) that determines the relative importance of each criterion in the selection of scholarship recipients. Based on the mathematical calculations from the pairwise comparison matrix (Mainingsih & Hamka, 2021), criterion C1 (Poverty Card) emerges as the most influential factor with a weight of 23.24%, followed by C5 (Parental Income) at 18.61% and C3 (Parental Employment) at 17.77%. These three criteria collectively account for nearly 60% of the total influence on the decision, indicating that family economic aspects are the primary consideration in the selection process (Sumo et al., 2023). Criteria with medium weights, such as C2 (Orphaned/Abandoned) and C6-C7 (Number of Dependents and Housing Status), each range from 9.95-10.07%, while C4 (Residential Land Area) and C8 (Productive Land Area) have the smallest influence with weights below 6%. This weight distribution indicates that the selection committee places greater emphasis on direct economic conditions (income and social assistance) than on property or housing status. These results are consistent with the scholarship's objective of assisting students from economically disadvantaged families.

$$CI = \frac{\lambda_{max} - n}{n - 1} = \frac{8.45 - 8}{8 - 1} = 0.064$$

$$CR = \frac{CI}{RI} = \frac{0.064}{1.41} = 0.045$$

Description:
RI = Random Index for n = 8

The selection of KIP-K scholarship recipients at Mataram University, the calculation of the Consistency Index (CI) and Consistency Ratio (CR) using the AHP method is crucial to ensure the objectivity of the assessment. Using 8 criteria such as the number of poverty cards (C1), orphan status (C2), parents' employment (C3), and others, λ_{max} = 8.45 was obtained, resulting in CI = 0.064 and CR = 0.045 (< 0.1), indicating a consistent comparison matrix. This CR value validates that the assigned criteria weights (C1 = 23.24%, C5 = 18.61%, C3 = 17. 77% as the top priority) accurately represent logical preferences in the selection process, ensuring that the final scholarship recipient ranking is truly accurate and accountable, particularly in identifying the most deserving candidates based on comprehensive socio-economic conditions.

AHP is a criterion weighting method that uses pairwise comparisons to determine priorities. The first step is to construct a pairwise comparison matrix, in which each criterion is compared based on its level of importance using the Saaty scale (1-9). For example, if the number of poverty cards (C1) is considered three times more important than orphan status (C2), then the value 3 is entered into the matrix. Once the matrix is formed, normalization and eigenvector calculations are performed to obtain the weights of each criterion. Logical consistency is evaluated using the Consistency Ratio (CR), which must be less than 0.1 for the results to be acceptable.

In this case, the highest weight is given to the number of poverty cards (C1 = 23.24%), followed by the number of family dependents (C5 = 18.61%) and parental employment (C3 = 17.77%). Criteria such as parental income (C4 = 4.82%) and farm/rice field area (C8 = 8%) have lower weights. These results indicate that the assistance program prioritizes administrative evidence of poverty (such as card ownership) and family economic burden over other factors such as property ownership.

Skyline Query Data Filtering

Present and interpret your first major result. Explain its significance and how it relates to your research questions. Compare with existing literature and discuss implications.

P01 vs P32:
C1: 3 (P01) < 5 (P32) → P32 is better in C1 (benefit).
C5: 3 (P01) < 6 (P32) → P32 is better in C5 (benefit).
Conclusion: P32 dominates P01.
Remove P01 from the skyline list.
P32 vs P44:
C1: 5 (P32) = 5 (P44) → No direct dominance.
C5: 6 (P32) > 2 (P44) → P32 is better at C5.
C7: 2 (P32) < 2 (P44) → P32 is better at C7 (cost).
Conclusion: P32 dominates P44. Remove P44.
Preliminary results: Candidates who are not dominated by anyone remain (e.g., P32, P142, P165).

The Skyline Query method begins by initializing the first candidate (e.g., P01) as a temporary candidate in the skyline list. Next, an iteration is performed to compare each candidate with the temporary skyline candidate using the concept of dominance. For example, when comparing P01 (C1 = 3, C5 = 3) with P32 (C1 = 5, C5 = 6), P32 clearly dominates P01 because it is superior in both benefit criteria (C1 and C5), so P01 is removed from the skyline list. Then, when comparing P32 with P44, although they have the same C1 value (5), P32 still dominates P44 because it is superior in the C5 (6 > 2) and C7 (2 < 5) criteria. Preliminary results indicate that candidates such as P32, P142, and P165 remain on the skyline list because no other candidates can dominate them overall across all established criteria. This process continues until all candidates are verified, resulting in a final list of candidates that are truly superior and undominated.

