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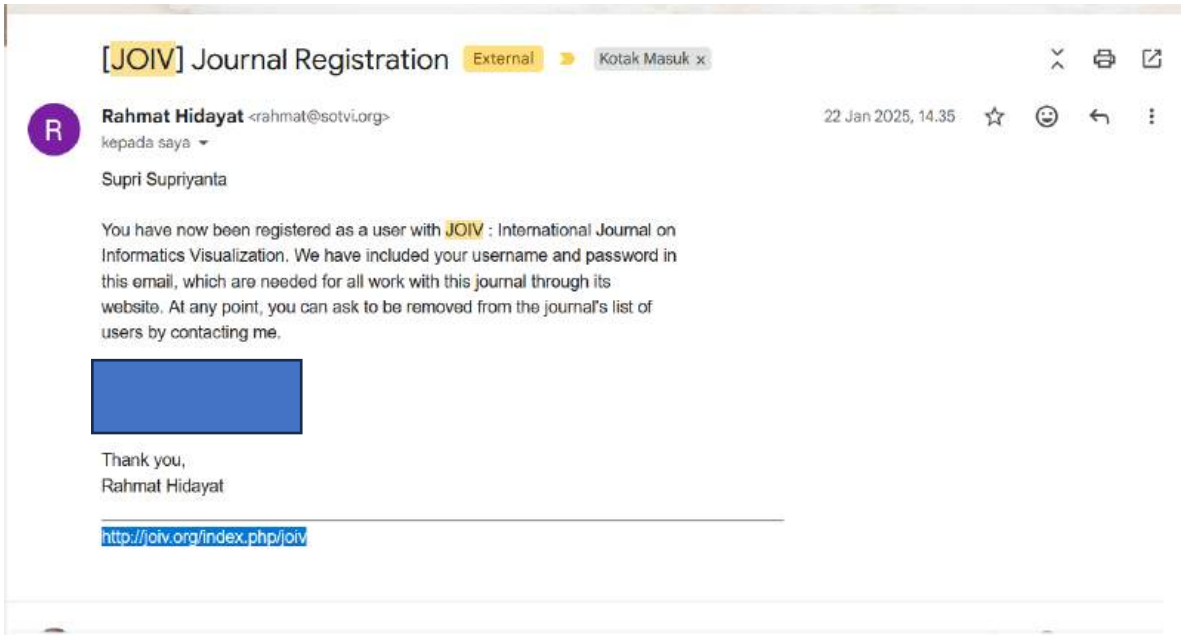

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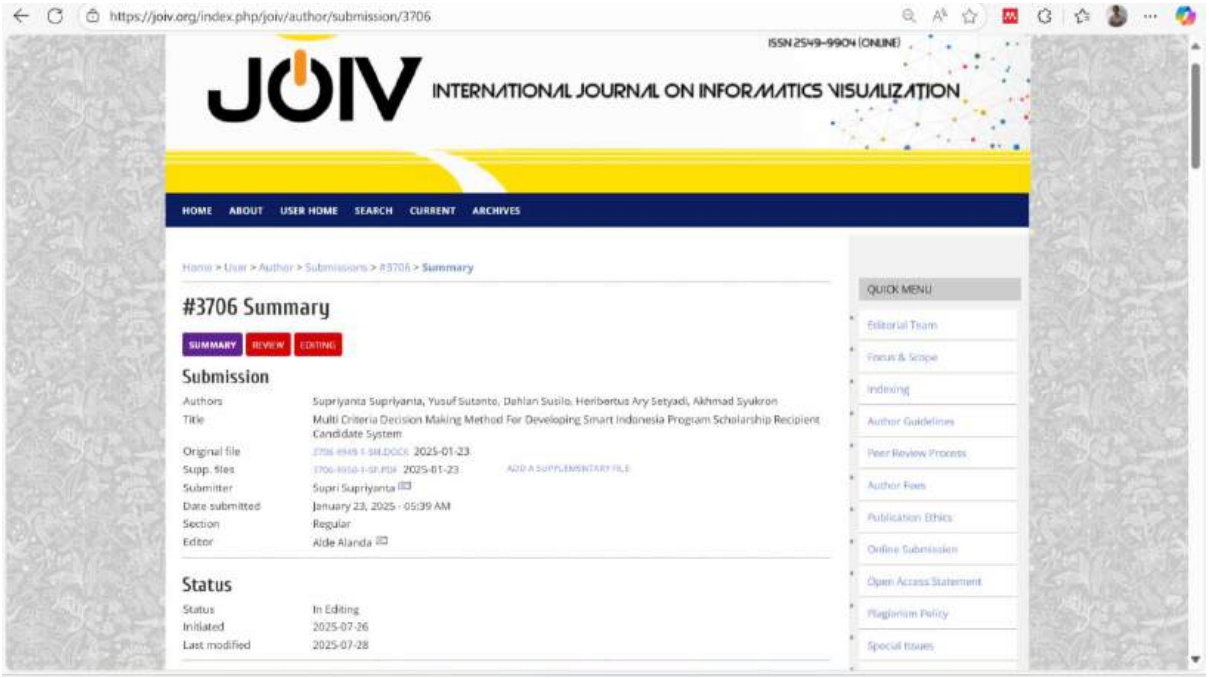


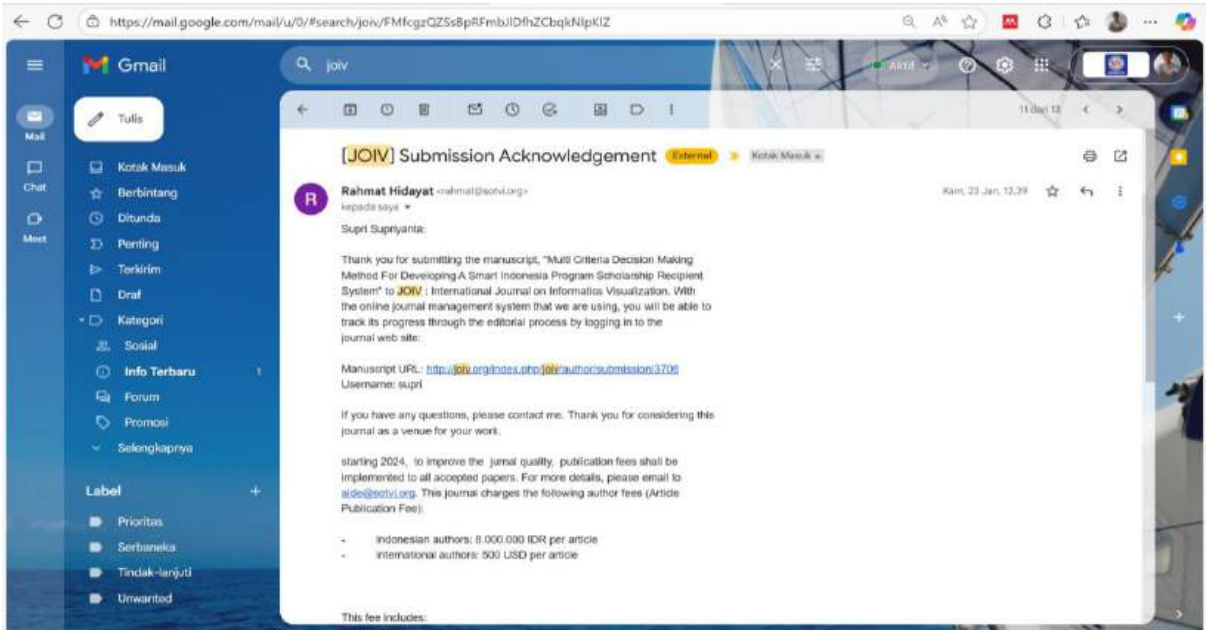

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# Multi Criteria Decision Making Method For Developing A Smart Indonesia Program Scholarship Recipient System

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***Abstract*— The Indonesian government is constantly trying to improve education through various assistance or scholarship programs, one of which is the Smart Indonesia Program (SIP). State Vocational High School 5 (SVHS 5) Surakarta was used as the object of case study in this research to find out selection process and collect data from previous year. The increasing number of students applying for SIP and selection process still using conventional methods is a situation that reduces the work of the SIP student selection team. Without adequate IT support, the process of selecting prospective SIP scholarship recipient students can be very difficult, not objective and without equality. Decision Support System (DSS) was created in this research to assist in determining which students are recommended for scholarships using Analytical Hierarchy Process (AHP) and Multi-Objective Optimization by Ratio Analysis (MOORA) methods. The DSS in this research will determine the weight of each predetermined criterion before entering the alternative ranking stage. The MOORA method is used to produce alternative rankings in the form of students passing the selection based on the weights produced in the AHP method. The criteria used in this DSS are: card or letter ownership status, total parental income and total sibling income. Each criterion is broken down into several sub-criteria and has a value that is used in the AHP method process. After testing accuracy by comparing data from 2021 to 2023. In 2021 the accuracy was 92.9%, while in 2022 it was 94.7% and the accuracy in 2023 was 92.3%.**

***Keywords*— Decision Support System; Recommendation; Smart Indonesia Program; AHP; MOORA.**
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## I. INTRODUCTION

Elementary and secondary education is an important thing in determining future life. However. Financial problems often force parents to stop continuing their children's education. Every country will of course pay attention to the development of the education sector, because good education is needed to create and improve a smart and skilled workforce [1]. The education provided today will determine the development of a nation in the future. Education plays an important role in creating a qualified, competitive and competent workforce. Faced with this problem, the Ministry of Education and Culture of the Republic of Indonesia issued the SIP [2]. SIP is a government program that aims to provide financial assistance or relief to students aged 6 to 21 years. 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 strive 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 can be very difficult, not objective and without equality [5]. SIC (Smart Indonesian Card) is a form of cash assistance program for school-age children from underprivileged, vulnerable families and Prosperous Family Card holders [6]. The aim of SIC is to help access education for students who have quality and from underprivileged parental backgrounds, prevent and reduce children dropping out of school and to meet educational needs. Disadvantaged students are expected to be able to use this program to meet school needs [7].

