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Table of Contents

Regular

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Multi-Criteria Decision Making Method for Developing Smart Indonesia Program Scholarship Recipient Candidate System

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Abstract—**The Government of Indonesia is continuously striving to improve its education quality with the provision of scholarship programs, one of which is the Smart Indonesia Program (SIP). Students' interest in obtaining SIPs is increasing, but the selection process still relies on conventional methods. Without adequate IT support, the selection process for SIP scholarship candidates will be complex, less objective, and somewhat unfair. State Vocational High School (SVHS) 5 Surakarta was selected as a case study for this research to establish the selection process and the data collection methods used in previous years. The research aims to develop a Decision Support System (DSS) to assist in nominating students deemed eligible for SIP scholarship recommendations. The applied methods include Analytical Hierarchy Process (AHP) and Multi-Objective Optimization by Ratio Analysis (MOORA). Four criteria have been set in this DSS: card ownership status, total parental income, household income, and number of siblings. Each of which is further broken down into several sub-criteria and assigned a value for use in the AHP process. Upon comparing data from 2021 to 2023, it was found that the accuracy in 2021 was 92.9%, in 2022 it reached 94.7%, and in 2023 it recorded 92.3%. Based on the results of this system accuracy test, it can be concluded that the AHP and MOORA methods can be used to objectively produce recommendations for students eligible for SIP scholarships, based on the input criteria.**

Keywords—**Decision making; recommendation; smart Indonesia program; AHP; MOORA.**

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I. INTRODUCTION

Elementary and secondary education is an essential factor in determining future life. However, due to financial constraints, some parents have to stop their children's education. Every country needs to pay attention to the development of the education sector, because good education is pivotal to creating and improving a smart and skilled workforce [1]. The present education system will determine a nation's future development. Education plays a vital role in creating a qualified, competitive, and competent workforce. To cope with this problem, the Ministry of Education and Culture of the Republic of Indonesia instituted SIP [2]. SIP is a government program that provides financial assistance or relief to students aged 6 to 21. SIP assistance is given to students whose parents have low incomes, so that it can lighten the burden and help them continue in school [3]. The Indonesian government continuously strives to facilitate access, expand equity, and increase the objectivity of national education with various initiatives, one of which is providing scholarships in the form of the Smart Indonesia Program (SIP) [4]. Without adequate IT support, the process of selecting prospective SIP recipient students may be complicated, not objective, and lack equality [5]. SIC (Smart Indonesian Card) is a cash assistance program for school-age children from underprivileged, vulnerable families, and prosperous family card holders [6]. SIC aims to help provide educational access for students who, despite having quality education, have underprivileged parental backgrounds, prevent and reduce dropouts, and meet their educational needs. It is expected that these disadvantaged students can capitalize on this program to fulfill their education [7].

State Vocational High School 5 (SVHS 5) in Surakarta city has a vision of producing graduates with strong character, employable skills, and an entrepreneurial spirit, grounded in environmentally friendly technology. In 2005, SVHS 5 Surakarta was the first vocational school to successfully obtain an ISO 9001-2000 certificate. It was also selected as a model school for all vocational schools and high schools in the Central Java region. SVHS 5 Surakarta obtained and implemented the ISO 9001:2015 certificate in 2017. The screening process for SIP recipients is conducted annually for students in state schools across Indonesia. Selecting students who receive SIP is a complex process that can be carried out only with adequate information system support [8]. This condition and system are also found at SVHS 5 Surakarta, which is selected as the case study object in this research. The SIP selection committee at SVHS 5 Surakarta faces significant responsibilities and challenges in choosing students who are really entitled to and need SIP assistance. The use of standard applications to process and calculate the large number of SIP registrants, as well as the handling of large volumes of data, undermines the selection team's performance. The assessment and selection process takes a long time; meanwhile, they must maintain high accuracy. This makes the process susceptible to abuse of authority or data manipulation and prone to errors in data input. Mistaken results of the selection process can cause students who deserve and need the SIP scholarship to lose their rights.

