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A Robust Multi-Criteria Decision Support Framework Using WASPAS For Transparent and Efficient Cooperative Ranking

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ABSTRACT: Cooperatives play a critical role in promoting inclusive economic development and strengthening community-based financial systems. However, the evaluation of cooperative performance remains a challenging task, particularly when traditional assessment processes rely on manual procedures that are time-consuming, inefficient, and prone to subjectivity. This study proposes a data-driven Decision Support System (DSS) based on the Weighted Aggregated Sum Product Assessment (WASPAS) method to enhance the objectivity, accuracy, and efficiency of cooperative performance evaluation. The proposed approach integrates the Weighted Sum Model (WSM) and the Weighted Product Model (WPM), enabling a more robust multi-criteria decision-making framework. The evaluation is conducted using seven key financial and operational indicators, including the number of members, capital, Return on Equity (ROE), Net Profit Margin (NPM), Return on Assets (ROA), Debt to Asset Ratio (DAR), and Debt to Equity Ratio (DER). The system is developed using a prototyping methodology and implemented through a web-based platform utilizing PHP and MySQL. To ensure system reliability and performance, comprehensive testing was conducted, including black-box testing and sensitivity analysis of the weighting parameter (λ). The results indicate that $\lambda = 0.5$ produces the most stable and consistent ranking outcomes, demonstrating the robustness of the proposed model. The findings confirm that the proposed WASPAS-based DSS significantly improves the transparency, consistency, and computational efficiency of cooperative evaluation compared to conventional manual approaches. This study contributes to the development of intelligent decision-making systems for cooperative management and provides a scalable framework for performance assessment in similar socio-economic institutions.

KEYWORDS: Decision Support System (DSS), WASPAS Method, Multi-Criteria Decision Making (MCDM), Cooperative Performance Evaluation, Hybrid Decision Model.

I. INTRODUCTION

Cooperatives play a pivotal role in fostering inclusive economic development and enhancing community welfare through democratically managed economic activities and active member participation. In many developing economies, cooperatives serve not only as business entities but also as instruments of social empowerment and equitable resource distribution [1], [2]. In Indonesia, the cooperative sector continues to demonstrate structural relevance, with the number of active cooperatives increasing from 127,846 units in 2021 to 131,617 units in 2024, indicating sustained institutional presence within the national economy.

Despite this positive growth, the increase in the number of cooperatives is not necessarily accompanied by improvements in institutional performance and governance quality. Several studies highlight persistent challenges faced by cooperatives, including low member participation, limited capital capacity, and weak managerial practices[3], [4]. These issues are also evident at the regional level. In Pekanbaru City, although the number of cooperatives has steadily increased, only a limited proportion consistently fulfills essential governance obligations such as conducting Annual Member Meetings (Rapat Anggota Tahunan – RAT), as reported by the Central Statistics Agency[5], [6], [7]. This discrepancy reflects a critical gap between institutional growth and operational effectiveness, thereby emphasizing the need for more systematic and reliable performance evaluation mechanisms.

To strengthen cooperative performance, the Indonesian government has introduced regulatory frameworks, including the Regulation of the Minister of Cooperatives and SMEs No. 06/Per/M.KUKM/V/2006, which aims to identify and reward high-performing cooperatives. However, in practice, the implementation of cooperative evaluation at the local level still encounters significant limitations. In the Pekanbaru City Cooperatives and MSMEs Office, the assessment process is predominantly conducted manually using spreadsheet-based tools, resulting in inefficiencies, prolonged processing time, and a high level of subjectivity in decision-making. Similar limitations have also been identified in previous studies, where traditional evaluation approaches tend to lack transparency and consistency [8], [9].

In response to these challenges, Decision Support Systems (DSS) have been widely recognized as effective tools for

enhancing decision-making processes in complex and multi-criteria environments. DSS enables systematic data processing and structured evaluation of alternatives, thereby improving objectivity and reducing human bias [10]. Furthermore, DSS plays a critical role in supporting data-driven decision-making in modern organizational contexts, including small and medium enterprise ecosystems [11].

Within DSS, Multi-Attribute Decision Making (MADM) methods have been extensively applied to evaluate and rank alternatives based on multiple criteria. Commonly used methods include Simple Additive Weighting (SAW), Technique for Order Preference by Similarity to Ideal Solution (TOPSIS), Multi-Objective Optimization on the Basis of Ratio Analysis (MOORA), and Analytical Hierarchy Process (AHP)[12], [13]. While these methods have demonstrated effectiveness in various domains, each presents inherent limitations. SAW, for instance, is computationally simple but may produce unstable results when handling complex datasets. TOPSIS is intuitive but highly sensitive to changes in criterion weights. MOORA provides a transparent evaluation structure but depends heavily on accurate normalization processes. Meanwhile, AHP and ANP rely on subjective pairwise comparisons, which may introduce inconsistency and bias in decision-making.