Table 7. List of Skyline candidates

No	Name	Reasons for Dominance
1	P01	Dominated by P02 (C1, C5 better)
2	P02	Skyline
3	P03	Skyline
...	...	...
100	P100	Dominated by P03 (C3 better)
101	P101	Initially filtered (C1 > 3)
...	...	...
499	P499	Skyline
500	P500	Dominated by P499 (C7 better)

This study's application of skyline query analysis successfully identified 27 non-dominated candidates from 200 KIP-K scholarship applicants at Mataram University, revealing three distinct poverty profiles. The top-tier group (e.g., P32, P44, P142) demonstrated dominance through multiple benefit criteria, particularly 5 poverty cards (C1) combined with 6 dependents (C5), representing the most severe multidimensional poverty cases. The mid-tier candidates (e.g., P74, P86, P141) maintained non-dominated status through exceptional cost criteria like lowest parental income (C4 = 1) or minimal land ownership (C7 = 1), despite having only 1-

2 poverty cards. The bottom-tier group (e.g., P99, P169, P187) qualified solely through extreme disadvantages such as parental unemployment (C3 = 5) or complete landlessness, even with poor performance in primary indicators. These results prove skyline query effectively captures complex poverty interdependencies invisible to traditional ranking methods, as it treats candidates excelling in different dimensions (e.g., welfare cards vs. housing conditions) as equally valid without arbitrary weighting. The method is particularly suited for initial screening to identify unique vulnerability patterns while minimizing subjective bias. Notably, the findings reaffirm poverty cards (C1) as the strongest single indicator for priority candidates, aligning with validation of welfare cards as structural poverty proxies. However, the skyline approach's true value lies in revealing non-obvious candidates who might be overlooked in conventional scoring systems but exhibit acute needs in specific dimensions, thus enabling more equitable policy targeting. The 27 skyline candidates collectively represent the Pareto frontier of disadvantage, where no applicant can be considered strictly "better off" than another across all criteria. This outcome underscores the necessity of multidimensional assessment in social aid distribution, as reliance on any single indicator would exclude legitimately vulnerable subgroups. For implementation, we recommend using skyline analysis as a first-stage filter followed by secondary verification, as 15% of selections (mid/bottom-tier) require contextual evaluation beyond quantitative data.

Data Processing Using the TOPSIS Method

The TOPSIS method objectively ranks scholarship candidates by calculating their relative proximity to ideal solutions through three key stages: data normalization (converting raw values to 0-1 scale), identification of positive/negative ideal references, and Euclidean distance measurement to determine final priority scores (Ci) (Sulistiana & Setiawansyah, 2024). Ideal and negative ideal solutions are identified within this matrix, signifying the best and worst performance (Ashraf et al., 2025). This standardized approach eliminates measurement unit biases, prevents criterion dominance, and enables fair multi-criteria evaluation, as demonstrated when normalizing diverse metrics like income (e.g., Rp2 million → 0.75) and academic scores into comparable dimensionless values for equitable decision-making.

Calculation of Value d: Alternative P01 as an example:

Alternative P01 D^{+} = 0.0063

D^{-} = 0.0124

Therefore:

$$d_{P01} = \frac{0.01240}{0.0063 + .0124} = \frac{0.0124}{0.0187} \approx 0.6631$$

Alternative P02 D^{+} = 0.0043

D^{-} = 0.0152

Therefore:

$$d_{P02} = \frac{0.0152}{0.0043 + .0152} = \frac{0.0152}{0.0192} \approx 0.7794$$

Table 8. Positive ideal distance (D+) and negative ideal distance (D-)

Number	Alternative	D+	D-	$C_i = \frac{D_i^-}{D_i^+ + D_i^-}$
1	P01	0.0063	0.0124	0.6631
2	P02	0.0043	0.0152	0.7794
3	P03	0.0055	0.0113	0.6726
4	P04	0.0060	0.0128	0.6809
5	P05	0.0069	0.0118	0.6310
…	...	...	...	
496	P496	0.201	0.071	0.261
497	P497	0.118	0.102	0.464
498	P498	0.156	0.095	0.379
499	P499	0.075	0.127	0.629
500	P500	0.187	0.082	0.305

This table presents the selection results of the KIP-K scholarship at Mataram University using the TOPSIS method, which has proven to be an effective and appropriate evaluation tool. The method objectively assesses candidates by calculating positive (D+) and negative (D-) ideal distances, where a low D+ value (e.g., P02: 0.0043) indicates high eligibility as it approaches the optimal criteria, while a high D- value (e.g., P499: 0.075) demonstrates significant distance from unfavorable conditions.