In an era where information technology is all about, DSS methods are decisive, ranging from simple to complex. DSS is a semi-structured information system in decision-making [9]. DSS is essentially an evolution of a computerized management information system, also known as a Decision Support System (DSS), which is designed to be used interactively [10]. DSS can be defined as the process of systematically selecting alternatives that are used as a way to solve problems by utilizing specific technology or systems [11]. DSS can be implemented in various fields to find solutions to different problems [12]. In this research, DSS was created using the AHP and MOORA methods. AHP can organize information using some alternatives and produce objective values for each criterion [13]. The value resulting from the AHP calculation shows the criteria that have the highest priority and influence the resolution of existing problems [14]. The AHP method has the advantage of creating a pairwise comparison matrix to determine the weight of each criterion and calculate the consistency value [15]. The Moora method is a multi-objective optimization technique that can be used to solve various types of complex decision-making problems [16]. The Moora method sorts (ranks) each attribute and alternatives based on specified criteria [17]. The Moora method performs simple calculations of minimum and maximum values. This method will determine alternatives with good selectivity [18]. The process runs simultaneously, which will produce two or more optimal levels [19]. The results of Moora approach are inconsistent and contain some errors [20]. The AHP method used in this research aims to calculate the weight of each criterion that has been determined before being entered to the alternative rankings process. AHP can describe complex multi-factor or multi-criteria problems in a hierarchy [21]. Meanwhile, the MOORA method is to establish student rankings when the weight of each criterion produced by the AHP method is known. By combining the AHP and MOORA methods, a solution will be generated that provides more objective and comprehensive recommendations for SIP recipients.

Some previous studies on the selection of SIP assistance beneficiaries with DSS have been conducted. They include research by Manuhutu et al [22], which developed a decision-support system to select beneficiaries of Smart Indonesia Program assistance using the weighted product method. Here, five criteria are set: student activity, certificate of poverty, orphan status, parents' salary, and absenteeism. The prototype model was chosen to develop a web-based decision support system using the PHP programming language and the Bootstrap framework. Research by Asnimar et al [23] compares the decision tree algorithm with Naive Bayes for classifying recipients of educational scholarship aid. Ten attributes are used in the study to identify prospective new STMIK AKBA students eligible to receive academic scholarships. They include smart Indonesia card ownership, a graduate for up to 2 years, a report card, and the student's average report card. This research produces a classification using a decision tree algorithm with an accuracy of 44.12% and an F1-score of 34.48%, while the Naïve Bayes algorithm achieves 76.47% accuracy based on diploma grades and average report cards. Based on these accuracy results, the Naïve Bayes algorithm performs better at classifying scholarship recipients than the decision tree algorithm.

A journal article detailing Anggrawan's [24] research results also use the AHP and MOORA methods to provide recommendations for educational scholarship recipients. This research compared the combined use of AHP and MOORA methods, and the MOORA method only. The research sets six attributes for application to the used method, including: cumulative grade point average for the last two semesters, total activity value, recommendation letter, participation in an organization, and compliance with the requirements. The results concluded that using AHP and Moora methods in combination was more accurate (94.07%) than Moora method (89.62%) alone. DSS was developed using a desktop-based programming language with VB.NET, which prevents it from being accessed via the internet.

Anggrawan's research is applied in universities and has different criteria when applied in schools. The scholarship type discussed is not for SIP assistance, so the criteria used are not a requirement to apply for SIP assistance. The system developed also still uses desktop-based programming, so it cannot be accessed using the internet. Our research was conducted to apply for SIP assistance using the criteria used by SVHS 5 Surakarta. Our research aim is to develop a DSS that provides recommendations to students eligible for SIP scholarships and to evaluate the system by calculating the method's accuracy grade.

II. Materials and Methods

From previous research results, which also discussed DSS for scholarship recipient selection that does not use AHP or MOORA methods, the results showed lower accuracy. DSS using the AHP and TOPSIS methods achieved accuracies of 56.72% for achievement scholarship recommendations and 65.21% for BIDIKMISI scholarship recipient recommendations [25]. Based on other research, DSS uses the Simple Additive Weighting (SAW) method to determine SIP scholarship recipients, resulting in an accuracy rate of 80% [26]. From previous research results, the accuracy using AHP-TOPSIS and SAW methods was lower than that of the accuracy compared to using AHP-MOORA method. The decision to use the AHP and MOORA methods in our research was based on Anggrawan's results, which also used the same techniques and achieved an accuracy of 94.7%.

A. Data Acquisition

This stage is a phase for collecting the data needed to develop a DSS. The data used in this research include both primary and secondary data. Primary data is data obtained directly from the agency or institution that becomes the subject of study, in this case, SVHS 5 Surakarta. Data were collected through internal interviews with stakeholders to determine the values of the criteria. Secondary data is a collection of data used as input to build a computational model, as test data during the classification process, and to obtain output in the form of system prediction results.