Although these MADM methods have been widely adopted, there remains a significant research gap in developing decision support systems that ensure not only computational efficiency but also robustness and stability of results, particularly in cooperative performance evaluation contexts. Previous studies on cooperative selection using methods such as SAW and WASPAS[14], [15],[9] primarily focus on implementation aspects without conducting in-depth analysis of result stability or sensitivity to parameter changes. Consequently, the reliability and generalizability of the decision outcomes remain insufficiently explored.

To address these limitations, the Weighted Aggregated Sum Product Assessment (WASPAS) method has emerged as a hybrid MADM approach that integrates the advantages of the Weighted Sum Model (WSM) and the Weighted Product Model (WPM). This integration enables WASPAS to produce more stable, consistent, and interpretable results by combining additive and multiplicative aggregation mechanisms[16]. However, empirical studies that investigate the robustness of WASPAS—particularly through sensitivity analysis of the weighting parameter (λ)—and its implementation in real-world institutional contexts are still limited.

Therefore, this study aims to bridge this gap by developing a data-driven Decision Support System based on the WASPAS method for cooperative performance evaluation in Pekanbaru City. Unlike previous studies, this research not only applies the WASPAS method but also incorporates sensitivity analysis of the λ parameter to evaluate the stability and consistency of ranking results. In addition, the system is implemented within a real governmental environment, providing practical insights into its applicability and effectiveness.

The significance of this study lies in three key contributions. First, it proposes a robust and transparent evaluation framework that enhances objectivity in cooperative performance assessment. Second, it demonstrates the practical integration of a hybrid MADM method into a web-based decision support system, thereby improving efficiency and scalability. Third, it provides empirical evidence on the stability of the WASPAS method through sensitivity analysis, contributing to the advancement of decision-making methodologies in socio-economic institutional contexts.

II. THEORETICAL BASIS

A. Decision Support System and MCDM Framework

Decision Support Systems (DSS) are computer-based systems designed to support complex decision-making processes by integrating data processing, analytical models, and knowledge-based components. DSS facilitates the transformation of raw data into structured and meaningful information, enabling decision-makers to evaluate alternatives more objectively and efficiently [10]. In modern organizational contexts, DSS plays a crucial role in enhancing transparency, reducing subjectivity, and improving decision accuracy, particularly in multi-criteria environments[11].

One of the most widely adopted approaches in DSS is Multi-Criteria Decision Making (MCDM), which enables the evaluation of multiple alternatives based on several criteria with varying levels of importance. MCDM methods have been extensively applied across various domains due to their ability to handle complex decision structures and reduce uncertainty in evaluation processes [12]. By incorporating weighted criteria, MCDM ensures a more balanced and systematic assessment, thereby increasing the reliability and accountability of decision outcomes [17].

B. WASPAS Method

The Weighted Aggregated Sum Product Assessment (WASPAS) method is a hybrid MCDM approach that integrates the advantages of the Weighted Sum Model (WSM) and the Weighted Product Model (WPM). This integration allows WASPAS to produce more robust and consistent ranking results compared to single-method approaches, as it combines additive and multiplicative aggregation mechanisms [16]. The core formulation of WASPAS is expressed as:

1. Determining Alternatives and Criteria

   Determine the alternatives to be assessed and establish criteria that are the basis for the assessment process.

2. Creating a Decision matrix

$$x = \begin{bmatrix} x1_1 & x1_2 & \dots & x1_n \\ x2_1 & x2_2 & \dots & x2_n \\ \dots & \dots & \dots & \dots \\ xm_1 & xm_2 & \dots & xm_n \end{bmatrix} \quad (1)$$

Where m represents the number of alternative candidates, n indicates the number of evaluation criteria, and Rij is the performance value of an alternative to the j criterion.