State Vocational High School 5 (SVHS 5) Surakarta city has a vision of producing graduates who have strong character, ready to work and become entrepreneurs based on environmentally friendly technology. In 2005, SVHS 5 Surakarta was the first vocational school to successfully obtain an ISO 9001-2000 certificate and was also selected to be the guiding school for all vocational schools and high schools in the Central Java region. Finally, in

2017, SVHS 5 Surakarta achieved and implemented the ISO 9001-2015 certificate. As a state school, screening of SIP recipient students is carried out every year in all schools in Indonesia. The process of selecting students who receive SIP is a fairly complicated process to carry out without adequate information system support [8]. These working conditions and systems are still applied at SVHS 5 Surakarta, which is the object of the case study in this research. The SIP selection committee at SVHS 5 Surakarta faces great responsibilities and challenges in selecting students who really have the right and need SIP assistance. The large number of SIP registrants, and data processing with piles of files and calculations which are still carried out only using standard applications, is one of the factors that influences the performance of the selection team. The selection team must sorting, searching and verification lots of student data. The assessment and selection process so far still requires a long process and must have high accuracy so that it is susceptible to abuse of authority or data manipulation and is also prone to errors caused by negligence in data input. Mistakes in the selection results can cause students who deserve and need a SIP scholarship to lose their rights.

In an era that is all about information technology, methods contained in DSS are really needed, ranging from simple methods to complex methods. DSS is an information system intended to be used semi-structuredly in decision making [9]. DSS is essentially an evolution of a computerized management information system or known as a Decision Support System (DDS), 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 certain technology or systems. DSS can be implemented in various fields to find solutions to various problems [11]. In this research, DSS was created using the AHP and MOORA method. AHP can organize information using a number of alternatives and produce objective values for each criterion [12]. The value resulting from the AHP calculation shows the criteria that have the highest priority and influences the resolution of existing problems [13]. The AHP method has the advantage of creating a pairwise comparison matrix to determine the weight of each criterion and calculate the consistency value [14]. The Moora method is a multi-objective optimization technique that can be used to solve various types of complex decision-making problems in decision making [15]. The Moora method sorts (ranks) each attribute based on specified criteria and can create alternatives based on the specified criteria [16]. The Moora method performs simple calculations of minimum and maximum values. This method determines which alternatives have good selectivity [17]. Processes run simultaneously Produce two or more optimal levels It is inconsistent and has some errors of Moora's approach [18]. The AHP method used in this research aims to calculate the weight of each criterion that has been determined before entering to determining alternative rankings process. AHP can describe complex multi-factor or multi-criteria problems into a hierarchy [19]. Meanwhile, The purpose of choosing MOORA method is to determine student rankings after knowing the weight of each criterion produced by the AHP method.

There have been several previous studies related to the theme of determining recipients of SIP assistance with DSS. Previous research by Manuhutu developed a decision support system to determine recipients of Smart Indonesia program assistance using the Weighted Product method. There are 5 criterias used including: students activeness, certificate of incapacity, Orphans, Parents salary, and Absences. The prototype model was chosen to develop a web-based decision support system that uses the PHP programming language and Bootstrap as a framework [20]. The journal Anggrawan's research results also uses the AHP and MOORA methods to provide recommendations for educational scholarship recipients. This research compared the combined use of the AHP and MOORA methods, and using the MOORA method alone. In his research uses 6 attributes that will be applied in the method used, including: average cumulative grade point average for the last two semesters, total activity value, recommendation letter, active organizationally, semester and completion of requirements. Results of his research concluded that using a combination of AHP and Moora methods was more accurate (94.07%) than using only one Moora method (89.62%). DSS was developed using a desktop-based programming language with VB.Net so it cannot be accessed via the internet [21]. Research by Asnimar compares the decision tree algorithm with Naive Bayes to classify educational scholarship aid recipients. There are 10 attributes used in the research to determine prospective new STMIK AKBA students who are entitled to receive educational scholarships. These ten attributes include: ownership of smart indonesia card, ownership of a prosperous family card, possession of a poor card, parents salary, the number of dependents, parents' job, high school graduation status or equivalent, has passed a maximum of 2 years, certificate value, and average student report

score. This research produces a classification using a decision tree algorithm with an accuracy value of 44.12% and an F1-Score of 34.48%, while the accuracy value of the Naive Bayes algorithm is 76.47% which uses data on diploma grades and average report cards. Based on these accuracy results, the Naïve Bayes algorithm is Better when used to classify scholarship recipients than the Decision Tree algorithm [22].

## II. Material And Methods

### A. Data Acquisition

This stage is the phase for collecting the data needed for research to develop DSS. Data used in this research includes primary and secondary data. Primary data is data obtained directly from the agency or institution that is the subject of research, in this case SVHSN 6 Surakarta. Data was collected by conducting internal interviews with stakeholders to obtain values from the criteria. Secondary data is a collection of data that is needed as input to build a computational model and functions as test data when carrying out the classification process and obtaining 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 is used to determine the criteria needed and used in alternative assessment. There are 3 criteria used in the developed system, the criteria and values are presented in table 1.

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 |
| Total siblings | < 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 developed is DSS to produce recommendations for recipients of SIP assistance. The DSS developed will be applied to provide recommendations for recipients of SIP assistance at SVHS 5 Surakarta. The block diagram of developed system is presented in Fig. 1.

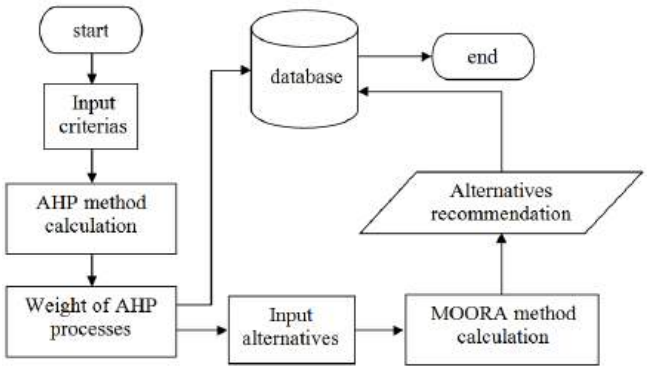


Fig. 1 System architecture

### C. AHP Method Process

AHP is a multiple criteria decision-making framework that has been used extensively for a variety of applications. In solving a problem, AHP method is used by compiling a hierarchy of criteria by drawing considerations from interested parties to develop weights [23]. AHP is an approach used to handle complex systems which is also related to determining decisions from options considered from several alternatives [24]. Stages in then AHP method process to determine weight values to be used in the MOORA method are as follows:

1) Defining the problem and determining the desired solution.
2) Create a hierarchical structure that begins with a general objective, followed by criteria, sub-criteria and alternative options that are ordered.
3) Determine each criteria 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 [25].
4) Value of each column is divided by corresponding column total to determine the normalization matrix so that the priority weights and criteria (Wi) can be known using formula (1):

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

5) Calculates the multiplication of each value in the first column by 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 of values in each row, results of this calculation produce a consistency matrix.
6) Adding rows result in consistency matrix is divided by corresponding relative priority elements and then adding the quotient to total of

elements will produce the λ max value. This stage was carried out by using (2):

$$CI = \frac{\lambda \max - n}{n - 1} \quad (2)$$

[26]

The process of calculating and creating a matrix for the AHP method is presented in the form of a flowchart which is presented in Fig. 2.

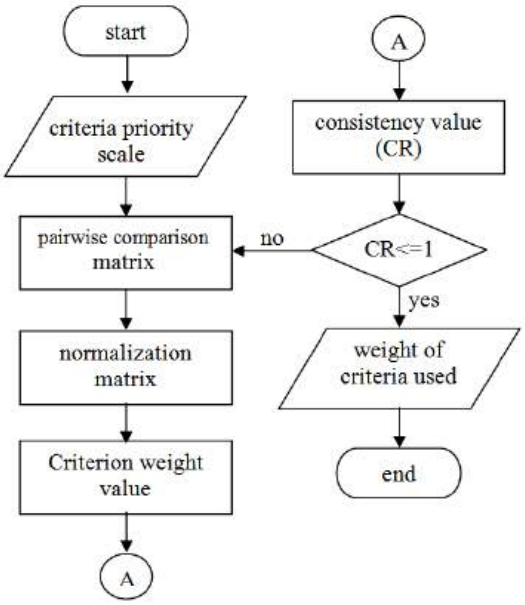


Fig. 2 AHP method process flowchart [27]

*D. MOORA Method Process*

Brauers and Zavadskas were the first to introduce the MOORA method which 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 [28]. The MOORA method working process is to carry out processes simultaneously to optimize two or more conflicting criteria. 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 [29]. The calculation process flow in generating alternative rankings with MOORA is presented in Fig. 3.