The data collected is information about students who apply for SIP assistance. Data obtained from the next data collection stage are used to set the criteria for the alternative assessment. For the developed system, three criteria have been established, and the requirements and values are presented in Table 1. Each criterion has several choices for system input, each with a value based on the choices made. Each value will affect the AHP process.

TABLE I
DSS CRITERIA

Criteria	Input	Score
Card/letter ownership	SIP Card	4
	Prosperous Family Card	3
	Certificate of indigence	2
	None	1
Total earnings	< IDR 2,000,000	4
	IDR 2,000,000 - IDR 6,000,000	3
	IDR 6,000,000 - IDR 10,000,000	2
	> IDR 10,000,000	1
Siblings amount	< 7	9
	7	8
	6	7
	5	6
	4	5
	3	4
	2	3
	1	2
	0	1

B. System Design

In this research, the system to be developed is a DSS that produces recommendations for recipients of SIP assistance. This DSS will be applied to recommend recipients eligible for SIP assistance at SVHS 5 Surakarta. A block diagram of the developed system is presented in Fig. 1.

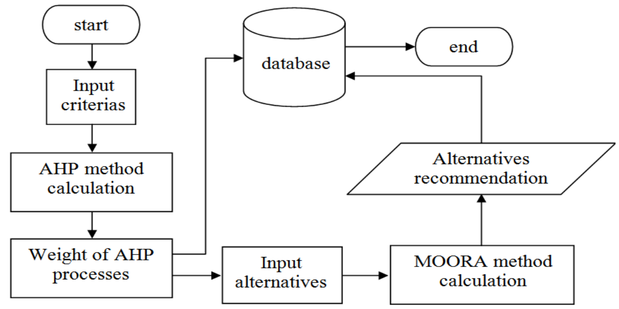

Fig. 1 System architecture

C. AHP Method Process

AHP is a multiple-criteria decision-making framework that has been extensively used for a variety of applications. In solving a problem, AHP method is used by compiling a hierarchy of criteria based on considerations from the interested parties to develop weights [27]. AHP is an approach aiming to deal with complex systems and the decisions so taken are based on relevant options considered from previous alternatives [28]. The process of calculating and creating a matrix with AHP method is presented in the form of a flowchart, as presented in Fig. 2.

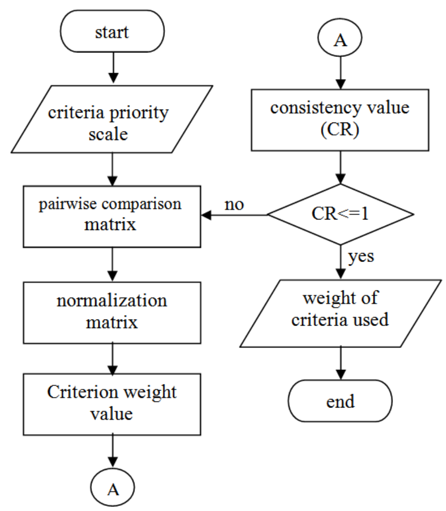

Fig. 2 AHP method process flowchart [29]

Stages in the AHP method process to determine weight values to be used in the MOORA method are as follows:

1) Define problems and determine the desired solution.

2) Create a hierarchical structure initiated with a general objective, followed by criteria, sub-criteria, and alternative options that have been set in order.

3) Determine each criterion value using pairwise comparisons based on a 1-9 scale made in matrix form, then add up the values in each matrix column. Comparisons are determined based on an assessment of the importance of one criterion compared to other criteria [30].

4) *Value of each column is divided by the corresponding column total* to determine the normalization matrix so that the priority weights and criteria (W_i) can be known using formula (1):

$$W_i = \frac{1}{n} \sum_i a_{ij} \quad (1)$$

W_i is the i-th weight goal of the weight vector.

5) *Testing or measuring consistency*: Suppose A is a pairwise comparison matrix and w is a weight vector, then the consistency of the weight vector W can be tested as follows:

Calculate (A)(W^t) using equation (2).

$$t = \frac{1}{n} \sum_{i=1}^{n} \frac{element\ i\ in\ (A)(W^t)}{element\ i\ in\ (W^t)} \quad (2)$$

Calculates the multiplication of each value in the first column by the relative priority of the first element, the second column value by the relative priority of the second element, and so on. The next step is to add up values in each row, from which consistency matrix is produced.

Calculate the Consistency Index (CI) using equation (3).

$$CI = \frac{t-n}{n-1} \quad (3)$$

If the result obtained is more than 0.01, then it means it is inconsistent and must be corrected; if the result is less than or equal to 0.01, then the value is consistent or correct [31].