3. Creating a Decision matrix
   Criterion Benefit

$$R_{ij} = \frac{Xij}{max\ Xij} \quad (2)$$

Kriteria Cost

$$R_{ij} = \frac{Min\ x_{ij}}{x_{ij}} \quad (3)$$

4. WSM and WPM Value Calculation

The WSM value is calculated by weighted summation, while the WPM value is obtained by weighted rank multiplication, using the following formula:

WSM Equation

$$S_i = \sum_{j=1}^{n} w_j R_{\{ij\}} \quad (4)$$

WSM Equation

$$P_i = \prod_{j=1}^{n} \left(R_{\{ij\}}\right)^{w_j} \quad (5)$$

5. Determine the value of each alternative (Qi) using the following equation:

$$Q_i = 0.5 \sum_{j=1}^{n} \left(R_{ij} w_j\right) + 0.5 \prod_{j=1}^{n} \left(R_{ij}\right)^{w_j} \quad (6)$$

Where:
Qi = Value from Q to i
xi = Multiply the value xij by the weight by the weight (w)
0.5 = Determination
The best alternative is the one with the highest Qi value[15].

The final ranking is determined based on the highest Qi value. Compared to other MCDM methods, WASPAS demonstrates higher stability and interpretability, making it suitable for complex evaluation problems [14], [15]. However, previous studies have rarely explored parameter sensitivity and robustness in real-world institutional contexts, which remains an important research gap.

C. Cooperatives Performance Evaluation

Cooperatives are socio-economic institutions grounded in the principles of mutual assistance and democratic governance, as regulated under Indonesian Law No. 25 of 1992. They play a strategic role in strengthening economic resilience, promoting equitable welfare distribution, and supporting community-based development [4], [18].

The evaluation of cooperative performance is typically conducted using financial ratio analysis based on regulatory guidelines, particularly the Regulation of the Minister of Cooperatives and SMEs No. 06/Per/M.KUKM/V/2006. Key performance indicators include:

1. Rasio Solvabilitas (leverage ratio)

The leverage ratio, also referred to as the solvency ratio, is a financial indicator used to evaluate an entity's ability to meet its long-term financial obligations. It reflects the extent to which a company's assets are financed by debt, thereby indicating the level of financial risk associated with its capital structure. More broadly, the solvency ratio assesses the firm's capacity to fulfill both short-term and long-term liabilities in the event of liquidation, providing a comprehensive measure of financial stability[19].

- The Debt to Asset Ratio (DAR) is a financial metric used to assess the proportion of a company's total liabilities relative to its total assets (Table 1). This ratio provides insight into the extent to which a firm's assets are financed through debt, thereby reflecting its financial leverage and risk exposure. A higher ratio indicates greater dependence on external financing, which may increase financial vulnerability. The ratio is calculated as follows:

$$Debt\ to\ Asset\ Ratio = \frac{Total\ Liabilities}{Total\ Assets} \times 100\% \quad (7)$$

Table 1. Debt to Asset Ratio

Criteria	Level Performance	Standard
Excellent	5	<40%
Good	4	>40% - 50%
Average	3	>50% - 60%
Below Average	2	>60% - 80%
Unsatisfactory	1	>80%

- The Debt to Equity Ratio (DER) is a financial indicator used to evaluate the proportion of a company's total liabilities relative to its shareholders' equity. This ratio reflects the extent to which a firm relies on debt financing compared to its own capital, thereby providing insight into its financial structure and leverage level (Table 2). A higher DER indicates greater financial risk, as it suggests increased dependence on external funding. The ratio is calculated as follows:

$$Debt\ to\ Equity\ Ratio = \frac{Total\ Liabilities}{Shareholders'\ Equity} \times 100\% \quad (8)$$

Table 2. Debt to Equity Ratio

Criteria	Level Performance	Standard
Excellent	5	<70%
Good	4	>70% - 100%
Average	3	>100% - 150%

Below Average	2	>150% - 200%
Unsatisfactory	1	>200%

2. Rasio Solvabilitas (leverage ratio)

Profitability ratios are financial indicators used to evaluate a cooperative's ability to generate profit within a specific period through the efficient utilization of its capital and assets. These ratios provide critical insights into operational performance and financial efficiency. Key profitability measures include Return on Equity (ROE), which assesses the return generated on shareholders' equity; Return on Assets (ROA), which evaluates the effectiveness of asset utilization in generating profit; and Net Profit Margin (NPM), which reflects the proportion of net income relative to total revenue [19].