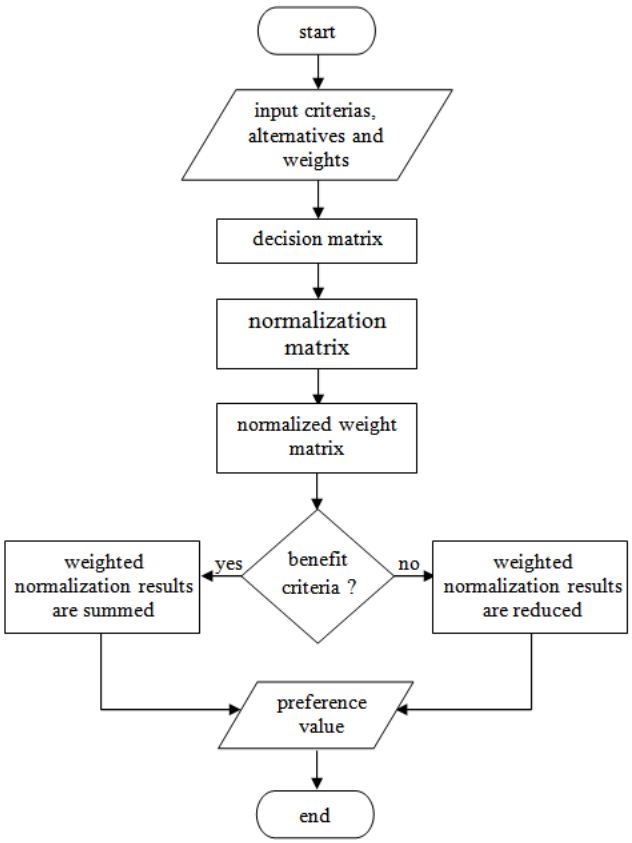


Fig. 3 Alternative Ranking Calculation In MOORA Method [30]

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

$$X_{ij} = \begin{matrix} x_{11} & x_{12} & x_{1n} \\ x_{21} & x_{22} & x_{2n} \\ x_{m1} & x_{m2} & x_{mn} \end{matrix} \quad (3)$$

2) Matrix Normalization: based on ratio value known as alternative value ($i$) to criterion value ($j$) which represents all alternatives ($i$) based on the criterion ($j$). The best denominator option is the square root from sum of each alternative squares per attribute obtained from equation (4).

$$X_{ij} = \frac{x_{ij}}{\sqrt{\sum_{i}^{m} = x_{ij}^2}} \quad (4)$$

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

$$y_i = \sum_{j=1}^{m} x_{ij} - \sum_{j=g+1}^{n} x_{ij} \quad (5)$$

4) Determine preference values: Order from the best alternative with the highest yi value to the alternative with the lowest yi value [31]:

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

## III. Result 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 Comparision Matrix

| | C-1 | C-2 | C-3 |
|---|---|---|---|
| **C-1** | 1 | 2 | 4 |
| **C-2** | 0,5 | 1 | 4 |
| **C-3** | 0,25 | 0,25 | 1 |
| **Total** | 1,75 | 3,25 | 9 |

2) Create a Normalization Matrix

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 |
|---|---|---|---|
| **C-1** | 1/1,75 | 2/3,25 | 4/9 |
| **C-2** | 0,51/1,75 | 1/3,25 | 4/9 |
| **C-3** | 0,251/1,75 | 0,25/3,25 | 1/9 |
| **Total** | 1 | 1 | 1 |

3) Calculating Priority Weights

To get the priority weights for the criteria and each alternative for each criterion by looking for the average value in each row of the normalized matrix.

TABLE IV
Criteria Weights

| | C-1 | C-2 | C-3 | Total | Weight |
|---|---|---|---|---|---|
| C-1 | 0,5714 | 0,6154 | 0,4444 | 1,6312 | 0,5438 |
| C-2 | 0,2857 | 0,3077 | 0,4444 | 1,0379 | 0,3460 |
| C-3 | 0,1429 | 0,0769 | 0,1111 | 0,3309 | 0,1103 |

4) Consistency Test

The pairwise comparison matrix is multiplied by the matrix on the average or weighted value.

$$\begin{matrix} 1 & 2 & 4 \\ 0{,}5 & 1 & 4 \\ 0{,}25 & 0{,}25 & 1 \end{matrix} \text{ X } \begin{matrix} 0{,}5438 \\ 0{,}3460 \\ 0{,}1103 \end{matrix} = \begin{matrix} 1{,}6768 \\ 0{,}0590 \\ 0{,}3327 \end{matrix}$$

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

$$t = \frac{1}{3} X \left[\frac{1{,}6768}{0{,}5438}\right] + \left[\frac{0{,}0590}{0{,}3460}\right] + \left[\frac{0{,}3327}{0{,}1103}\right] = 3{,}0539$$

5) Calculate the Consistency Ratio (CR)

After getting the t value, the next stage is finding the CI value.

$$CI = \frac{3{,}0539}{3-1} = 0{,}0269$$

Based on existing provisions, a CR value < 10% or 0.1 is said to be consistent. And if <10% or 0.10 means it is inconsistent, then the repetition is repeated starting from the second step and so on until the data becomes consistent.

$$CR = \frac{0{,}0269}{0{,}58} = 0{,}0464$$

### 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 consistent AHP.

TABLE V
Scoring Scale

| Criteria | Description | Weight |
|---|---|---|
| C-1 | Profit | 0,5438 |

| | | |
|---|---|---|
| C-2 | Profit | 0,3460 |
| C-3 | Profit | 0,1103 |

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

TABLE VI

DECISION MATRIX

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

3) Matrix Normalization: The next stage is matrix normalization by dividing the elements in the column by the square root of the column and so on, the results of which are presented in Table VII.

TABLE VII

NORMALIZATIOON MATRIX

| Alternative | C-1 | C-2 | C-3 |
|---|---|---|---|
| **A-1** | 0.1443 | 0.6509 | 0.7071 |
| **A-2** | 0.7217 | 0.2604 | 0.1414 |
| **A-3** | 0.433 | 0.2604 | 0.5657 |
| **A-4** | 0.2887 | 0.6509 | 0.2828 |
| **A-5** | 0.433 | 0.1302 | 0.2828 |

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

TABLE VIII

WEIGHTED NORMALIZATION MATRIX

| Alternative | C-1 | C-2 | C-3 |
|---|---|---|---|
| **A-1** | 0.0785 | 0.2252 | 0.078 |
| **A-2** | 0.3925 | 0.0901 | 0.0156 |
| **A-3** | 0.2355 | 0.0901 | 0.0624 |
| **A-4** | 0.157 | 0.2252 | 0.0312 |
| **A-5** | 0.2355 | 0.045 | 0.0312 |

5) Determine Preference Values: The calculation at this stage is by adding up the profit attribute with other profits and adding the cost attribute with other cost attributes. Calculation of preference value is sought by reducing the value of benefits from costs.

TABLE IX

PREFERENCE VALUE

| Aternative | Total Profit | Preference |
|---|---|---|
| **A-1** | 0.0785 + 0.2252 + 0.078 | 0.3817 |
| **A-2** | 0.3925 + 0.0901 + 0.0156 | 0.4981 |
| **A-3** | 0.2355 + 0.0901 + 0.0624 | 0.388 |
| **A-4** | 0.157 + 0.2252 + 0.0312 | 0.4134 |
| **A-5** | 0.2355 + 0.045 + 0.0312 | 0.3117 |

6) Sorting Preference Values: Sort the preference values in descending order (from large to small) to obtain priorities or recommendations for alternatives that are entitled to receive SIP assistance.

TABLE X

ALTERNATIVE RANGKING

| Aternative | Preference |
|---|---|
| A-2 | 0.4981 |
| A-4 | 0.4134 |
| A-3 | 0.388 |
| A-1 | 0.3817 |
| A-5 | 0.3117 |

*C. Implementation AHP Method Process*

Implementation is the stage for implementing the system according to 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 that will be used and calculations to determine which students are entitled to receive SIP assistance. Student scores in applying for SIP assistance are used as consideration to determine the student's eligibility to receive assistance. The information page for student grades can be seen in Fig. 4.

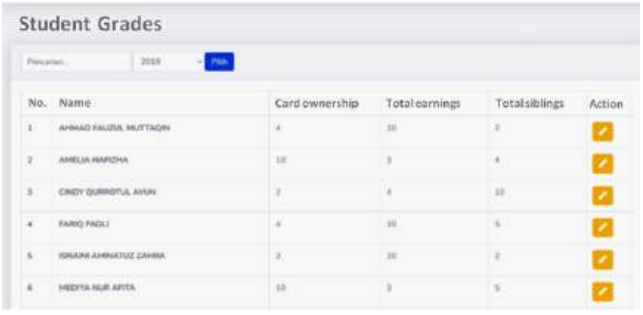


Fig. 4 Student Assessment Page

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

Pairwise Comparison Matrix

| Code | Card ownership | Total earnings | 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 earnings | 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 | 0.11 |

Fig. 6 AHP Normalization Matrix Display

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

Consistency Testing

| Code | Card ownership | Total earnings | 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

Calculation of CI and CR values to determine the consistency of the resulting 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 MOORA Method Process*

After calculating the AHP method, the next stage is the MOORA method calculation process to obtain results in the form of a sequence of students who deserve assistance. Alternative values function to input student grades which still consist of 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 into a scale of 1-5. Fig. 10 presents the system display for calculation results in normalization matrix.