D. MOORA Method Process

The MOORA method, which Brauers and Zavadskas first introduced, is quite flexible and easy to understand because it can break down the subjectivity of an evaluation process into weighting criteria values using several attributes [32]. The MOORA method optimizes two or more conflicting criteria by running processes in parallel. The MOORA method is flexible and easy to understand, and separates the subjective part of the evaluation process into decision weight criteria with several decision-making attributes [33]. The calculation process flow in generating alternative rankings with MOORA is presented in Fig. 3.

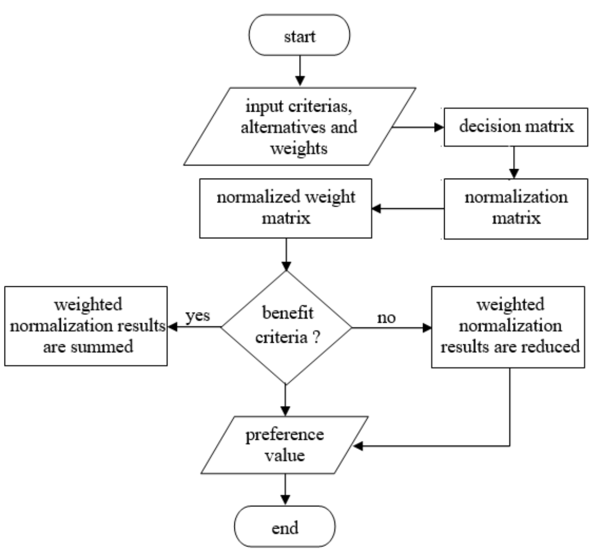

Fig. 3 Alternative Ranking Calculation In the MOORA Method [34]

1) *Decision Matrix*: shows the performance of various alternatives with respect to multiple criteria. Each criterion and alternative is listed in a column and row of the decision matrix.

$$X_{ij} = \begin{array}{ccc} x_{11} & x_{12} & x_{1n} \\ x_{21} & x_{22} & x_{2n} \\ x_{m1} & x_{m2} & x_{mn} \end{array} \quad (4)$$

X_{ij} is the Alternative response j to criteria i.
i is a large number of attributes or criteria.
j is a large number of alternatives.

2) *Matrix Normalization*: based on the ratio value known as the alternative value (i) to the criterion value (j), which represents all alternatives (i) based on the criterion (j). The best denominator option is the square root of the sum of each alternative's squares per attribute obtained from equation (5).

$$X_{ij} = \frac{x_{ij}}{\sqrt{\sum_i^m = x_{ij}^2}} \quad (5)$$

3) *Determine the weighted Normalization Matrix*: to determine whether a criterion is more important than another, so the criterion is multiplied by the corresponding weight. Where Wj is the weight value of j-th criterion.

$$y_i = \sum_{j=1}^{m} x_{ij} - \sum_{j=g+1}^{n} x_{ij} \quad (6)$$

4) *Determine preference values*: Order from the best alternative with the highest yi value to the alternative with the lowest yi value [35]:

$$y_i = \sum_{j=1}^{g} w_j x_{ij} - \sum_{j=g+1}^{n} w_j x_{ij} \quad (7)$$

where i are attributes or criteria with maximized status. j are attributes or criteria with minimized status. Wj is weight against alternatives. y_i is the normalized assessment value of alternative j against all attributes

III. RESULTS AND DISCUSSION

A. AHP Method Calculation

AHP method steps for completing student selection cases receiving SIP assistance are as follows:

1) *Determine the Criteria Priority Scale by Creating a Pairwise Comparison Matrix:* Criteria assessment is carried out by providing an importance scale value for each criterion. After assigning priority scale values, these values are used as a pairwise comparison matrix. So, the criteria and alternatives have their own pairwise comparison matrix.

TABLE II
PAIRWISE COMPARISON MATRIX

	C-1	**C-2**	**C-3**
C-1	1	3	5
C-2	0.333	1	3
C-3	0.2	0.333	1
Total	1.533	4.333	9

C-1: Card/letter ownership, C-2: Total earnings, C-3: Sibling amount

From Table II, it can be seen that a value of 3 in row C-1 and column C-2 indicates that total earnings are slightly more critical than card/letter ownership. In row C-1 column C-3, the comparison value is 5, meaning that the sibling amount is more critical than Card/letter ownership. Likewise, a value of 3 in row C-2 column C-3 means that the sibling amount is slightly more important than the total earnings.

