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GDSS Prototype Model for Supplier Selection at MDM Cooperative

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Abstract— **MDM is a trade cooperative business unit that supplies healthy food options for consumers around the Andalas University campus. So far, the selection of suppliers that provide supply goods to the stores is only based on the trust between both parties, which is the principle of mutual acquaintance and kinship. The problems that may arise from a process like this are the lack of the right supplier, unavailability of goods, relatively higher product prices, late delivery, and low-quality goods. Therefore, we need a GDSS that is capable of overcoming these problems. This GDSS helps in decision-making by determining the right supplier for each of the stores owned by the MDM Cooperative. The methods used are AHP, TOPSIS, and BORDA, involving six criteria and five tested alternatives. The AHP method is used to obtain the weight of each criterion taken from the pairwise comparison matrix. The TOPSIS method is used to determine which suppliers get priority for supply goods. Combining the AHP and TOPSIS methods can reduce the weaknesses of the TOPSIS itself by giving subjective weights. The use of the BORDA method can provide maximum results in selecting this supplier. This GDSS also involves three decision-making bodies: the head of the cooperative, the deputy, and the treasurer. The results of this prototype can show the best alternative selected based on the ranking method.**

Keywords— **AHP; BORDA; GDSS; MDM cooperative; TOPSIS.**

I. INTRODUCTION

One of the enterprises in society that takes advantage of the development of information technology is cooperative. The MDM Cooperative or Koperasi Mandiri dan Merdeka (KMDM) is one of the collective organizations that collaborate with the Independent Farmers and Breeders Cooperative and the Melati Mini Women's Farmers Group Cooperative to create a business unit called the "Pasar Rabu Tani". This organization provides healthy food options for consumers, especially the lecturers and education personnel at the Andalas University Campus and also for the general public. This establishment also aims to help the community around the campus promote and market farmer products by creating new markets where a supply of goods and services is available in the local community. So far, the supplier selection process is based on subjective judgments, kinship, and the principle of knowing each other only. Hence, several problems arise lack of the right supplier, unavailability of goods, relatively higher product prices, late delivery, and poor quality. Of course, this has an adverse effect on consumers. Therefore, the KMDM management decided to use Group

DSS in selecting suppliers through groups to get suppliers that were on schedule and under the KMDM.

Many methods can be employed to implement this type of decision support system when selecting the best supplier. There are AHP and TOPSIS strategies [1]–[4], and for group decisions, there is the BORDA method. The group decision support systems themselves have been used in previous research [5]–[10]. Here are some studies that use group decision support systems.

In the Group Decision Support System (GDSS) research, the selection for the student study concentrations used AHP and TOPSIS [11]. This research helped students in choosing the concentration of their study. The weight values of both the criteria and the sub-criteria calculated using the AHP method, then these weights are used as input for further calculations using the TOPSIS method. Finally, each alternative's ranking is measured based on the priority value obtained by the two methods. This study involved three criteria and several sub-criteria, where three alternatives were assessed. The next study is a multi-criteria GDSS in determining the best college marketing strategy [12]. In this study, AHP is used in calculating the weight and TOPSIS for ranking. Furthermore,

three decision-makers played a role in making the best marketing decision.

Another GDSS research is the Performance Assessment and Teacher Ranking in ASISI Education Foundaruib with AHP and BORDA Method [13]. The method used in this research is the Analytical Hierarchy Process (AHP) and Borda. The AHP method was used in determining the performance appraisal for each teacher. Meanwhile, the Borda method was used in calculating the instructor rankings. The result obtained a GDSS running using a LAN and can be accessed by multi-users, namely the Principal, the faculties, and the students. The AHP and Borda methods are also used in the Group Decision Support System (GDSS) research for the construction work evaluation, offering both the AHP and Borda methods [14]. In this study, the GDSS designed to evaluate the construction work offered at the ULP Pokja of the Bali Provincial Government was developed by adopting the AHP and Borda procedures.

Another research is the Group Decision Support System (GDSS) as an entropy method in determining the priority of hospital service queues via Multiple Channel Model [15]. In this paper, ten criteria were tested using the entropy approach.

From the results of several studies above, it can be seen that the combination of AHP, TOPSIS, and BORDA show superior abilities in executing decision support systems. However, for this research's objective, namely KMDM, the combined AHP, TOPSIS, and BORDA methods have never been applied. Meanwhile, KMDM really needs this decision support system for the sustainability of its store management in the future.