- The Net Profit Margin (NPM) specifically measures the percentage of residual operating income relative to total revenue, indicating the cooperative's ability to convert revenue into net profit (Table 3). A higher NPM value signifies better operational efficiency and profitability. The ratio is calculated as follows:

$$Net\ Profit\ Margin\ = \frac{Net\ Income}{Revenue} \times 100\% \quad (9)$$

Table 3. Net Profit Margin

Criteria	Level Performance	Standard
Excellent	5	≥ 15%
Good	4	10% - <15%
Average	3	5% - <10%
Below Average	2	1% - <5%
Unsatisfactory	1	<1%

- Return on Assets (ROA) is a financial ratio used to evaluate the efficiency of an entity in utilizing its total assets to generate profit over a given period. This ratio reflects how effectively management employs available resources to produce earnings, thereby serving as an indicator of operational performance and asset productivity (Table 4). A higher ROA value indicates more efficient use of assets in generating income. The ratio is calculated as follows:

$$Return\ On\frac{Asset}{ROA} = \frac{Net\ Income}{Total\ Assets} \times 100\%. \quad (10)$$

Tabel 4. Return on Assets (ROA)

Criteria	Level Performance	Standard
Excellent	5	≥ 10%
Good	4	7% - <10%
Average	3	3% - <7%
Below Average	2	1% - <3%
Unsatisfactory	1	<1%

- Return on Equity (ROE) is a ratio used to assess the ratio between net profit after tax and own capital[19] (Table 5). The calculation formula is as follows:

$$Return\ On\frac{Equility}{ROE} = \frac{Net\ Income}{Shareholders'\ Equity} \times 100\%. \quad (11)$$

Table 5. Return on Equity (ROE)

Criteria	Level Performance	Standard
Excellent	5	≥ 21%
Good	4	15% - <21%
Average	3	9% - <15%
Below Average	2	3% - <9%
Unsatisfactory	1	<3%

D. Analisis Sensitivitas

Sensitivity analysis was carried out to test the stability and robustness of the ranking results against fluctuations in input parameters. In the WASPAS method, this analysis is crucial because the validity of the final decision is highly dependent on the weight of the criteria and the preference parameter λ.

1. Sensitivity Parameter λ

The λ parameter serves as a counterbalance between the Weighted Sum Model (WSM) and the Weighted Product Model (WPM). The test was performed by varying the value of λ in the range of 0 to 1 at intervals of 0.25 (0; 0.25; 0.5; 0.75; and 1). The final preference value is calculated using the equation:

$$Q_i = \lambda \cdot Q_i^{(1)} + (1 - \lambda) \cdot Q_i^{(2)} \quad (12)$$

Variable Description:

Qi: The final preference value for the ith alternative.

λ: Preference weight parameter ($0 \leq \lambda \leq 1$).

λ = 1: The pure method uses WSM.

λ = 0: The pure method uses WPM.

λ = 0.5: WSM and WPM contributions are balanced (WASPAS standard).

Qi(1): An alternative score based on WSM calculations.

Qi(2): An alternative score based on WPM calculations.

The primary goal of this test was to identify whether the shift in method orientation (from multiple to additive) affected the consistency of the best alternative sequences

2. Weight Sensitivity Criteria

This analysis aims to observe the effect of changes in the level of importance of criteria on final rankings. The simulation was carried out by changing the weight of one of the focus criteria (wf) and adjusting the weight of the other criteria proportionally so that the total weight remained 1. The adjustment of the weight of the non-focus criterion (w'j) is calculated by the formula:

$$W'_j = \frac{1 - w'_f}{1 - w_f} \times w_j \quad (13)$$

Description:

w'j:New weights for criteria that are not being tested.

w'f:New weights for the criteria being tested (increased by 10%).

wf:The initial weight of the criterion being tested.

wj:A different kind of starting point.

This procedure ensures that even if one criterion is changed in importance, the relative importance ratio between the other criteria is consistently maintained

III.METHODS

This study adopts a systematic and iterative research methodology to develop a Decision Support System (DSS) for cooperative performance evaluation. The research process begins with problem identification through field observations and structured interviews conducted at the Pekanbaru City Cooperatives and MSMEs Office. This stage aims to capture real-world challenges in the existing evaluation process, particularly issues related to inefficiency, subjectivity, and lack of transparency, which are commonly observed in traditional evaluation practices [8], [9].

Subsequently, data collection is carried out through a combination of primary data, including interviews and institutional records, and secondary data obtained from literature studies and regulatory frameworks. This approach ensures that both empirical and theoretical perspectives are incorporated into the system design. Based on the collected data, a system requirements analysis is performed to define both functional and non-functional specifications of the proposed DSS. Such a structured approach is essential to ensure that the system aligns with decision-making needs and supports multi-criteria evaluation effectively [10].

The system is developed using a prototyping approach, which allows iterative refinement through continuous user feedback. This approach is particularly suitable for decision support systems, as it enables dynamic adaptation to user requirements and enhances system usability. The design phase includes database modeling using Entity Relationship Diagrams (ERD) and user interface design to ensure accessibility and user-friendliness. The system is implemented using PHP as the programming language and MySQL as the database management system, providing a scalable and flexible platform for data processing and analysis.