2) Create a Normalization Matrix and Calculate Weights: The way to make a normalization matrix is to divide each element of the pairwise comparison matrix by the sum of the values for each column.

TABLE III
NORMALIZATION MATRIX

	C-1	C-2	C-3	Weight
C-1	0.625	0.692	0.566	0.633
C-2	0.217	0.231	0.333	0.260
C-3	0.130	0.077	0.111	0.106

Here is an example calculation for the first row.

1/1.533=0.652, 3/4.333=0.692, 5/9=0.566

0.333/1.533=0.217, 1/4.333=0.231, 3/9=0.333

0.2/1.533=0.217, 0.333/4.333=0.231, 1/9=0.106

The calculation continues until the last row.

Calculations to produce weights for each criterion:

(0.652 + 0.692 + 0.566)/3 = 0.633

(0.217 + 0.231 + 0.333)/3 = 0.260

(0.217 + 0.231 + 0.106)/3 = 0.106

3) Consistency Test: The pairwise comparison matrix is multiplied by the matrix of the average or weighted value.

$$\begin{matrix} 1 & 3 & 5 \\ 0.333 & 1 & 3 \\ 0.2 & 0.333 & 1 \end{matrix} \; \mathrm{X} \; \begin{matrix} 0.633 \\ 0.260 \\ 0.106 \end{matrix} = \begin{matrix} 1.946 \\ 0.790 \\ 0.320 \end{matrix}$$

The next stage is to enter the value from multiplying the comparison matrix by the normalization matrix.

$$\mathrm{t} = \frac{1}{3}\mathrm{X}\left(\frac{1.946}{0.633} + \frac{0.790}{0.260} + \frac{0.320}{0.106}\right) = 3.039$$

4) Calculate the Consistency Ratio (CR): After getting the t-value, the next stage is finding the CI value.

$$\mathrm{CI} = \frac{3.039}{3-1} = 0.019$$

Based on existing provisions, a CR value < 10% (0.1) is considered consistent. And if <10% or 0.10 indicates it is inconsistent, the repetition starts from the second step and continues until the data becomes consistent.

$$\mathrm{CR} = \frac{0{,}019}{0{,}58} = 0{,}033$$

B. MOORA Method Calculation

Process of applying a method to determine the order or ranking of alternatives by carrying out several calculation steps:

1) Rating Scale: An assessment scale value is required, which aims to determine which students at SVHS 5 Surakarta are worthy of receiving assistance. Values in the table are taken from the weights that have been calculated in a consistent AHP.

TABLE IV
SCORING SCALE

Criteria	Description	Weight
C-1	Profit	0.633
C-2	Profit	0.260
C-3	Profit	0.106

2) Decision Matrix: After determining the assessment scale, the next stage is to create a decision matrix (Table V) with the assessment results for each existing alternative.

TABLE V
DECISION MATRIX

Alternative	C-1	C-2	C-3
A-1	1	5	3
A-2	5	3	1
A-3	3	2	4
A-4	2	5	1
A-5	3	1	3

3) Matrix Normalization: dividing the elements in the column by the square root of the column and so on, the results of which are presented in Table VI.

TABLE VI
NORMALIZATION MATRIX

Alternative	C-1	C-2	C-3
A-1	0.1443	0.6250	0.5000
A-2	0.7217	0.3750	0.1667
A-3	0.4330	0.2500	0.6667
A-4	0.2887	0.6250	0.1667
A-5	0.4330	0.1250	0.5000

4) Weighted *Normalization* Matrix: The next stage is normalization of the weighted matrix, by multiplying the criteria weights from the AHP method with the normalized matrix.

TABLE VII
WEIGHTED NORMALIZATION MATRIX

Alternative	C-1	C-2	C-3	Preference
A-1	0.0194	0.1628	0.0531	0.3073
A-2	0.4571	0.0977	0.0177	0.5725
A-3	0.2742	0.0651	0.0708	0.4101
A-4	0.1828	0.1628	0.0177	0.3633
A-5	0.2742	0.0326	0.0531	0.3599

An example calculation for the first row is as follows:

0.1443 x 0.633 = 0.0194

0.6350 x 0.260 = 0.1628

0.5000 x 0.106 = 0.0531

The calculation continues until the last row.

The preference value is obtained by summing all the criterion values (columns) for each alternative (rows). An example preference calculation for the first row is:

0.0194 + 0.1628 + 0.0531 = 0.3073

The addition is continued until the last row.