The objectives of this research are as follows:
1. Design and build a group decision support system using a combination of AHP, TOPSIS, and BORDA.
2. Implement this group decision support system on projects that have never been done, namely KMDM.

3. Prove that the combination of AHP, TOPSIS, and BORDA is a better regulation option than only AHP or only TOPSIS.

II. MATERIAL AND METHOD

A decision is an activity of selecting actions from a set of alternatives to solve a problem [6]. Based on the management hierarchy, decisions are divided into three categories, namely: (1) Strategic Decisions, that is, decisions to answer challenges and environmental changes, which are usually long-term in nature, (2) Administrative/Tactical Decisions that are related to resource management, and power administration (financial, technical and personnel), and (3) Operational Decisions, that are related to daily operational activities.

A. Decision Support System

Michael S. Scott Morton defined decision Support Systems (DSS) as an interactive computer-based system that helps decision-governing makers use data and various models to solve unstructured problems. Little defines Decision Support Systems as a set of model-based procedures for processing and assessing data to help managers come up with decisions [16].

In this study, 3 methods were used, namely AHP, TOPSIS, and BORDA. AHP is used to find the weighted values, TOPSIS is used to get the final score for each alternative after the ranking made by each decision-maker, and BORDA is used to determine the alternatives' final ranking.

B. AHP (Analytical Hierarchy Process)

The following are the steps taken when using the AHP method [17]:
1. Defining the problem and determining the desired solution, then arranging a hierarchy of existing problems.

Fig 1. AHP Hierarchy[18]
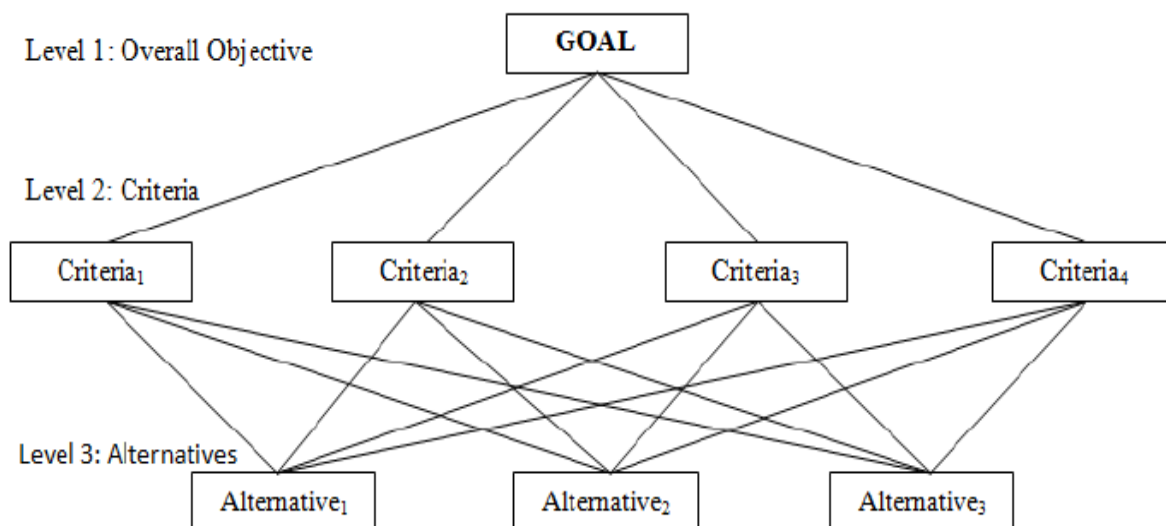
- Determining the priority of elements by making pairwise comparisons and comparing elements in pairs according to the specified criteria. Next, the pairwise comparison matrix filling uses numbers to represent the

relative importance of one element to another. The value and definition of a qualitative opinion from the Saaty comparison scale can be measured as shown in Table 1 below.

Intensity of Importance	Description
1	Two elements contribute equally to the objectives
3	Experience and judgment slightly favor one element over another
5	Experience and judgment strongly favor one element over another
7	One element is favored very strongly over another, and its dominance is demonstrated in practice
9	The evidence favoring one element over another is of the highest possible order of affirmation
2,4,6,8	Where compromise is needed

2. Synthesizing by adding up each column's values in the matrix, then dividing each value from the column by the total column concerned to obtain the normalization of the matrix. Then, adding up the values from each row and dividing them by the number of elements to get the average value. It aims to obtain the overall priority from considering the pairwise comparisons.