To evaluate system performance and reliability, two types of testing are conducted. First, black-box testing is employed to verify system functionality and ensure that all features operate according to user requirements. This testing method focuses on validating input-output behavior without examining internal code structures, making it suitable for functional verification of DSS applications.

Second, sensitivity analysis is performed by varying criterion weights and the WASPAS parameter (λ) to assess the stability and robustness of ranking results. Sensitivity analysis is critical in multi-criteria decision-making models, as it evaluates how changes in parameters influence the final decision outcomes, thereby ensuring the reliability and consistency of the model [12], [16]. Changes in ranking results are systematically analyzed to determine the robustness of the decision model under different scenarios. This approach strengthens the validity of the proposed DSS by demonstrating its ability to produce stable and consistent results across varying conditions.

IV.RESULTS AND DISCUSSION

A. Theoretical Analysis

The cooperatives evaluated in this study were selected from the dataset of active cooperatives obtained from the Cooperative Governance Data Based on Cooperative Groups for the 2023 Fiscal Year, Pekanbaru City, Quarter IV 2024. This dataset has been officially validated by the Pekanbaru City Cooperatives and MSMEs Office and further refined to align with the requirements of the decision-making process for determining the best cooperative. The evaluation framework is based on the Regulation of the State Minister of Cooperatives and Small and Medium Enterprises of the Republic of Indonesia No. 06/Per/M.KUKM/V/2006 and interviews. In accordance with this regulation, seven evaluation criteria were established, as presented in Table 6.

Table 6. The Description of Criteria

NO	Code (C)	Criteria	Weight	Type	References
1	C1	Number of Cooperative Members	0.1	Benefit	[9]
2	C2	Amount of Capital	0.1	Benefit	[9]
3	C3	Return on Equality (ROE)	0.2	Benefit	[20]
4	C4	Net Profit Margin (NPM)	0.15	Benefit	[20]
5	C5	Return on Asset(ROA)	0.15	Benefit	[20]
6	C6	Debt to Asset Ratio(DAR)	0.15	Cost	[20]
7	C7	Debt to Equity Ratio(DER)	0.15	Cost	[20]

After defining the evaluation criteria, assigning weights to each criterion, and determining the corresponding criterion types, the subsequent step involves establishing the conversion scale for the weights of each sub-criterion. This conversion facilitates the standardization of sub-criteria values to ensure consistency in the evaluation process based on Equation [7-11] for Cooperatives Performance Evaluation. The detailed conversion of sub-criterion weights is presented in Table 7.

Table 7. The Conversion Weight of Sub Criteria

Value	Sub-criteria						
	Number of Members	Amount of Capital	ROE	NPM	ROA	DAR	DER
5	> 10.001	>IDR 10.000.000.000	>21%	>15%	>10%	< 40%	< 70%
4	2.501 - 10.000	IDR 5,000,000,000 – <IDR 9,999,999,999	15% - <21%,	10% s/d <15%	7% - <10%	>40% - 50%	>70% - <100%
3	1.001 - 2.500	1,000,000,000 – <IDR 4,999,999,999	9% - <15%	5% - <10%	3% - <7%,	>50% - 60%,	>100- <150%,
2	501 - 1.000	500.000.000 – < IDR999.999.999	3% - <9%,	1% - <5%	1% - <3%	>60% - 80%	>150- 200%
1	1 - 500	< IDR499,999,999	<3%	<1%	<1%	>80%	>200%

Subsequently, based on the Cooperative Governance Data by Cooperative Groups for the 2023 Fiscal Year, Pekanbaru City, Quarter IV 2024, the data of active cooperatives were transformed into the required analytical format, as presented in Table 8. The normalization process was then performed using Equations (2)–(3) to standardize the values of each criterion across all cooperatives. The resulting normalized matrix is also shown in Table 8.

Table 8. Matrix Normalization

Alternatif	Matrix Normalization						
	C1	C2	C3	C4	C5	C6	C7
KUD	0.6	0.4	0.4	0.6	0.4	0.25	0.25
Kop. Pertanian	0.4	0.6	0.4	0.8	0.6	0.2	0.2
Kopti	0.2	0.2	0.4	1	0.6	0.25	0.25
kopinkra	0.2	0.2	1	1	1	0.2	0.2
Koppontren	0.2	0.2	0.4	0.4	0.4	0.5	0.5
.....	....	....	....	....	....	....	.....
Kop. Simpan Pinjam dan Pembiayaan Syariah	1	1	0.4	0.6	0.6	0.25	0.25
Kop. Sekunder	0.2	0.6	0.2	0.4	0.4	0.2	0.2

The subsequent step involves computing the preference values from the normalized matrix using Equation [6]. The final ranking results are presented in Table 9 and 10.