5) Sorting Preference Values: Sort the preference values in descending order (from largest to smallest) to obtain priorities or recommendations for alternatives that are entitled to receive SIP assistance. The alternative eligibility order for the SIP scholarship is presented in Table VIII.

TABLE VIII
ALTERNATIVE RANKING

Alternative	Preference
A-2	0.5725
A-3	0.4101
A-4	0.3633
A-5	0.3599
A-1	0.3073

C. Implementation of the AHP Method Process

Implementation is the stage of implementing the system according to the design to solve the problems identified in the research. The steps for implementing the system include a calculation process using the AHP method to determine the weight of each criterion to be used, and calculations to determine which students are entitled to receive SIP assistance. Student scores in applying for SIP assistance are considered in determining the student's eligibility to receive help. The information page for student grades is shown in Fig. 4.

Student Grades

Search... 2022

No.	Name	Card ownership	Total income	Total siblings	Action
1	AHMAD FAUZUL MUTTAQIN	4	10	2	
2	AMELIA HAFIZNA	10	2	4	
3	CINDY QURROTUL AYUN	2	3	10	
4	FARIQ FADLI	4	10	5	
5	ISNAINI AMINATUS ZAHRA	3	10	2	
6	MEDIYA NUR AFITA	10	3	5	

Fig. 4 Student Assessment Page

The initial stage of the AHP method is to determine the pairwise comparison matrix. In the developed system, a pairwise matrix display is presented as shown in Fig. 5.

Pairwise Comparision Matrix

Code	Card ownership	Total income	Total siblings
1	1	2	4
2	0.5	1	4
3	0.25	0.25	1
Total	1.75	3.25	9

Fig. 5 Paired Comparison Matrix Display

As explained previously, after pairwise comparisons have been determined, a normalization matrix can be calculated or created as shown in Fig. 6.

Normalization Matrix

Code	Card ownership	Total income	Total siblings	Weight
1	0.571	0.615	0.444	**0.544**
2	0.286	0.308	0.444	**0.346**
3	0.143	0.077	0.111	**0.110**

Fig. 6 AHP Normalization Matrix Display

The consistency test results or calculating consistency measure values can be seen in Fig. 7.

Test of Consistency

Code	Card ownership	Total income	Total siblings	Consistency measure
1	0.571	0.615	0.444	**3.084**
2	0.286	0.308	0.444	**3.061**
3	0.143	0.077	0.111	**3.017**

Fig. 7 AHP Consistency Test Display

CI and CR values are calculated to determine the consistency of the obtained weight values, whether they are consistent or not. The calculation results are presented in Fig. 8.

Index Ratio Based on Matrix Ordo

Matrix ordo	1	2	3	4	5	6	7
Index Ratio	0	0	0.58	0.9	1.12	1.24	1.32

Consistency Index: 0.032
Ratio Index: 1.24
Consistency Ratio: 0.026

Fig. 8 CI and CR Value Calculation Display

D. Implementation of MOORA Method Process

After calculating the AHP, the next stage is the MOORA method to obtain results in the form of a ranked sequence of students who deserve assistance. Alternative values are used to input student grades, which still include data on card ownership, parents' occupation, parents' income, and number of siblings, obtained from SVHS 5 Surakarta and presented in Fig. 9. These values are converted to a scale of 1-5. Fig. 10 shows the system display of the calculation results for the normalization matrix.

MOORA Method

Student Grades

2022

No.	Name	Card ownership	Total income	Total siblings
1	AHMAD FAUZUL MUTTAQIN	4	10	2
2	AMELIA HAFIZNA	10	2	4
3	CINDY QURROTUL AYUN	2	3	10
4	FARIQ FADLI	4	10	5
5	ISNAINI AMINATUS ZAHRA	3	10	2
6	MEDIYA NUR AFITA	10	3	5
7	NADYA PUJI LESTARI	3	2	5
8	ZUHROTUL LAILIYAH	3	3	3