MOORA Method

Student Grades

2022 Pilih

| | Card ownership | Total earnings | Total siblings |
|---|---|---|---|
| AHMAD FAUZUL MUTTAQIN | 4 | 10 | 2 |
| AMELIA HAFIZHA | 10 | 3 | 4 |
| CINDY QURROTUL AYUN | 2 | 4 | 10 |
| FARIQ FADLI | 4 | 10 | 5 |
| ISNAINI AMINATUZ ZAHRA | 3 | 10 | 2 |
| MEDIYA NUR AFITA | 10 | 3 | 5 |
| NADYA PUJI LESTARI | 3 | 2 | 5 |
| ZUHROTUL LAILIYAH | 3 | 3 | 3 |

Fig. 9 Student Grade Conversion Display

Matrix Normalization

| | Card ownership | Total earnings | Total siblings |
|---|---|---|---|
| WEIGHT | 0.543752543752543 | 0.349903498990035 | 0.110297110297311 |
| AHMAD FAUZUL MUTTAQIN | 0.133744662331999 | 0.302752420998834 | 0.046212674871078 |
| AMELIA HAFIZHA | 0.331881055799999 | 0.090825726296501 | 0.092425349742157 |
| CINDY QURROTUL AYUN | 0.066372311359967 | 0.121100966839633 | 0.231063374399599 |
| FARIQ FADLI | 0.133744662331999 | 0.302752420998834 | 0.115553168771777 |
| ISNAINI AMINATUZ ZAHRA | 0.099558498730996 | 0.302752420998834 | 0.046212674871078 |
| MEDIYA NUR AFITA | 0.331881055799999 | 0.090825726296501 | 0.115553168771777 |
| NADYA PUJI LESTARI | 0.099558498730996 | 0.060550484197667 | 0.115553168771777 |
| ZUHROTUL LAILIYAH | 0.099558498730996 | 0.090825726296501 | 0.069319012308617 |
| FATKHUR ROKHMAN ARDIANSYAH | 0.099558498730996 | 0.090825726296501 | 0.115553168771777 |
| HAULIK MUBAYYINAH | 0.099558498730996 | 0.060550484197667 | 0.092425349742157 |

Fig. 10 MOORA Normalization Matrix Display

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

Weighted Normalization Matrix

| | Card ownership | Total earnings | Total siblings |
|---|---|---|---|
| AHMAD FAUZUL MUTTAQIN | 0.072380247806069 | 0.104737304779222 | 0.005097124497379 |
| AMELIA HAFIZHA | 0.180456061953317 | 0.031423191433466 | 0.010319424899476 |
| CINDY QURROTUL AYUN | 0.036090123903034 | 0.042894921811788 | 0.025489632486899 |
| FARIQ FADLI | 0.072380247806069 | 0.104737304779222 | 0.012742811243445 |
| ISNAINI AMINATUZ ZAHRA | 0.054135185854552 | 0.104737304779222 | 0.005097124497379 |
| MEDIYA NUR APITA | 0.180456061953317 | 0.031423191433466 | 0.012742811243445 |
| NADYA PUJI LESTARI | 0.054135185854552 | 0.020947460956644 | 0.012742811243445 |
| ZUHROTUL LAILIYAH | 0.054135185854552 | 0.031423191433466 | 0.007645686746606 |
| FATKHUR ROHMAN ARDIANSYAH | 0.054135185854552 | 0.031423191433466 | 0.012742811243445 |
| HAULIK MUBAYYINAH | 0.054135185854552 | 0.020947460956644 | 0.010319424899476 |
| KHOTWATIN HASANAH | 0.054135185854552 | 0.031423191433466 | 0.012742811243445 |

Fig. 11 Weighted Normalization Matrix Display

Optimization Value

| | Optimization Results | Ranking |
|---|---|---|
| AHMAD FAUZUL MUTTAQIN | 0.10232902825024 | 62 |
| AMELIA HAFIZHA | 0.049596097965832 | 83 |
| CINDY QURROTUL AYUN | 0.12176314530366 | 3 |
| FARIQ FADLI | 0.097680946001226 | 80 |
| ISNAINI AMINATUZ ZAHRA | 0.10602553695134 | 47 |
| MEDIYA NUR APITA | 0.11806663660256 | 12 |
| NADYA PUJI LESTARI | 0.10041762524239 | 74 |
| ZUHROTUL LAILIYAH | 0.11552405093044 | 15 |
| FATKHUR ROHMAN ARDIANSYAH | 0.10602553695134 | 50 |

Fig. 12 Preference Value Display

The final stage is to sort 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 Results

| No | No. Reg | Student Name | Class | Entry Year | Grade |
|---|---|---|---|---|---|
| 1 | 1190323 | ALIF SYAHRIANI | IPS 2 | 2019 | 0.122674548311S |
| 2 | 1190265 | MCHUSNI TAMMI | IPS 1 | 2019 | 0.123043356564723 |
| 3 | 1190007 | CINDY QURROTUL AYUN | BAHASA | 2019 | 0.121763145303666 |
| 4 | 1190271 | MUTIA ADELIA | IPS 1 | 2019 | 0.121763145303666 |
| 5 | 1190149 | AHSANATUL FAROHOH | IPA 4 | 2019 | 0.119372069983154 |
| 6 | 1190113 | DENY ANSHORI | IPA 3 | 2019 | 0.119372069983154 |
| 7 | 1190328 | ARGA PUTRA BHASWARA | IPS 2 | 2019 | 0.118970674677434 |
| 8 | 1190261 | HANNYATUL AZKA | IPS 1 | 2019 | 0.118182933917I5 |

Fig. 13 Student Ranking Display

*E. Accuracy Testing*

From the data obtained using direct research at SVHS 5 Surakarta, there are 3 recapitulation data on the results of receiving SIP assistance, namely data for 2021, 2022 and 2023. In 2021 there were 73 students who received SIP assistance from the 86 students who registered, in 2022 there were 68 out of 79 students applied and in 2023 there will be 49 out of 54 students. From the calculations of the system developed, 70 students received aid in 2021, there is a difference of 3 received which does not match the facts. For 2022, 66 students were produced, 2 students were accepted without the facts. For 2023, 46 students were produced, 3 were not accepted according to facts. Accuracy values for each calculated value were obtained using a confusion matrix which can be presented in Table XI.

TABLE XI
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 the values in Table XI, 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:

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

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

## IV. CONCLUSION

The DSS developed in this research uses the AHP and MOORA methods. The system was developed

on a web basis that is responsive so that it can appear well when called from a smartphone. The criteria used include ownership of a card or letter, Parental income and lot of siblings. In each criterion there are sub-criteria that have values to be processed in the AHP method. Sub-criteria for card or letter ownership include a SIP card, a prosperous family card or the family hope program, a certificate of indigence and not having a letter. Other sub-criteria are as presented in table 1. The weight of the AHP calculation results is used as a reference in MOORA calculations and produces recommendations for the order of students who are entitled to receive SIP assistance. To test the system being developed, a comparison was made between the results of system calculations using existing facts at SVHS 5 Surakarta in 2021, 2022 and 2023. From the accuracy test with revenue data from 2021 to 2023, the accuracy level was above 93.3%, so it can be concluded that the results calculations using the AHP and MOORA methods are accurate. The system being developed currently still enters student data manually, for further development it would be better if the system could upload student data simultaneously and directly so that there is no need to enter grades one by one. For further research, you can use one or two other methods so that you can compare the accuracy results obtained in this research.

## ACKNOWLEDGMENT

We would like to thank Bina Sarana Informatika University especially the LPPM team, Dharma AUB University, and Bhakti Mulia Indonesia Health Polytechnic for support in this research.