Table 9. The calculation of preference values

Alternative	Criteria	Weight	Criteria Value	WSM	WPM	Preference Value
KUD	C1	0.1	0.6	0.06	0.950200217	0.394728074
	C2	0.1	0.4	0.04	0.912443537	
	C3	0.2	0.4	0.08	0.832553207	
	C4	0.15	0.4	0.09	0.926238199	
	C5	0.15	0.6	0.06	0.871583497	
	C6	0.15	0.25	0.0375	0.812252396	
	C7	0.15	0.25	0.0375	0.812252396	
Kop. Pertanian	C1	0.1	0.4	0.04	0.912443537	0.401871034
	C2	0.1	0.6	0.06	0.950200217	
	C3	0.2	0.6	0.08	0.832553207	
	C4	0.15	0.8	0.12	0.967082441	
	C5	0.15	0.6	0.09	0.926238199	
	C6	0.15	0.2	0.03	0.785515503	

	C7	0.15	0.2	0.03	0.78551503	
Kopti	C1	0.1	0.2	0.02	0.85133 9923	0.52360 6798
	C2	0.1	0.2	0.02	0.85133 9923	
	C3	0.2	0.4	0.08	0.83255 3207	
	C4	0.15	1	0.15	1	
	C5	0.15	0.6	0.09	0.92623 8199	
	C6	0.15	0.25	0.0375	0.81225 2396	
	C7	0.15	0.2	0.0375	0.81225 2396	
kopinkra	C1	0.1	0.2	0.02	0.85133 9923	0.38116 4557
	C2	0.1	0.2	0.02	0.85133 9923	
	C3	0.2	1	0.2	1	
	C4	0.15	1	0.15	1	
	C5	0.15	1	0.15	1	
	C6	0.15	0.2	0.03	0.78551503	
	C7	0.15	0.2	0.03	0.78551503	
	C1	0.1	0.2	0.02	0.85133 9923	0.63037 2045
	C2	0.1	0.2	0.02	0.85133 9923	
	C3	0.2	0.4	0.08	0.83255 3207	
	C4	0.15	0.4	0.06	0.87158 3497	
	C5	0.15	0.4	0.06	0.87158 3497	
	C6	0.15	0.5	0.0975	0.90125 0463	
	C7	0.15	0.5	0.0975	0.90125 0463	
....	....	....	....	....	....	.....
Kop. Simpan Pinjam dan Pembiayaan Syariah	C1	0.1	1	0.1	1	0.50311 8496
	C2	0.1	1	0.1	1	
	C3	0.2	0.4	0.08	0.83255 3207	
	C4	0.15	0.6	0.09	0.92623 8199	
	C5	0.15	0.6	0.09	0.92623 8199	
	C6	0.15	0.25	0.0375	0.81225 2396	
	C7	0.15	0.25	0.0375	0.81225 2396	
Kop. Sekunder	C1	0.1	0.2	0.02	0.85133 9923	0.28741 0881
	C2	0.1	0.6	0.06	0.95020 0217	
	C3	0.2	0.2	0.04	0.72477 9664	
	C4	0.15	0.4	0.06	0.87158 3497	
	C5	0.15	0.4	0.06	0.87158 3497	
	C6	0.15	0.2	0.03	0.78551 503	
	C7	0.15	0.2	0.03	0.78551 503	

Table 10. The Rank value of Cooperative

Rank	Cooperative Name	Value
1	Kop. Pasar	0.749444953
2	Kop. Pertanian	0.733972892
3	Kop. Angkutan Darat	0.724613083
4	Kop. Mahasiswa	0.719447246
5	Kopkar	0.630372045
6	Kop. Angkatan Udara	0.621650864
7	Kop. Pegawai Negeri (KPRI)	0.593370298
8	Kop. Angkatan Darat	0.586395725
9	Kop. Angkatan Darat	0.575145725
10	Kop. Simpan Pinjam	0.733972892
11	Kop. Wanita	0.561329249
12	kopinkra	0.523606798
13	Kop. Pepabri	0.523606798
14	Kop. Pegawai Negeri (KPRI)	0.512943999
15	Kop. Simpan Pinjam dan Pembiayaan Syariah	0.503118496
16	Kop. Wredatama	0.491507364
17	Kop. Pemuda	0.46994922
18	Kop. Pertanian	0.424479518
19	Kopti	0.401871034
20	KUD	0.394728074
21	Koppontren	0.381164557
22	Koppontren	0.287410881
23	Kop. Pengrajin	0.2

The WASPAS-based evaluation results indicate varying performance levels among the assessed cooperatives. The Market Cooperative achieved the highest preference score (0.7494), ranking first as the best-performing cooperative. These results provide a structured and objective basis to support decision-making by relevant authorities, particularly the Cooperatives and MSMEs Office, while the final decision remains subject to institutional policies.