Fig. 9 Student Grade Conversion Display

Normalization Matrix

Name	Card ownership	Total income	Total siblings
WEIGHT	**0.54375254375254**	**0.34595034595035**	**0.11029711029711**
AHMAD FAUZUL MUTTAQIN	0.13274466231999	0.30275242098834	0.045212674871078
AMELIA HAFIZNA	0.33186165579999	0.09085726296501	0.092425349742157
CINDY QURROTUL AYUN	0.66372331159997	0.12110096839533	0.23106337435539
FARIQ FADLI	0.13274466231999	0.30275242098834	0.1155316871777
ISNAINI AMINATUS ZAHRA	0.099558496739996	0.30275242098834	0.045212674871078
MEDIYA NUR AFITA	0.33186165579999	0.09085726296501	0.1155316871777
NADYA PUJI LESTARI	0.099558496739996	0.060550484197667	0.1155316871777
ZUHROTUL LAILIYAH	0.099558496739996	0.09085726296501	0.069319012306617
FATKHUR ROHMAN ARDIYANSAH	0.099558496739996	0.09085726296501	0.1155316871777
HAULIK MUBAYYINAH	0.099558496739996	0.060550484197667	0.092425349742157

Fig. 10 MOORA Normalization Matrix Display

After carrying out normalization process, the next stage is the weighted normalization stage. The calculation process is to multiply the normalization results by the criteria weights that have been obtained from earlier stages of the AHP process.

Weighted Normalization Matrix

Name	Card ownership	Total income	Total siblings
AHMAD FAUZUL MUTTAQIN	0.07218024706069	0.104773730477822	0.005097124497380
AMELIA HAFIZNA	0.18045061951517	0.031421191433466	0.01019424899476
CINDY QURROTUL AYUN	0.02609012303034	0.041894921911288	0.02548622486899
FARIQ FADLI	0.072180247806069	0.104773730477822	0.01274281124345
ISNAINI AMINATUS ZAHRA	0.054135185854552	0.104773730477822	0.005097124497380
MEDIYA NUR AFITA	0.18045061951517	0.031421191433466	0.01274281124345
NADYA PUJI LESTARI	0.054135185854552	0.020947460955644	0.01274281124345
ZUHROTUL LAILIYAH	0.054135185854552	0.031421191433466	0.0076456867460697
FATKHUR ROHMAN ARDIYANSAH	0.054135185854552	0.031421191433466	0.01274281124345
HAULIK MUBAYYINAH	0.054135185854552	0.020947460955644	0.01019424899476
KHOTWATIN HASANAH	0.054135185854552	0.031421191433466	0.01274281124345

Fig. 11 Weighted Normalization Matrix Display

After performing the weighted normalization, the next step is to determine the preference or optimization value. The optimization results of the system process are shown in Fig. 12.

Optimization Value

Name	Optimization result	Ranking
AHMAD FAUZUL MUTTAQIN	0.10232902825024	62
AMELIA HAFIZNA	0.049596097965832	83
CINDY QURROTUL AYUN	0.12176314530366	3
FARIQ FADLI	0.097680946001226	80
ISNAINI AMINATUS ZAHRA	0.10602553695134	47
MEDIYA NUR AFITA	0.11806663660256	12
NADYA PUJI LESTARI	0.10041762524239	74
ZUHROTUL LAILIYAH	0.11552405093044	15
FATKHUR ROHMAN ARDIYANSAH	0.10602553695134	50

Fig. 12 Preference Value Display

The final stage is to sort the preference values that have been obtained in Fig. 12 to produce recommendations for the priority of students who are entitled to SIP assistance. Student ranking or order results can be seen in Fig. 13.

Ranking Result

Refresh

No.	No. Reg.	Student name	Class	Entry year	Grade
1	1220323	ALIF SYAHRANI	IPS 3	2022	0.1236745483115
2	1220265	M.CHUSNI TAMIMI	IPS 1	2022	0.12304336564723
3	1220007	CINDY QURROTUL AYUN	BAHASA	2022	0.12176314530366
4	1220271	MUTIA ADELIA	IPS 1	2022	0.12176314530366
5	1220149	AHSANATUL FARIDHOH	IPA 4	2022	0.11922055963154
6	1220113	DENY ASHORY	IPS 3	2022	0.11922055963154
7	1220328	ARGA PUTRA BHASWARA	IPS 3	2022	0.11870674677434
8	1220261	FANNIYATUL AZKA	IPS 1	2022	0.11819293391715

Fig. 13 Student Ranking Display

E. Accuracy Testing

From the data obtained through direct research at SVHS 5 Surakarta, there are three recapitulation results detailing the number of students receiving SIP assistance: 2021, 2022, and 2023. In 2021, there were 73 students who received SIP assistance from 86 registered students; in 2022, there were 68 out of 79 students who applied, and in 2023, there will be 49 out of 54 students. Calculation from the system developed shows that in 2021, 70 students received the assistance, with 3 other students failing because of unmatched facts. For 2022, 66 students were produced, 2 students were accepted without fact verification. For 2023, 46 students were made, three students failed to meet fact verification. The accuracy of each value calculated from a confusion matrix is presented in Table IX.