3. Measuring consistency by multiplying each value in the first column by the relative priority of the first element. The second column's value by the relative priority of the second element, and so on and then getting the total from each row. Consequently, summing of the rows divided by the element's relative priority. Next, tallying the quotient with the many existing elements. The result is called the λmax.

4. Calculating the Consistency Index (CI) using the formula:

$$CI = (\lambda max - n) / n \qquad (1)$$

where n is the number of elements.

5. Calculating the Consistency Ratio (CR) with the formula:

$$CR = CI / RC \qquad (2)$$

where RC is the Random Consistency index.

6. Checking the hierarchy's consistency, if the value is more than 10%, then the judgment data must be improved. However, if the consistency ratio (CI/CR) is less or equal to 0.1, the calculation result can be said to be correct.

Matrix Size	1	2	3	4	5	6	7	8	9	10
RC	0	0	0.58	0.90	1.12	1.24	1.32	1.41	1.45	1.49

C. TOPSIS Method (Technique for Others Preference by Similarity to Ideal Solution)

TOPSIS is one of the methods used in multi-criteria decision support introduced by Yonn and Hwang [19]. In this method, the chosen alternative has the closest distance to the positive ideal solution and has the farthest distance from the negative ideal solution. The stages of using the TOPSIS method are as follows:

1. Determining the normalized decision matrix, that is, each element in the V matrix is normalized to get the normalized matrix R. Any normalization of the rij value can be done with the following formula:

$$r_{ij} = \frac{x_{ij}}{\sqrt{\sum_{i=1}^{m} x^2_{ij}}} \qquad (3)$$

where $i = 1,2,3,…,m$ and $j = 1,2,3,…,n$

2. Carrying out weights on the normalized matrix, by giving the weight $W = (w1, w2, ..., wn)$ so that the normalized weight matrix V can be produced as follows:

$$V = \begin{bmatrix} w_{11}r_{11} & \cdots & w_{1n}r_{1n} \\ \vdots & \ddots & \vdots \\ w_{m1}r_{m1} & \cdots & w_{nm}r_{nm} \end{bmatrix} \qquad (4)$$

where $i = 1,2,3,…, m$ and $j = 1,2,3,…, n$

3. Establishing the ideal positive and ideal negative solutions. This regulation is influenced by the nature of the criteria whether it is benefit or cost.

$$A^+ = \{(\max v_{ij} \mid j \in J)(\min v_{ij} \mid j \in J'), i = 1,2,3,...m\} = \{v_1^+, v_2^+,...v_m^+\}$$
$$A^- = \{(\max v_{ij} \mid j \in J)(\min v_{ij} \mid j \in J'), i = 1,2,3,...m\} = \{v_1^-, v_2^-,...v_m^-\} \qquad (5)$$

where,
Vij = matrix element V 1st row and jth column
J = {j = 1,2,3,…, n and j in relation to the benefit criteria}
J' = {j = 1,2,3,…, n and j related to cost criteria}

4. Calculating the distance between each alternative's value by measuring the distance from an alternative to the ideal positive solution and the negative ideal solution.
The ideal positive separation measure is defined as follows:

$$S_i^+ = \sqrt{\sum_{j=1}^{n}(Vij - V_j^+)^2}, with\ i = 1,2,3,…,n \qquad (6)$$

The ideal negative separation measure is defined as follows:

$$S_i^- = \sqrt{\sum_{j=1}^{n}(Vij - V_j^-)^2}, with\ i = 1,2,3,…,n \qquad (7)$$

5. Measuring the relative proximity to a positive ideal, which represents the relative proximity of alternative A + to the ideal solution A- with the following formula:

$$Ci = \frac{S_i^-}{S_i^- + S_i^+}, with\ 0 < Ci < 1\ and\ i = 1,2,3,…,m \qquad (8)$$

6. Sorting alternatives by ranking alternatives based on the order Ci, where the best alternative is the one with the farthest distance from the negative ideal solution and the closest distance to the positive ideal solution.