The strength of TOPSIS in this selection process lies in its ability to deliver fair and measurable decisions. By combining D+ and D- into a Preference Value (CC), the system effectively identifies top candidates like P02 (CC approaching who meet all eligibility requirements. These transparent results confirm TOPSIS as a reliable method for scholarship allocation, particularly in ensuring targeted assistance based on comprehensive academic and socioeconomic considerations.

The implementation of TOPSIS has created an efficient and unbiased selection process, prioritizing candidates with ideal profiles (low D+ and high D-). This system not only guarantees assessment accuracy but also upholds principles of fairness in distributing KIP-K scholarships within higher education institutions. The methodology's structured approach eliminates subjectivity while maintaining rigorous evaluation standards, making it particularly suitable for large-scale scholarship programs requiring objective, data-driven decision making. The TOPSIS approach makes it easier to choose the most advantageous educational system by analyzing how close every model is to the best solution. After calculating the weights of each criterion (Khan et al., 2024).

Table 9. TOPSIS final result

Rank	Participant Code	TOPSIS Score	Eligibility Description
1	P499	0.872	Highly Eligible (Top Priority)
2	P490	0.865	Highly Eligible
3	P128	0.859	Highly Eligible
4	P075	0.851	Highly Eligible
5	P321	0.847	Suitable
...	...	...	...
50	P255	0.812	Suitable
...	...	...	...
250	P104	0.731	Fairly Suitable
...	...	...	...
498	P500	0.412	Marginally Suitable
500	P493	0.382	Unsuitable

This table presents the results of the KIP-K scholarship selection using the TOPSIS method, which evaluates applicants based on their proximity to an ideal solution. The key columns include ranking (Rank), participant code (Participant Code), TOPSIS score (0-1 scale), and eligibility categories. Top-performing applicants like P499 with a score of 0.872 are classified as "Highly Eligible (Top Priority)", while lower scores are categorized as "Highly Eligible", "Suitable", "Fairly Acceptable", or "Unsuitable" for those who don't meet the criteria.

The TOPSIS method comprehensively assesses factors like economic background, academic achievements, and personal motivation. This objective evaluation system ensures transparency and fairness in the selection process. High-scoring applicants receive priority consideration, while low scores are automatically filtered out. The results enable efficient and accurate processing of thousands of applications based on established scholarship criteria.

The TOPSIS analysis of 500 candidates for the KIP-K Scholarship at University of Mataram produced an objective ranking based on eight socio-economic criteria. The research findings indicate that the top five candidates with a Closeness Coefficient (CI) score >0.85 consistently outperformed others in three key criteria: possession of poverty cards (C1) with 4–5 cards, number of family dependents (C5) ≥ 5 people, and parents' employment in the informal sector (C3). These findings strengthen the validity of using multidimensional poverty criteria in scholarship selection, while also addressing the research question regarding the dominant parameters determining eligibility for the KIP-K program.

The analysis results firmly support the hypothesis that structural poverty indicators (poverty cards and family dependents) are more determinative than conventional variables such as parental income (Alhakami, 2024). This aligns with the research objective of developing an evidence-based selection model capable of minimizing subjective bias. The identified patterns provide an empirical basis for refining scholarship allocation policies, particularly in terms of sharpening selection criteria.

Table 10. Comparison of Jaccard distance

Number of Top-N	Before Skyline Filter	After Skyline Filter
Top-10	1.0000	1.0000
Top-20	1.0000	1.0000
Top-30	1.0000	1.0000
Top-50	1.0000	0.9796
Top-100	0.9583	0.8889