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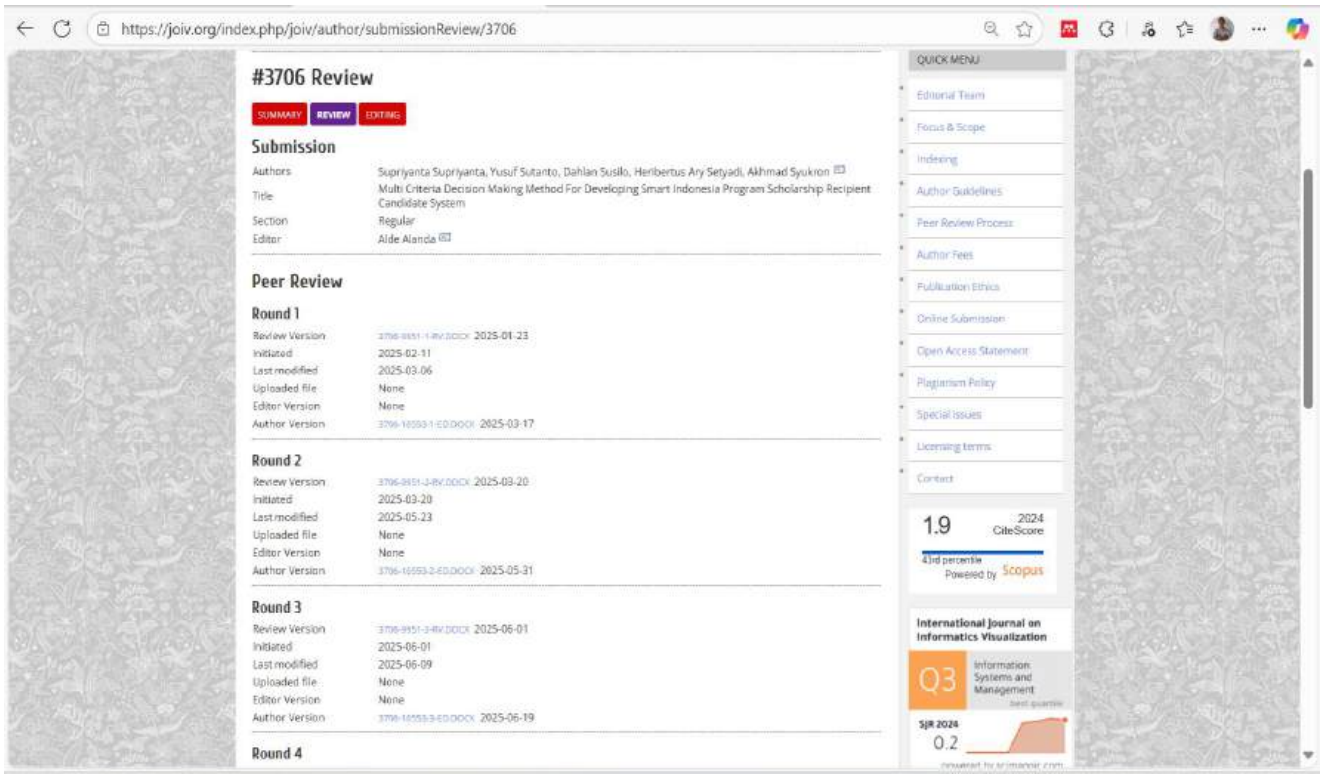


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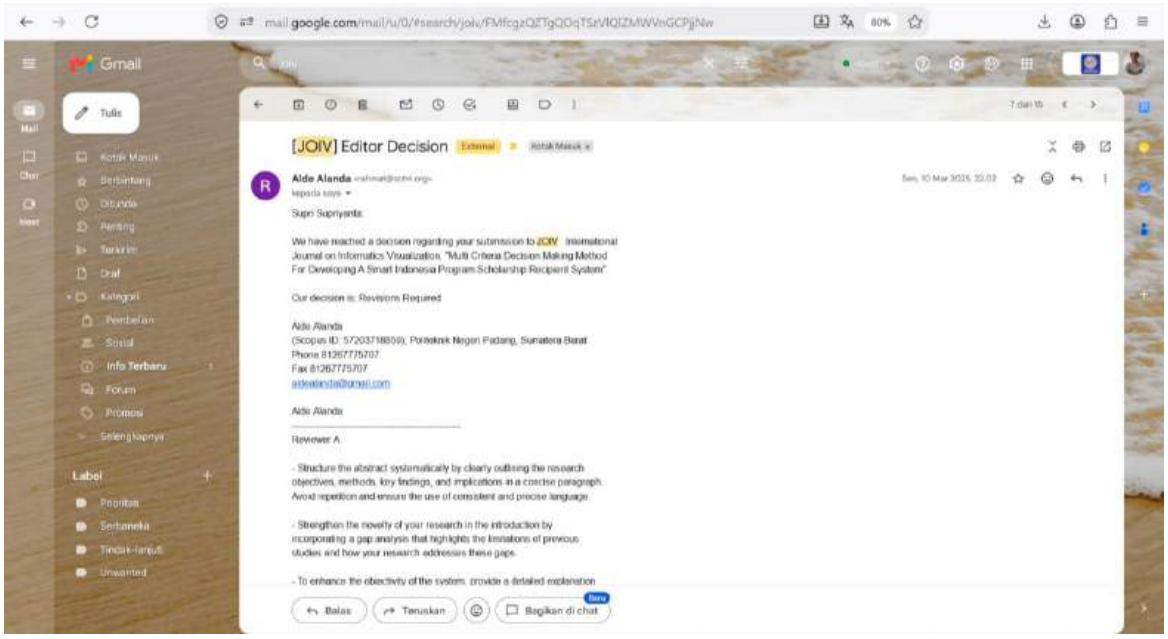


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aldealanda@gmail.com

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- Structure the abstract systematically by clearly outlining the research objectives, methods, key findings, and implications in a concise paragraph. Avoid repetition and ensure the use of consistent and precise language.

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- To enhance the objectivity of the system, provide a detailed explanation of the formulas, validity and reliability testing procedures, as well as statistical analyses (e.g., sensitivity or robustness tests).

- Expand the discussion by comparing your research findings with previous studies, emphasizing both the strengths and limitations of the developed system.

- Ensure that all tables and figures are comprehensively explained within the text.

- Reinforce the conclusion by clearly stating the main contributions, research implications, and existing limitations.

- Explain the practical implications of this study in the context of technological development and educational policy, as well as its contributions to the scientific literature.

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1. The abstract should consist of objectives, materials, methods, results, and implications for further research. However, the current abstract does not clearly present the implications for further research. Please revise the abstract according to the template.
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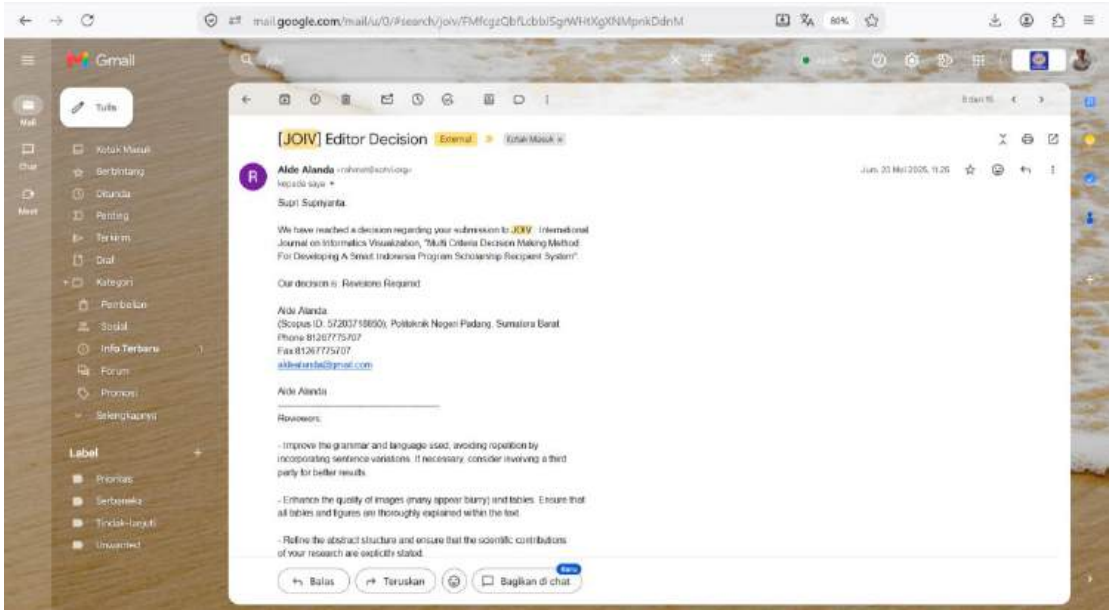


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- Improve the grammar and language used, avoiding repetition by incorporating sentence variations. If necessary, consider involving a third party for better results.

- Enhance the quality of images (many appear blurry) and tables. Ensure that all tables and figures are thoroughly explained within the text.

- Refine the abstract structure and ensure that the scientific contributions of your research

are explicitly stated.

- The background section is too general. Consider adding a research gap analysis to differentiate your study from previous research. Strengthen your arguments with the latest literature on Decision Support Systems (DSS) in the field of education.

- Justify the selection of criteria. Utilize pseudocode or tables to facilitate understanding.

- Compare the advantages of the AHP-MOORA method with other approaches (e.g., TOPSIS, VIKOR).

- The results are presented without in-depth analysis (for example, why did accuracy decrease in 2023?).

- There is no discussion regarding limitations (e.g., data bias or generalizability issues).

- The conclusion is too generic and does not directly address the research objectives. Include recommendations for future research.