B. System Implementation

The developed system produced an application that delivers comprehensive evaluation results, including cooperative scores, ranking positions, and synthesized analytical insights with corresponding recommendations. The example of system designed can be depicted at Figure 1.

Figure 1. The Design of Matrix Decision Page

C. Testing

1. Blacbox Testing

System functionality was assessed using a manual black-box testing approach, focusing on input–output validation without reference to internal code structures. This post-development evaluation was conducted to ensure system reliability and performance, with the results summarized in Table 11.

Table 11. The Blackbox Testing Result

NO	Tested Features	Testing Scenarios	Input	Expected Output	Results	Description
1	Login	User enters a valid username & password	Data login valid	Successfully log in to the system	Conform	Valid
2	Login	Incorrect username or password	Invalid login data	System displays error message	Conform	Valid
3	Cooperative Data Input	Add new cooperative data	Complete cooperative data	Data stored in the database	Conform	Valid
4	Cooperative Data Input	Incomplete data	Empty/incorrect data	System rejects input	Conform	Valid
5	Input Criteria	Add assessment criteria	Criteria data	Stored data	Conform	Valid
6	Input Weight	Enter the weighting criteria	Total weight = 1	Weight data received	Conform	Valid
7	WASPAS calculation	Running the calculation process	Alternative data & criteria	Preference values appear	Conform	Valid
8	Ranking	Display rankin	Data from the calculati	Cooperative rankin	Conform	Valid

		g results	on results	gs displayed		
9	Results Report	View assessment reports	Yield data	Complete report	Conform	Valid
10	Logout	User logs out of the system	Click logout	System returns to the login page	Conform	Valid

2. Sensitivity Test

The sensitivity analysis results demonstrate that variations in both criterion weights and λ parameters do not significantly influence the ranking outcomes. As depicted in Figure 2, changes in λ values (0, 0.25, 0.50, 0.75, and 1) result in only minor fluctuations in preference scores, while the top-ranked alternative remains unchanged. Likewise, Figure 3 illustrates that increasing individual criterion weights by 10% across different scenarios does not alter the ranking structure.

These findings confirm that the WASPAS method exhibits a high degree of robustness and stability in handling parameter uncertainty. The consistency of ranking outcomes suggests that the hybrid integration of the Weighted Sum Model (WSM) and Weighted Product Model (WPM) effectively balances additive and multiplicative aggregation processes, thereby reducing sensitivity to variations in input parameters. This characteristic is particularly important in multi-criteria decision-making contexts, where subjective weighting and parameter selection may introduce bias.

Furthermore, the results are consistent with prior studies indicating that WASPAS provides stable and reliable decision outcomes compared to single-method approaches such as SAW or WPM alone. The demonstrated stability enhances the credibility of the model and supports its applicability in real-world decision-making scenarios, particularly in cooperative performance evaluation where data variability and uncertainty are inevitable.

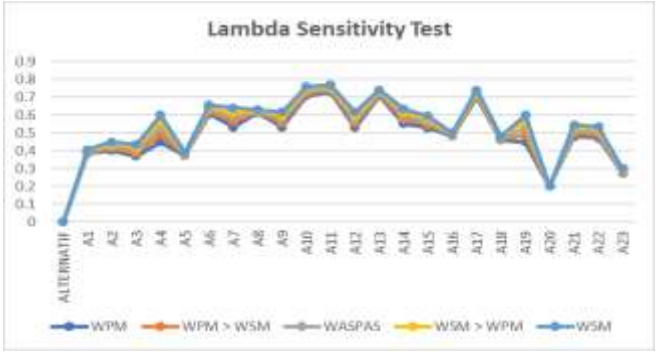

Figure 2. Sensitivity Analysis Result based on Lamda Values

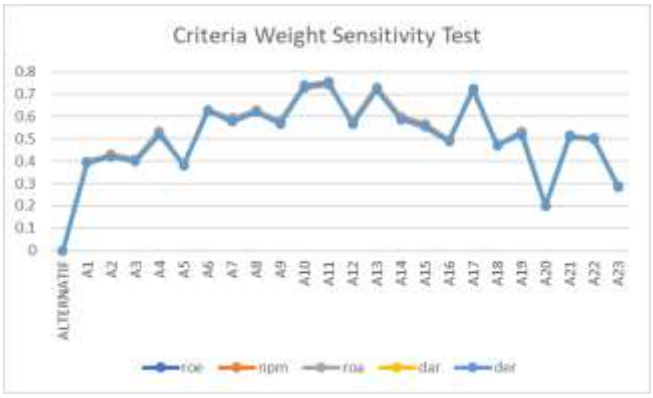

Figure 3. Sensitivity Analysis based on Weighting Criteria.