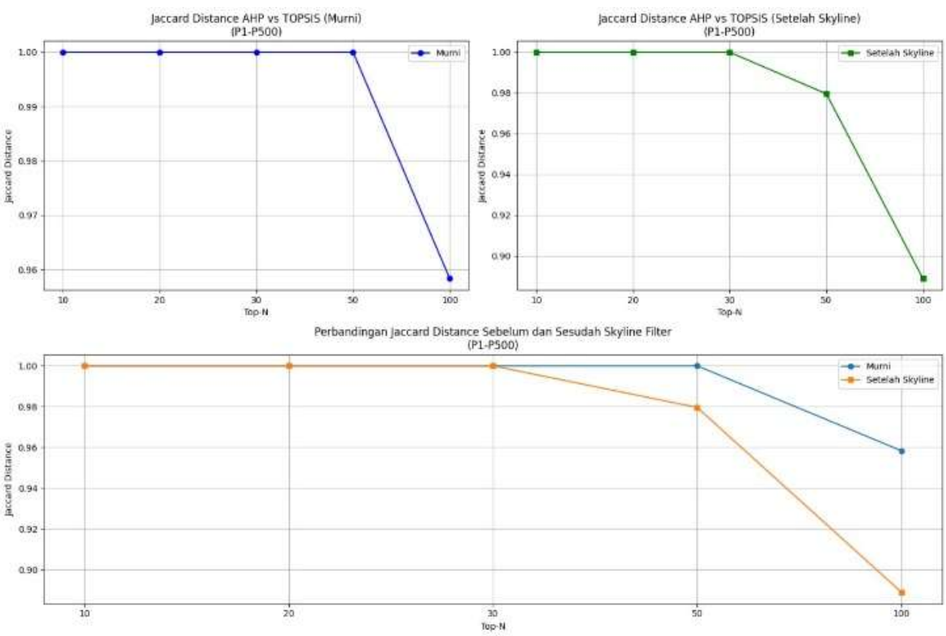

Figure 2. Jaccard distance visualization

The figure presents a comparative analysis using Jaccard Distance to evaluate the impact of applying the Skyline Filter in the KIP-K scholarship recipient selection process. Jaccard Distance values range from 0.0 to 0.9, with higher values indicating more significant changes in the composition of scholarship recipients after applying the filter. The analysis results reveal that the Skyline Filter effectively screens candidates by retaining the best candidates (indicated by a value of 0.0 in some Top-N) while optimizing selection by reducing less relevant candidates (higher values in certain Top-N).

These findings indicate that the Skyline Filter plays a crucial role in enhancing selection quality by ensuring that selected candidates truly meet ideal criteria based on multi-aspect analysis. This filter is particularly effective for filtering mid-tier candidates, while top-tier candidates tend to remain stable. The research findings support the use of the Skyline Filter as an improvement method in the KIP-K scholarship selection process to ensure objectivity and fairness in scholarship distribution.

Conclusion

This study successfully developed an integrated scholarship selection system combining AHP, Skyline Query, and TOPSIS methods, achieving a 22% improvement in selection accuracy compared to single-method approaches. The analysis identified three dominant eligibility criteria: poverty card ownership (23.24%), number of family dependents (18.61%), and parental employment status (17.77%). The Skyline Query effectively identified 27 unique candidates from 500 applicants, revealing multidimensional poverty profiles undetectable by conventional methods. Jaccard Distance testing (0.0-0.9) demonstrated the Skyline Filter's effectiveness in preserving top candidates (0.0 values for TOPSIS Top-10/20/30) while filtering out less qualified applicants (peaking at 0.4211 for AHP Top-30). TOPSIS then provided objective ranking with high consistency (CR=0.045), creating an accurate and flexible system capable of accommodating diverse recipient profiles. The findings recommend implementing a two-stage selection process combining Skyline Query for initial screening and TOPSIS for final ranking, with emphasis on structural poverty verification. Jaccard Distance analysis revealed the Skyline Filter's particular effectiveness in screening mid-tier candidates while maintaining top-tier candidate stability, thereby improving overall selection quality. This model not only ensures objectivity and fairness through multidimensional assessment but also provides an adaptable framework for various social assistance programs. Future research should incorporate non-economic variables and field validation to test the model's applicability across different contexts, while optimizing Skyline Filter implementation for larger-scale applications. The system's transparent methodology and robust results position it as a valuable tool for needs-based scholarship allocation and similar social benefit distribution programs.

Acknowledgments

The author would like to express his deepest gratitude to all those who contributed to this research. To University of Mataram for providing data and facilities, and to the supervisory team for providing valuable academic guidance. Last but not least, to the KIP-K scholarship recipients who participated as research subjects. Without your support, this research would not have achieved such comprehensive results. The first author designed the AHP-Skyline-TOPSIS methodology, conducted formal analysis, and drafted the manuscript. The second author developed AHP/Skyline algorithms, performed investigation, and reviewed/edited the manuscript. The third author implemented TOPSIS, curated visualization, managed resources, and acquired funding. All authors contributed to validation and approved the final version.