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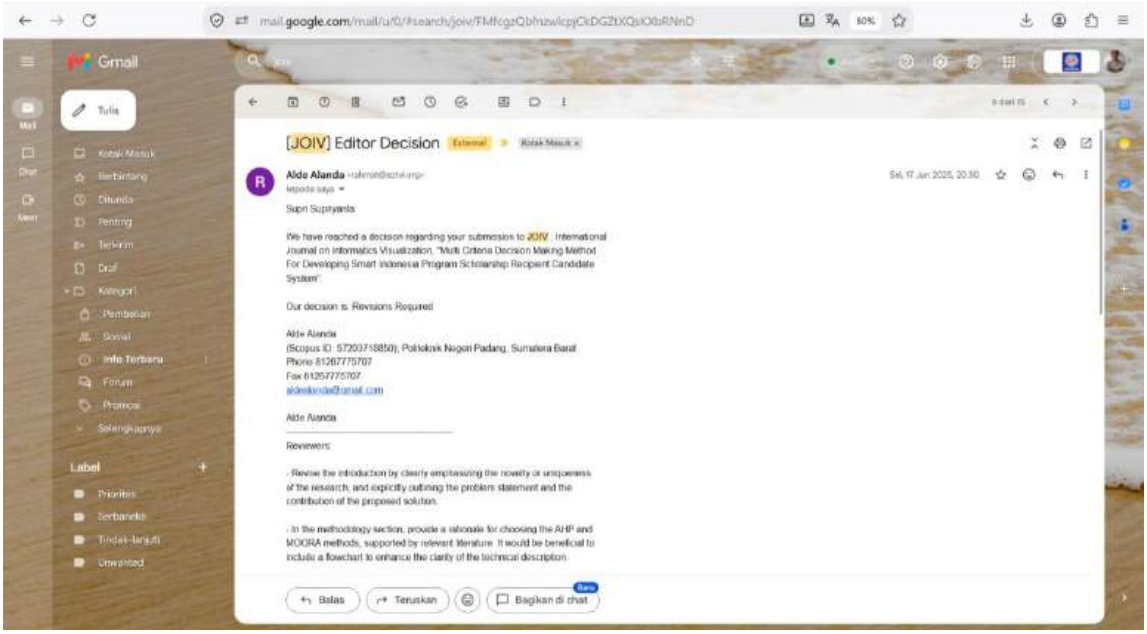


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Reviewers:

- Revise the introduction by clearly emphasizing the novelty or uniqueness of the research, and explicitly outlining the problem statement and the contribution of the proposed solution.

- In the methodology section, provide a rationale for choosing the AHP and MOORA methods, supported by relevant literature. It would be beneficial to include a flowchart to enhance the clarity of the technical description.

- Include a more in-depth discussion on why the AHP-MOORA approach yields accurate results; this can be further supported by comparisons with alternative methods.

- Discuss the system's limitations, such as manual input processes, potential data bias, and propose directions for future development.

- In the conclusion, elaborate on the implications for educational policy or future development of Decision Support Systems (DSS). Additionally, provide suggestions for future research directions.

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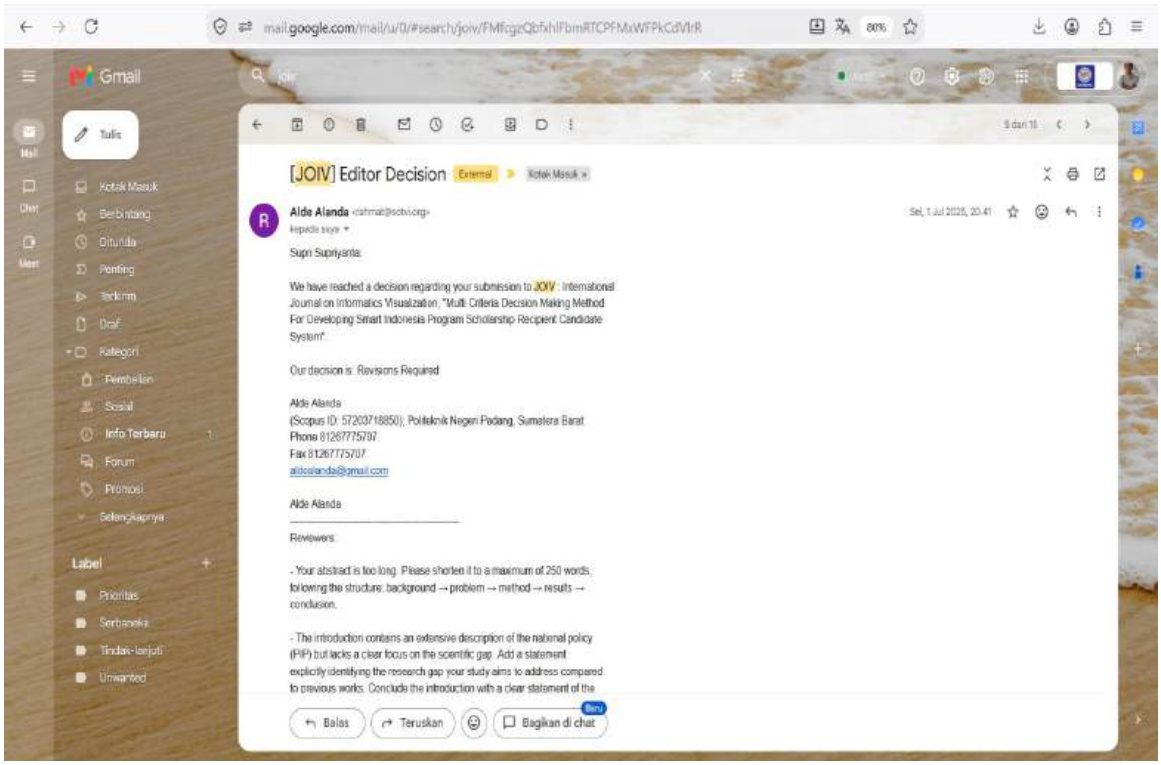


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Phone 81267775707
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aldealanda@gmail.com

Alde Alanda
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Reviewers:

- Your abstract is too long. Please shorten it to a maximum of 250 words, following the structure: background → problem → method → results → conclusion.

- The introduction contains an extensive description of the national policy (PIP) but lacks a

clear focus on the scientific gap. Add a statement explicitly identifying the research gap your study aims to address compared to previous works. Conclude the introduction with a clear statement of the main research objective.

- In the methodology section, explain why AHP and MOORA were selected over other possible methods.

- A large portion of the Results and Discussion section consists of calculation steps without sufficient analytical interpretation. Provide a more in-depth discussion of the accuracy results, and consider including a discussion of potential data bias and methodological limitations.

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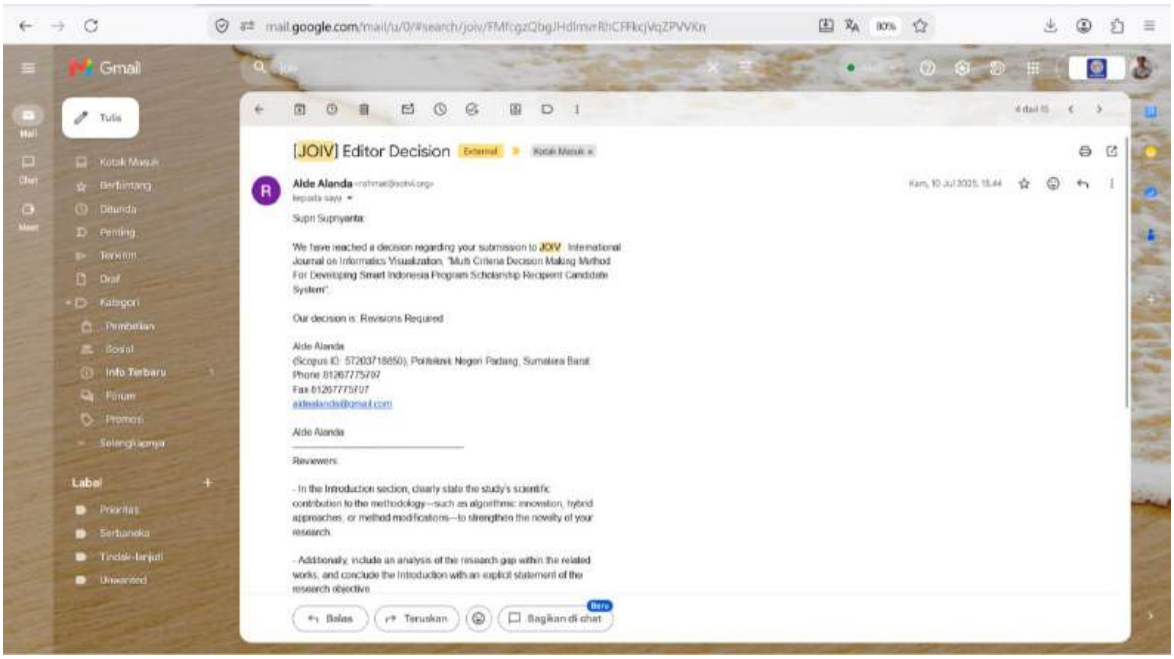


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2025-07-10 08:44 AM

Subject: [JOIV] Editor Decision

Supri Supriyanta:

We have reached a decision regarding your submission to JOIV : International Journal on Informatics Visualization, "Multi Criteria Decision Making Method For Developing Smart Indonesia Program Scholarship Recipient Candidate System".

Our decision is: Revisions Required

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Alde Alanda
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Reviewers:

- In the Introduction section, clearly state the study's scientific contribution to the methodology—such as algorithmic innovation, hybrid approaches, or method modifications—to strengthen the novelty of your research.