TABLE IX
DATA CONFUSION MATRIX

2021			
n=86	(+)	(-)	
(+)	True Positive=70	False Positive=3	73
(-)	False Negative=3	False Positive=8	11
	73	11	
2022			
n=79	(+)	(-)	
(+)	True Positive=66	False Positive=2	68
(-)	False Negative=2	False Positive=6	8
	67	8	
2023			
n=54	(+)	(-)	
(+)	True Positive=46	False Positive=2	48
(-)	False Negative=2	False Positive=2	4
	48	4	

From Table IX, the level of precision and accuracy can be calculated as follows:

2021:

$$\text{Precision} = \frac{70}{70+3}\ x\ 100\% = 95.9\%$$

$$\text{Accuracy} = \frac{70+8}{70+3+3+8}\ x\ 100\% = 92.9\%$$

2022:

$$\text{Precision} = \frac{66}{66+2}\ x\ 100\% = 97.1\%$$

$$\text{Accuracy} = \frac{66+6}{66+2+2+6}\ x\ 100\% = 94.7\%$$

2023:

$$\text{Precision} = \frac{46}{46+2}\ x\ 100\% = 95.8\%$$

$$\text{Accuracy} = \frac{46+2}{46+2+2+2}\ x\ 100\% = 92.3\%$$

From these results, it can be explained that students who received PIP assistance from all students predicted to receive PIP assistance (precision) were 95.9% for 2021, 97.1% for 2022, and 95.8% for 2023. The accuracy rate for students who received PIP assistance from all students who applied (accuracy) was 92.9% for 2021, 94.7% for 2022, and 92.3% for 2023. Precision decreased in 2023 compared to 2022. This could be due to regulatory changes regarding requirements or priorities for granting SIP. Other reasons include a less objective selection process during interviews or data manipulation.

TABLE X
EXAMINE AVERAGE

Category	Precision	Accuracy
2021 data	95.9%	92.9%
2022 data	97.1%	94.7%
2023 data	95.8%	92.3%
Average	96.3%	93.3%

Based on Table X, the average precision is 96.3% and the average accuracy is 93.3%. The accuracy level of more than 90% is included in an excellent classification so that the results are very worthy to use. Previous research has also resulted in a DSS for determining scholarship recipients using other methods. Research by Wardana compared the collaborative performance of Smarter-Fuzzy and SmarterFuzzy-Topsis methods for determining scholarship recipients. Smarter-Fuzzy method accuracy was 86.6% with a precision of 85.5%. SmarterFuzzy-Topsis method test yielded an accuracy of 75.7% and a precision of 73% [36]. Another study, which also aimed to determine scholarship recipients, used only the MOORA method and resulted in an accuracy rate of 5.61% [37]. From the comparison with these two previous studies, it can be concluded that the accuracy of using AHP and MOORA methods in this research is better than using only MOORA method, using Smarter-Fuzzy method, or the combined SmarterFuzzy-Topsis method.

IV. Conclusion

The DSS developed in this research uses AHP and MOORA methods. The system was created on a web-based, responsive platform, which makes it appear correctly on a smartphone during a call. The criteria used include ownership of a card or letter, Parental income, and number of siblings. Each criterion is further divided into sub-criteria with values for processing in the AHP method. Sub-criteria for card or letter ownership include a SIP card, a prosperous family card or family hope program, a certificate of indigence, and a recommendation letter, whether or not the applicant has one. Other sub-criteria are presented in Table I. The weight value obtained from the AHP calculation serves as a reference in the MOORA calculations and yields recommendations for the order of students eligible to receive SIP assistance. To test the system under development, a comparison of system calculations results was made using existing facts from SVHS 5 Surakarta in 2021, 2022, and 2023. Based on an accuracy test using total income data from 2021 to 2023, the accuracy exceeded 93.3%, indicating that the calculations using the AHP and MOORA methods are accurate. The accuracy results of this research fall within the outstanding classification category, indicating that the AHP and MOORA methods are suitable for assisting decision-making and providing recommendations for SIP assistance recipients at SVHS 5 Surakarta.

Based on the system developed in this research, student data is still entered manually. For further development, it would be better if the system could upload student data simultaneously or retrieve data from an external system. For further research, one or two other methods can be used to compare the accuracy results shown in this research.

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