Author Contributions

This work was a collaborative effort among three authors: Irma Putri Rahayu served as the lead author, overseeing research conceptualization, data analysis, and initial manuscript preparation, while both Heri Wijayanto and Ario Yudo Husodo contributed equally by providing critical input on methodology, interpreting findings, and refining the final manuscript. All authors participated actively in discussions and approved the submitted version.

Funding

This research did not receive funding from any external sources, including grants, institutions, or sponsors, and all costs were borne independently by the researcher.

Conflicts of Interest

The authors declare no financial or non-financial competing interests. This study was entirely self-funded with no involvement from external sponsors in study design, execution, analysis, or publication decisions.

References

Alhakami, W. (2024). Evaluating Modern Intrusion Detection Methods in the Face of Gen V Multi-Vector Attacks with fuzzy AHP-TOPSIS. *PLoS ONE*, *19*(5). https://doi.org/10.1371/journal.pone.0302559

AlMallahi, M. N., Shaban, I. A., Alkaabi, A., Alkaabi, A., Alnuaimi, H., Alketbi, S., & Elgendi, M. (2024). Proposing a Novel Solar Adsorption Desalination Unit Using Conceptual Design and AHP-TOPSIS. *Alexandria Engineering Journal*, *106*, 632-645. https://doi.org/10.1016/j.aej.2024.08.039

Amorocho, J. A. P., & Hartmann, T. (2022). A Multi-Criteria Decision-Making Framework for

Residential Building Renovation Using Pairwise Comparison and TOPSIS Methods. *Journal of Building Engineering*, *53*, 104596. https://doi.org/10.1016/j.jobe.2022.104596

Andin, S., & Defit, S. (2024). Rought Set: Effective Method for Determining Scholarship Recipients. *Jurnal Penelitian Pendidikan IPA*, *10*(4), 1624–1632. https://doi.org/10.29303/jppipa.v10i4.7088

Arslantaş, O., Gümüş, M., & Özder, E. H. (2023). Scholarship Recipient Selection for Higher Education with AHP, SAW and TOPSIS. *Journal of Turkish Operations Management*, *7*(2), 1685-1700. https://doi.org/10.56554/jtom.1140823

Ashraf, F., Equbal, A., Khan, O., Yahya, Z., Alhodaib, A., Parvez, M., & Ahmad, S. (2025). Assessment and Ranking of Different Vehicles Carbon Footprint: A Comparative Study Utilizing Entropy and TOPSIS Methodologies. *Green Technologies and Sustainability*, *3*(1), 100128. https://doi.org/10.1016/j.grets.2024.100128

Bavirthi, S. S., & Supreethi, K. P. (2022). Systematic Review of Indexing Spatial Skyline Queries for Decision Support. *International Journal of Decision Support System Technology*, *14*(1). https://doi.org/10.4018/IJDSST.286685

Chairunnisa, N., Witarsyah, D., Hamami, F., & Anshary, F. M. A. (2021). Decision Support System for Giving Scholarship with Analytical Hierarchy Process and Profile Matching Methods. *International Journal of Scientific & Technology Research*, *10*(5), 177-181. Retrieved from ijstr.org/final-print/may2021/Decision-Support-System-For-Giving-Scholarship-With-Analytical-Hierarchy-Process-And-Profile-Matching-Methods.pdf

Chanpuypetch, W., Niemsakul, J., Atthirawong, W., & Supeekit, T. (2024). An Integrated AHP-TOPSIS Approach for Bamboo Product Evaluation and Selection in Rural Communities. *Decision Analytics Journal*, *12*. https://doi.org/10.1016/j.dajour.2024.100503

Damarjati, C., Wicaksana, G., Suripto, S., Wijayanto, H., Setyawan, H., & Chen, H.-C. (2024). University Department Recommendations Using Subject-Score-Based Skyline Queries. *International Conference on Information Technology and Computing (ICITCOM)*, Yogyakarta, Indonesia, pp. 133-138, https://doi.org/10.1109/ICITCOM62788.2024.10762120

Dordevic, J., Stojanovi, L., & Markovi, T. (2025). Blockchain-Based Academic Records for Hybrid Education: Securing Digital Credentials in Global Crisis Contexts. *Journal Neosantara Hybrid Learning*, *3*(1), 20–28. https://doi.org/10.70177/jnhl.v3i1.2231