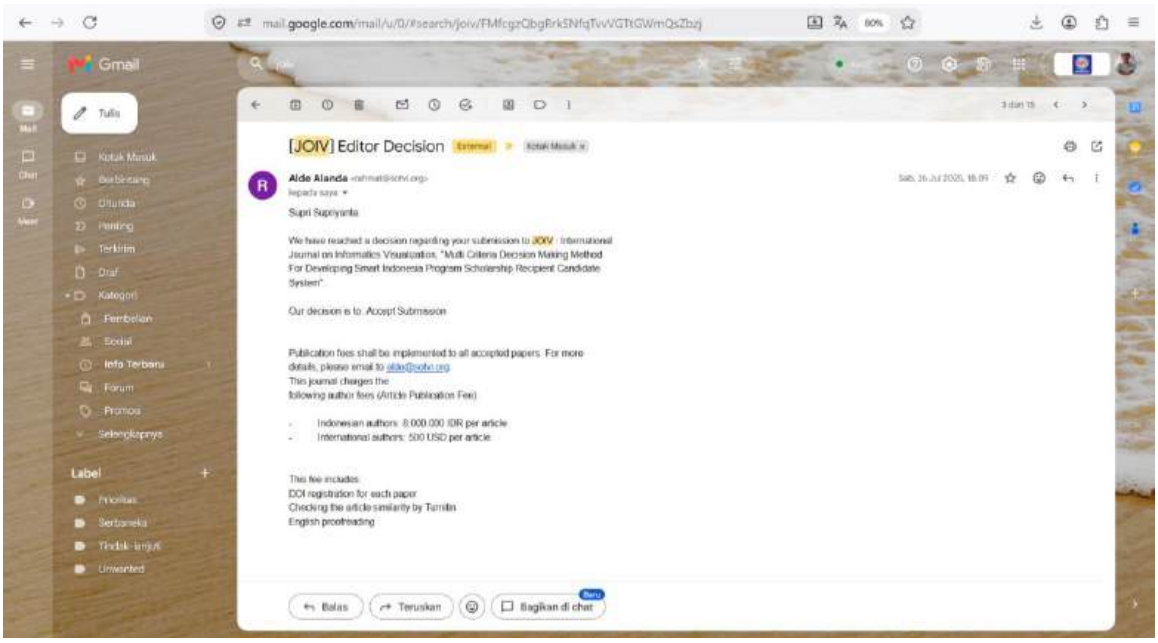
- Additionally, include an analysis of the research gap within the related works, and conclude the Introduction with an explicit statement of the research objective.

- In the Discussion section, address questions such as: “Why was the accuracy higher in 2022?” and “What factors contributed to the decrease in precision in 2021?” Add a comparative analysis of the AHP-MOORA accuracy with alternative methods such as SAW or Decision Tree.

- In the Conclusion section, include a clear statement of the study’s scientific contributions, its limitations, and suggested directions for future research.

To facilitate the review process, it is recommended that you highlight all revised sections in the manuscript.

## Bukti 6 artikel di terima (Accept Submission)

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2025-07-26 11:09 AM

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Artikel setelah di review pertama

# Multi Criteria Decision Making Method For Developing A Smart Indonesia Program Scholarship Recipient System

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***Abstract*— The Indonesian government continues to strive to improve the quality of education through various assistance or scholarship programs, one of which is the Smart Indonesia Program (SIP). The increasing number of students registering for SIP and the selection process still using conventional methods is a situation that reduces the performance of the SIP student selection team. Without adequate IT support, the selection process for prospective SIP scholarship recipients can be very difficult, not objective and not fair. State Vocational High School (SVHS) 5 Surakarta was used as a case study object in this research to determine selection process and data collection from previous year. The purpose of this study is to produce a Decision Support System (DSS) to assist in determining students who are recommended to receive SIP scholarships. The methods used are Analytical Hierarchy Process (AHP) and Multi-Objective Optimization by Ratio Analysis (MOORA). The criteria used in this DSS are: card or letter ownership status, total parental income, total income and total siblings. Each criterion is described into several sub-criteria and has a value that is used in the AHP method process. After accuracy testing by comparing the data from 2021 to 2023. In 2021 the accuracy was 92.9%, while in 2022 it was 94.7% and the accuracy in 2023 was 92.3%. From the system accuracy test results, it can be concluded that using the AHP and MOORA methods can be used to generate recommendations for students who are entitled to SIP scholarships.**

***Keywords*— Decision Support System; Recommendation; Smart Indonesia Program; AHP; MOORA.**

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## I. INTRODUCTION

Elementary and secondary education is an important thing in determining future life. However. Financial problems often force parents to stop continuing their children's education. Every country will of course pay attention to the development of the education sector, because good education is needed to create and improve a smart and skilled workforce [1]. The education provided today will determine the development of a nation in the future. Education plays an important role in creating a qualified, competitive and competent workforce. Faced with this problem, the Ministry of Education and Culture of the Republic of Indonesia issued the SIP [2]. SIP is a government program that aims to provide financial assistance or relief to students aged 6 to 21 years. 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 strive 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 can be very difficult, not objective and without equality [5]. SIC (Smart Indonesian Card) is a form of cash assistance program for school-age children from underprivileged, vulnerable families and Prosperous Family Card holders [6]. The aim of SIC is to help access education for students who have quality and from underprivileged parental backgrounds, prevent and reduce children dropping out of school and to meet educational needs. Disadvantaged students are expected to be able to use this program to meet school needs [7].

State Vocational High School 5 (SVHS 5) Surakarta city has a vision of producing graduates who have strong character, ready to work and become entrepreneurs based on

environmentally friendly technology. In 2005, SVHS 5 Surakarta was the first vocational school to successfully obtain an ISO 9001-2000 certificate and was also selected to be the guiding school for all vocational schools and high schools in the Central Java region. Finally, in 2017, SVHS 5 Surakarta achieved and implemented the ISO 9001-2015 certificate. As a state school, screening of SIP recipient students is carried out every year in all schools in Indonesia. The process of selecting students who receive SIP is a fairly complicated process to carry out without adequate information system support [8]. These working conditions and systems are still applied at SVHS 5 Surakarta, which is the object of the case study in this research. The SIP selection committee at SVHS 5 Surakarta faces great responsibilities and challenges in selecting students who really have the right and need SIP assistance. The large number of SIP registrants, and data processing with piles of files and calculations which are still carried out only using standard applications, is one of the factors that influences the performance of the selection team. The selection team must sorting, searching and verification lots of student data. The assessment and selection process so far still requires a long process and must have high accuracy so that it is susceptible to abuse of authority or data manipulation and is also prone to errors caused by negligence in data input. Mistakes in the selection results can cause students who deserve and need a SIP scholarship to lose their rights.

In an era that is all about information technology, methods contained in DSS are really needed, ranging from simple methods to complex methods. DSS is an information system intended to be used semi structuredly in decision making [9]. DSS is essentially an evolution of a computerized management information system or known as a Decision Support System (DDS), 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 certain technology or systems. DSS can be implemented in various fields to find solutions to various problems [11]. In this research, DSS was created using the AHP and MOORA method. AHP can organize information using a number of alternatives and produce objective values for each criterion [12]. The value resulting from the AHP calculation shows the criteria that have the highest priority and influences the resolution of existing problems [13]. The AHP method has the advantage of creating a pairwise comparison matrix to determine the weight of each criterion and calculate the consistency value [14]. The Moora method is a multi-objective optimization technique that can be used to solve various types of complex decision-making problems in decision making [15]. The Moora method sorts (ranks) each attribute based on specified criteria and can create alternatives based on the specified criteria [16]. The Moora method performs simple calculations of minimum and maximum values. This method determines which alternatives have good selectivity [17]. Processes run simultaneously Produce two or more optimal levels It is inconsistent and has some errors of Moora's approach [18]. The AHP method used in this research aims to calculate the weight of each criterion that has been determined before entering to determining alternative rankings process. AHP can describe complex multi-factor or multi-criteria problems into a hierarchy [19]. Meanwhile, the purpose of choosing MOORA method is to determine student rankings after knowing the each criterion weight produced by the AHP method.

There have been several previous studies related to the theme of determining recipients of SIP assistance with DSS. Previous research by Manuhutu developed a decision support system to determine smart indonesia program recipients assistance using the weighted product method. There are 5 criterias used including: students activeness, incapacity's certificate, Orphans, Parents salary, and Absences. The prototype model was chosen to develop a web based decision support system that uses PHP programming language and Bootstrap as a framework [20]. The journal by Anggrawan's research results also uses the AHP and MOORA methods to provide recommendations for educational scholarship recipients. This research compared the combined use of the AHP and MOORA methods, and only using the MOORA method. There are six attributes use in this research that will be applied in the method used, including: average cumulative grade point average for the last two semesters, total activity value, recommendation letter, active organizationally, semester and completion of requirements. This research results concluded that using a combination of the AHP and Moora methods was more accurate (94.07%) than using only the Moora method (89.62%). DSS was developed using a desktop based programming language with VB.Net so it cannot be accessed via the internet [21]. Research by Asnimar compares the decision tree algorithm with Naive Bayes to classify educational scholarship aid recipients. There are ten attributes used in the research to determine prospective new STMIK AKBA students who are entitled to receive educational scholarships. The ten attributes are include: smart indonesia card ownership, a prosperous family card ownership, a poor card possession, parents salary, total of dependents, parents' job, high school graduation status or equivalent, has passed a maximum of 2 years, certificate value, and average student report score. This research produces a classification using a decision tree algorithm with an accuracy value of 44.12% and F1-Score of 34.48%, while the Naive Bayes algorithm accuracy value is 76.47% which uses data on diploma grades and average report cards. Based on these accuracy results, the Naïve Bayes algorithm is better when used to classify scholarship recipients than the decision tree algorithm [22].