D. BORDA

The Borda method is a method used to assign ratings to preferential voting. The selected alternative with the top-ranking position is scored higher than the candidate in the next ranked position in a pairwise comparison. The case resolution

stage using the Borda Method can be explained as follows [20]:
1. Determining the ranking value in an alternative sequence with the top order is given points m, where m is the total number of choices or alternatives.
2. Selection of m point is used as the multiplier of the votes obtained at the position concerned based on the calculation of the value of the Borda function of the alternative options, then the choice with the highest value is the choice most preferred by the decision-maker.

III. RESULTS AND DISCUSSIONS

In supporting supplier selection decisions, several criteria are used:
- Price
- Quality
- Delivery
- Location
- Inventory
- Flexibility

Meanwhile, three decision-governing bodies provided an assessment of each supplier, namely, the Chairman of KMDM, the Deputy Chairperson, and the Treasurer. The three of them contributed fully to the ranking results of each alternative supplier.

A. AHP Calculation

The first step that must be taken in the AHP calculation is to find the priority of the criteria by determining the pairwise comparison matrix for each criterion. In this step, the decision-maker chooses which criteria are more important than the other criteria. The paired matrix for each criterion can be seen in Table III below:

TABLE IIIII
CRITERIA PAIRWISE MATRIX

	C1	C2	C3	C4	C5	C6
C1	1.00	2.00	2.00	2.00	4.00	2.00
C2	0.50	1.00	3.00	3.00	3.00	2.00
C3	0.50	0.33	1.00	3.00	2.00	3.00
C4	0.50	0.33	0.33	1.00	2.00	4.00
C5	0.25	0.33	0.50	0.50	1.00	2.00
C6	0.50	0.17	0.33	0.25	0.50	1.00

The next step is to synthesize the criteria matrix. The synthesis of the criteria matrix can be seen in Table IV.

TABLE IVV
SYNTHESIS OF THE CRITERIA MATRIX

	C1	C2	C3	C4	C5	C6	Total	Priority
C1	0.36	0.50	0.29	0.21	0.33	0.15	1.85	**0.31**
C2	0.18	0.25	0.44	0.32	0.25	0.15	1.59	**0.27**
C3	0.18	0.08	0.15	0.32	0.17	0.23	1.12	**0.19**
C4	0.18	0.08	0.05	0.11	0.17	0.31	0.89	**0.15**
C5	0.09	0.08	0.07	0.05	0.08	0.15	0.54	**0.09**
C6	0.18	0.04	0.05	0.03	0.04	0.08	0.42	**0.07**

Next step is to calculate the consistency ratio as shown in Table V. With n = 6, λmax = 1.18, the CI can be seen that the value is -0.80 and the value of CR = -0.6642. The CR value obtained was -0.72, so the CR was acceptable.

TABLE V
CONSISTENCY RATIO

	Total/Rows	Priority	Results
C1	1.87	0.31	2.18
C2	1.70	0.27	1.96
C3	1.06	0.19	1.24
C4	0.63	0.15	0.78
C5	0.42	0.09	0.51
C6	0.34	0.07	0.41

B. TOPSIS Calculation

Before calculating the TOPSIS, we must first compute the weight for each criterion for selecting suppliers. This weight is obtained from the AHP calculations that have been obtained previously. Table VI shows the weight of each sub-criterion.

TABLE VI
WEIGHT FOR EACH SUB CRITERIA

Criteria	Weight
Price	0.31
Quality	0.27
Delivery	0.19
Location	0.15
Inventory	0.09
Flexibility	0.07

In this case, five suppliers were given an assessment of the loan provision. The assessment data from each member can be seen in Table VII. In equation (3), R's normalized value can be seen in table VIII, and the weighted normalized matrix is shown in table IX.

TABLE VII
ASSESSMENT OF EACH SUPPLIER FROM A DECISION MAKER

Criteria	Price	Quality	Delivery	Location	Inventory	Flexibility
A1	7.00	9.00	10.00	9.00	10.00	10.00
A2	6.00	6.00	9.00	10.00	6.00	9.00
A3	6.00	6.00	10.00	9.00	9.00	7.00
A4	8.00	8.00	6.00	9.00	6.00	9.00
A5	9.00	9.00	9.00	6.00	7.00	10.00