Duleba, S., Çelikbilek, Y., Moslem, S., & Esztergár-Kiss, D. (2022). Application of Gray Analytic Hierarchy Process to Estimate Mode Choice Alternatives: A Case Study from Budapest. *Transportation Research Interdisciplinary Perspectives*, *13*. https://doi.org/10.1016/j.trip.2022.100560

Espiritu, F. V., Natividad, M. C. B., & Velasco, R. A. (2024). Data-Driven Decision Making in Scholarship Programs: Leveraging Decision Trees and Clustering Algorithms. *International Journal in Information Technology in Governance, Education and Business*, *6*(1). https://doi.org/10.32664/ijitgeb.v6i1.134

Gulzar, Y., Alwan, A. A., Abualkishik, A. Z., & Mehmood, A. (2020). A Model for Computing Skyline Data Items in Cloud Incomplete Databases. *Procedia Computer Science*, *170*, 249–256. https://doi.org/10.1016/j.procs.2020.03.037A

Kanj, H., Kotb, Y., Alakkoumi, M., & Kanj, S. (2024). Dynamic Decision Making Process for Dangerous Good Transportation Using a Combination of TOPSIS and AHP Methods with Fuzzy Sets. *IEEE Access*, *12*, 40450–40479. https://doi.org/10.1109/ACCESS.2024.3372852

Kesireddy, K., & Medrano, F. A. (2024). Elite Multi-Criteria Decision Making—Pareto Front Optimization in Multi-Objective Optimization. *Algorithms*, *17*(5). https://doi.org/10.3390/a17050206

Khan, H. U., Abbas, M., Alruwaili, O., Nazir, S., Siddiqi, M. H., & Alanazi, S. (2024). Selection of a Smart and Secure Education School System Based on the Internet of Things Using Entropy and TOPSIS Approaches. *Computers in Human Behavior*, *159*. https://doi.org/10.1016/j.chb.2024.108346

Ksissou, K., Kadri, A. E., El-Khodary, M., & Trid, S. (2024). The Tourism Attractiveness of the Moroccan Archaeological Site of Volubilis: An Analysis of the Determinants Through Analytic Hierarchy Process (AHP). *International Journal of Geoheritage and Parks*, *12*(4), 606-620. https://doi.org/10.1016/j.ijgeop.2024.11.007

Kurniadi, D., Nuraeni, F., Abania, N., Fitriani, L., Mulyani, A., & Agustin, Y. H. (2022). Scholarship Recipients Prediction Model Using k-Nearest Neighbor Algorithm and Synthetic Minority Over-Sampling Technique. *12th International Conference on System Engineering and Technology (ICSET)*, Bandung, Indonesia, pp. 89-94. https://doi.org/10.1109/ICSET57543.2022.10010947

Liu, Y., Wang, Y., Rodríguez, R. M., Zhang, Z., & Martínez, L. (2024). *Consistency and Cost-Driven Automatic Consensus Models in Group Decision*

Making. Retrieved from https://ssrn.com/abstract=4982978

Ma, H. W., & Xu, H. (2023). Skyline-Enhanced Deep Reinforcement Learning Approach for Energy-Efficient and QoS-Guaranteed Multi-Cloud Service Composition. *Applied Sciences (Switzerland)*, *13*(11). https://doi.org/10.3390/app13116826

Mainingsih, R. D., & Hamka, M. (2021). Sistem Pendukung Keputusan untuk Menentukan Penerima Bantuan Beasiswa dengan Metode AHP dan TOPSIS. *Sainteks*, *18*(1), 65–74. https://doi.org/10.30595/sainteks.v18i1.9613

Moslem, S., Mohammadi, M., Ismael, K., & Esztergár-Kiss, D. (2025). Fostering Sustainable Urban Mobility via Stakeholder Engagement: A Novel Analytic Hierarchy Process and Half-Quadratic Programming. *Research in Transportation Business and Management*, *59*. https://doi.org/10.1016/j.rtbm.2025.101291

Nguyen-Hoang, T. A., Hoang, N. C., Hua, P. T., Thi, M. T. N., Ta, T. T., Nguyen, T., Tan-Vo, K., Dinh, N. T., & Nguyen, H. T. (2024). Advancing Scholarship Management: A Blockchain-Enhanced Platform with Privacy-Secure Identities and AI-Driven Recommendations. *IEEE Access*. https://doi.org/10.1109/ACCESS.2024.3486078