D. Discussion

The results indicate that the Market Cooperative achieved the highest ranking with a preference value (Qi) of 0.7494, reflecting its superior overall performance among the evaluated alternatives . This outcome is primarily driven by strong profitability indicators, particularly Return on Equity (ROE) and Return on Assets (ROA), which signify efficient utilization of capital and assets. These findings are consistent with prior studies emphasizing that financial performance remains a dominant determinant in cooperative evaluation and competitiveness [4], [19].

However, a deeper examination reveals an important trade-off. Despite its high ranking, the cooperative exhibits relatively high leverage ratios (DAR and DER), indicating potential financial risk. This suggests that the WASPAS method, while effective in aggregating multiple criteria, may still prioritize benefit criteria more heavily when their assigned weights dominate. Such behavior aligns with the hybrid nature of WASPAS, which combines additive (WSM) and multiplicative (WPM) models to enhance ranking robustness[14], [15], [16]. Nevertheless, it also raises a critical concern on the sensitivity of final rankings to weight distribution, which may introduce bias if not carefully validated.

From a methodological perspective, the results reinforce the advantages of hybrid MCDM approaches over single-method techniques. Previous research has shown that methods such as SAW tend to produce less stable rankings due to their purely additive structure[8], whereas WASPAS improves decision consistency by integrating multiple aggregation mechanisms [9], [12]. This study confirms these findings, demonstrating that WASPAS provides a more balanced and reliable evaluation framework for cooperative performance assessment.

Despite these strengths, the study also highlights a structural limitation in the evaluation model. The dominance of financial criteria—such as capital, profitability ratios, and leverage—reflects a conventional performance measurement approach that may not fully capture the multidimensional nature of cooperatives. As highlighted in the literature,

cooperatives are not purely profit-oriented entities but also play a significant role in social welfare, member participation, and community development [1], [2], [3]. Therefore, the exclusion of non-financial indicators—such as governance quality, innovation capacity, and digital adoption—may reduce the comprehensiveness of the evaluation.

Furthermore, the reliance on static weighting schemes may limit the adaptability of the model in dynamic decision environments. Recent studies suggest that integrating advanced approaches such as fuzzy-based weighting or data-driven decision models can improve the handling of uncertainty and subjectivity in MCDM applications[11], [16]. This indicates a clear research gap and opportunity for enhancing the robustness of cooperative evaluation systems.

V. CONCLUSION

This study demonstrates that the implementation of a Decision Support System based on the WASPAS method provides an effective and systematic approach for evaluating and ranking cooperatives. The method successfully transforms multi-criteria data into preference values that support objective and transparent decision-making. Compared to conventional manual approaches, the proposed system reduces subjectivity and significantly improves the efficiency of the evaluation process. The selected criteria—comprising membership size, capital, and key financial ratios (ROE, NPM, ROA, DAR, and DER)—offer a structured representation of cooperative performance in accordance with regulatory standards[20]. However, the findings also indicate that reliance on financial indicators alone may not fully reflect the broader socio-economic role of cooperatives, as emphasized in previous studies [1], [2]. From a methodological standpoint, this research confirms the robustness and applicability of the WASPAS method in multi-criteria decision-making contexts. Its hybrid structure enhances stability and consistency compared to single-method approaches [12], [16]. Nevertheless, the effectiveness of the model remains dependent on the accuracy of input data and the appropriateness of assigned weights, highlighting the need for careful validation and expert involvement.

For future research, several improvements are recommended. First, the inclusion of non-financial criteria—such as governance quality, member participation, and technological adoption—would provide a more holistic evaluation framework. Second, the integration of WASPAS with advanced techniques, such as fuzzy logic or machine learning, could enhance its ability to handle uncertainty and dynamic data conditions. Third, broader validation across different regions or sectors would improve the generalizability of the findings.

In conclusion, this study contributes not only to the practical implementation of decision support systems in cooperative evaluation but also to the advancement of MCDM methodologies by highlighting the importance of integrating methodological rigor with multidimensional performance indicators. Such an approach is essential for achieving more accurate, transparent, and policy-relevant decision-making in the cooperative sector.

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