TABLE VIII
NORMALIZED VALUE OF R

Alternative	Price	Quality	Delivery	Location	Inventory	Flexibility
A1	0.43	0.55	0.48	0.39	0.47	0.51
A2	0.37	0.33	0.48	0.44	0.36	0.46
A3	0.37	0.33	0.48	0.48	0.41	0.46
A4	0.49	0.49	0.42	0.44	0.36	0.31
A5	0.55	0.49	0.36	0.48	0.59	0.46

TABLE IX
WEIGHTED NORMALIZED MATRIX

Alternative	Price	Quality	Delivery	Location	Inventory	Flexibility
A1	0.13	0.15	0.09	0.06	0.04	0.04
A2	0.11	0.09	0.09	0.06	0.03	0.03
A3	0.11	0.09	0.09	0.07	0.04	0.03
A4	0.15	0.13	0.08	0.06	0.03	0.02
A5	0.17	0.13	0.07	0.07	0.05	0.03

TABLE X
POSITIVE IDEAL SOLUTION

Alternative	Price	Quality	Delivery	Location	Inventory	Flexibility
A1	-0.04	-0.02	-0.04	0.00	0.00	-0.01
A2	-0.06	0.00	-0.01	-0.03	0.00	0.00
A3	-0.06	0.00	0.00	-0.02	-0.01	0.00
A4	-0.02	0.00	0.00	0.00	0.00	0.00
A5	0.00	-0.02	-0.04	-0.03	0.00	-0.01

TABLE XI
NEGATIVE IDEAL SOLUTION

Alternative	Price	Quality	Delivery	Location	Inventory	Flexibility
A1	0.02	0.01	0.01	0.03	0.01	0.00
A2	0.00	0.00	0.02	0.02	0.00	0.00
A3	0.00	0.04	0.02	0.00	0.01	0.00
A4	0.04	0.00	0.00	0.01	0.01	0.01
A5	0.06	0.04	0.02	0.02	0.01	0.01

In reference to equation (5), we can get a positive ideal solution matrix (A+) and a negative ideal solution matrix, as shown in Table X and Table XI. Table XII shows the results of the ranking done by one of the decision-makers.

TABLE XII
NEGATIVE IDEAL SOLUTION

No	Member	Di+	Di-	Vi
1	A1	0.05	0.04	0.47
2	A2	0.07	0.03	0.31
3	A3	0.07	0.05	0.43
4	A4	0.06	0.04	0.42
5	A5	0.01	0.08	0.91

Furthermore, it can be calculated in the same way for the remaining results of each assessment of the decision-maker, namely the Chairman of the Cooperative, the Deputy Chair of the Cooperative and the Treasurer of the cooperative. So that different evaluation results are obtained from each decision-maker, such as the sample in table XIII.

TABLE XIII
DECISION MAKER EVALUATION RESULTS

RANK	DM1 Chairman	DM2 Deputy Chair	DM3 Treasurer
1	A5	A5	A1
2	A1	A2	A5
3	A2	A1	A2
4	A4	A4	A4
5	A3	A3	A3

C. BORDA

After getting the Borda calculation value from each decision-maker, the system proceeds with the Borda voting results which can be seen in Table XIV.

TABLE XIV
BORDA VOTING RESULTS

Alternative	DM1 Chairman	DM2 Deputy Chair	DM3 Treasurer	Value
A1	4	3	5	12
A2	3	4	3	10
A3	1	1	1	3
A4	2	2	2	6
A5	5	5	4	14

From the calculation using the Borda method, an alternative is obtained for the selected supplier. Supplier A5 is the alternative that has the highest value, so it is more preferred than the other alternatives. The alternative ranking order by each decision maker affects the final result in the Borda calculation.

IV. CONCLUSION

This research has proven that the combination of AHP, TOPSIS, and BORDA methods can adequately implement a group decision support system. However, it should be noted that the Decision Support System is designed to assist or support decision-making by providing alternative suppliers who are entitled to supply goods to KMDN and not take over the sole decision-making process. The AHP method is used to obtain the weight of each criterion taken from the pairwise comparison matrix. The TOPSIS method is used to determine which suppliers get priority for supply goods. Combining the AHP and TOPSIS methods can reduce the weaknesses of the TOPSIS itself by giving subjective weights. The use of the BORDA method can provide maximum results in selecting this supplier.

To improve performance, further development of this decision support system can be done by adding other methods such as Fuzzy Multiple Attribute Decision Making (FMADM).

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