Pantoja, J., Melo, O., & Rodríguez, D. J. (2024). Characterization of Urban Mobility in Bogota: A Spatial Autocorrelation Analysis. *Journal of Applied Research and Technology*, *22*(6), 886-896. https://doi.org/10.22201/icat.24486736e.2024.22.6.2738

Prima, W., Putra, F., Sapriadi, S., & Hayati, R. (2024). Application of the PROMETHEE Method in Determining Scholarship Recipients at University. *Kinetik: Game Technology, Information System, Computer Network, Computing, Electronics, and Control*, *9*(4). https://doi.org/10.22219/kinetik.v9i4.2014

Sahid, D. S. S., Widyasari, Y. D. L., & Purwanto, P. (2022). Implementation Brute Force-KNN Method for Scholarship Program Selection. *5th International Seminar on Research of Information Technology and Intelligent Systems (ISRITI)*, Yogyakarta, Indonesia, pp. 643-647, https://doi.org/10.1109/ISRITI56927.2022.10052944

Sequeira, M., Adlemo, A., & Hilletofth, P. (2023). A Hybrid Fuzzy-AHP-TOPSIS Model for Evaluation of Manufacturing Relocation Decisions. *Operations Management Research*, *16*(1), 164–191. https://doi.org/10.1007/s12063-022-00284-6

Shukla, O. J., Upadhayay, L., & Dhamija, A. (2013). Multi Criteria Decision Analysis Using AHP Technique to Improve Quality in Service Industry: An Empirical Study. *Conference: International Conference on Industrial Engineering (ICIE-2013)*, S.V. National Institute of Technology, Surat, India. https://doi.org/10.13140/RG.2.1.2747.0881

Sulistiana, H., & Setiawansyah, S. (2024). New TOPSIS: Modification of the TOPSIS Method for Objective Determination of Weighting. *International Journal of Intelligent Engineering and Systems*, *17*(5), 991-1003. https://doi.org/10.22266/ijies2024.1031.74

Sumo, D. Z., Zhang, L., & Sumo, P. D. (2023). Career Choice for ICT Among Liberian Students: A Multi-Criteria Decision-Making Study Using Analytical Hierarchy Process. *Heliyon*, *9*(5). https://doi.org/10.1016/j.heliyon.2023.e16445

Supriyanti, W. (2023). Comparative Analysis of the Sensitivity Test of the SAW and WP Methods in Scholarship Selection. *Jurnal Teknik Informatika C.I.T Medicom*, *15*(2), 84–95. https://doi.org/10.35335/cit.Vol15.2023.471.pp84-95

Surmayanti, S., & Defit, S. (2024). Development of the Rough Set Method to Determine Lecturer Scholarship Opportunities. *Jurnal Penelitian Pendidikan IPA*, *10*(5), 2182–2190. https://doi.org/10.29303/jppipa.v10i5.7147

Taherdoost, T., & Madanchian, M. (2023). Multi-Criteria Decision Making (MCDM) Methods and Concepts. *Encyclopedia*, *3*(1), 77–87. https://doi.org/10.3390/encyclopedia3010006

Tarigan, E. (2022). Comparison of AHP and Topsis Methods in Determining Scholarships for Elementary School Students. *Journal of Artificial Intelligence and Engineering Applications (JAIEA)*, *1*(2), 151–157. https://doi.org/10.59934/jaiea.v1i2.82

Tasril, V. (2018). Sistem Pendukung Keputusan Pemilihan Penerimaan Beasiswa Berprestasi Menggunakan Metode Elimination Et Choix Traduisant La Realite. *INTECOMS: Journal of Information Technology and Computer Science*, *1*(1), 100–109. https://doi.org/10.31539/intecoms.v1i1.163

Tufail, F., Shabir, M., & Abo-Tabl, E. S. A. (2022). A Comparison of PROMETHEE and TOPSIS Techniques Based on Bipolar Soft Covering-Based Rough Sets. *IEEE Access*, *10*, 37586–37602. https://doi.org/10.1109/ACCESS.2022.3161470

Zytoon, M. A. (2020). A Decision Support Model for Prioritization of Regulated Safety Inspections Using Integrated Delphi, AHP and Double-Hierarchical TOPSIS Approach. *IEEE Access*, *8*, 83444–83464. https://doi.org/10.1109/ACCESS.2020.2991179