In previous studies, there were also who use the AHP and Moora methods to determine recommendations for students who are eligible to receive scholarships. The scholarship type and six criteria used are not requirements for SIP

assistance. The research results concluded that using a combination of the AHP and Moora methods is more accurate than only using the Moora method. The system was developed using VB.Net programming language which is desktop based so it cannot be accessed using the internet. In the research, which also created a DSS to determine students who are eligible for SIP assistance, the weighted product method was used. SIP assistance focuses on students who are declared poor so that it does not require criteria for percentage of attendance, student status as used in previous studies.

## II. Material And Methods

### A. Data Acquisition

This stage is the phase for collecting the data needed for research to develop DSS. Data used in this research includes primary and secondary data. Primary data is data obtained directly from the agency or institution that is the subject of research, in this case SVHS 5 Surakarta. Data was collected by conducting internal interviews with stakeholders to obtain values from the criteria. Secondary data is a collection of data that is needed as input to build a computational model and functions as test data when carrying out the classification process and obtaining 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 is used to determine the criteria needed and used in alternative assessment. There are 3 criteria used in the developed system, the criteria and values are presented in table 1.

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 |
| Total siblings | < 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 developed is DSS to produce recommendations for recipients of SIP assistance. The DSS developed will be applied to provide recommendations for recipients of SIP assistance at SVHS 5 Surakarta. The block diagram of developed system is presented in Fig. 1.

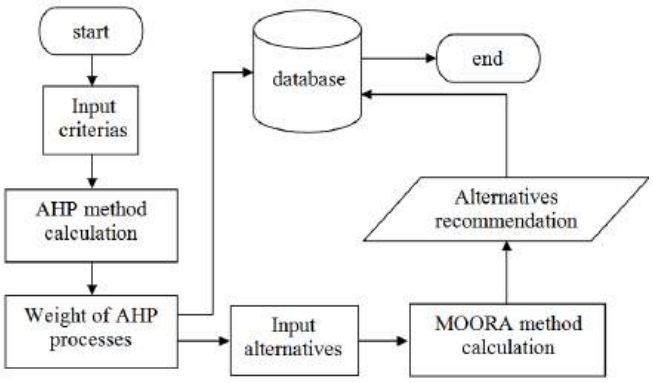


Fig. 1 System architecture

### C. AHP Method Process

AHP is a multiple criteria decision-making framework that has been used extensively for a variety of applications. In solving a problem, AHP method is used by compiling a hierarchy of criteria by drawing considerations from interested parties to develop weights [23]. AHP is an approach used to handle complex systems which is also related to determining decisions from options considered from several alternatives [24]. The process of calculating and creating a matrix for the AHP method is presented in the form of a flowchart which is presented in Fig. 2.

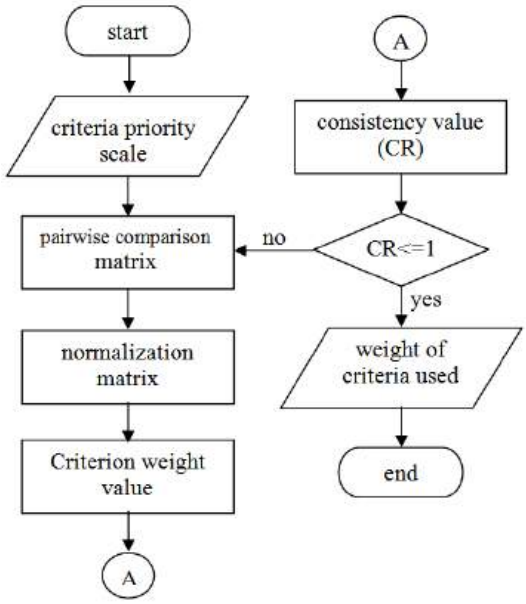


Fig. 2 AHP method process flowchart [27]

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

7) Defining the problem and determining the desired solution.
8) Create a hierarchical structure that begins with a general objective, followed by criteria, sub-criteria and alternative options that are ordered.
9) Determine each criteria 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 [25].

10) Value of each column is divided by 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 ith weight goal of weight vector.

11) 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 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 of values in each row, results of this calculation produce a consistency matrix.

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 is to be inconsistent and must be corrected, if the result is less than or equal to 0.01 then the value is consistent or correct [26].

### *D. MOORA Method Process*

Brauers and Zavadskas were the first to introduce the MOORA method which 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 [28]. The MOORA method working process is to carry out processes simultaneously to optimize two or more conflicting criteria. 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 [29]. The calculation process flow in generating alternative rankings with MOORA is presented in Fig. 3.

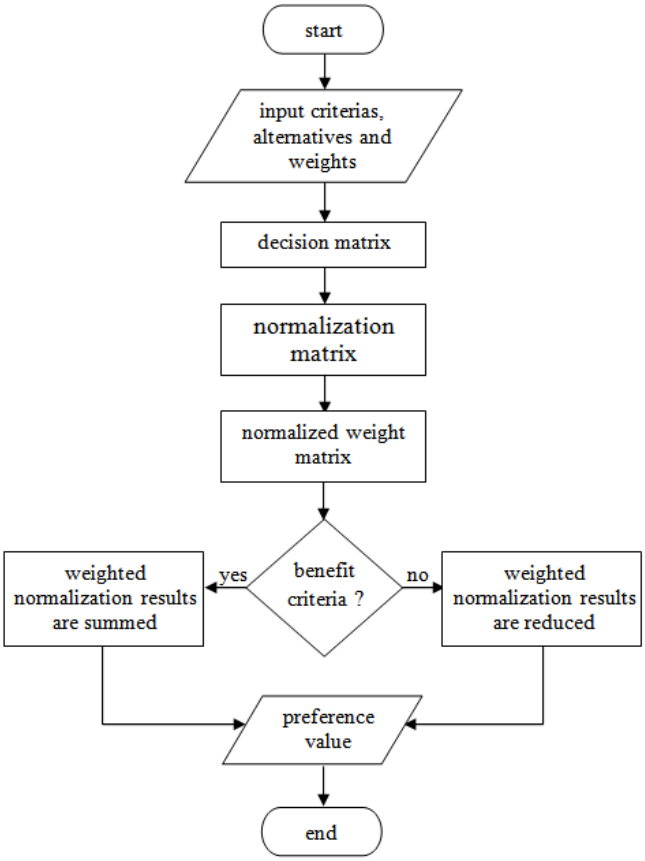


Fig. 3 Alternative Ranking Calculation In MOORA Method [30]

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

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

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

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

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

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

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

8) Determine preference values: Order from the best alternative with the highest yi value to the alternative with the lowest yi value [31]:

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

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. Result 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 Comparision 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: Total sibling

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

(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 on the average or weighted value.

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

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

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

5) Calculate the Consistency Ratio (CR)

After getting the t value, the next stage is finding the CI value.

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

Based on existing provisions, a CR value < 10% or 0.1 is said to be consistent. And if <10% or 0.10 means it is inconsistent, then the repetition is repeated starting from the second step and so on until the data becomes consistent.

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

### 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 consistent AHP.

TABLE V
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 VI) with the assessment results for each existing alternative.

TABLE VI
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 VII.

TABLE VII
NORMALIZATIOON 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 AHP method with the normalized matrix.

TABLE VIII
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 adding up all the criteria values (columns) in 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.

6) Sorting Preference Values: Sort the preference values in descending order (from large to small) to obtain priorities or recommendations for alternatives that are entitled to receive SIP assistance. The alternative order of eligible for the SIP scholarship is presented in Table IX.

TABLE IX
ALTERNATIVE RANGKING

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

### *C. Implementation AHP Method Process*

Implementation is the stage for implementing the system according to 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 that will be used and calculations to determine which students are entitled to receive SIP assistance. Student scores in applying for SIP assistance are used as consideration to determine the student's eligibility to receive assistance. The information page for student grades can be seen in Fig. 4.

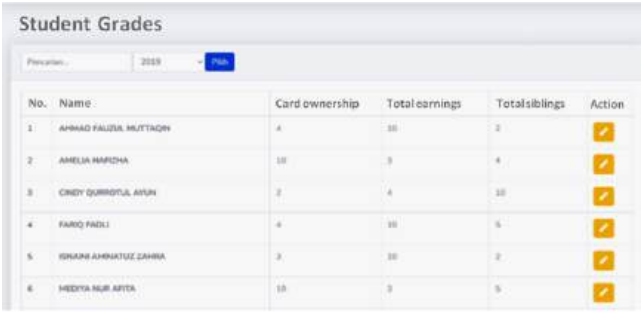


Fig. 4 Student Assessment Page

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

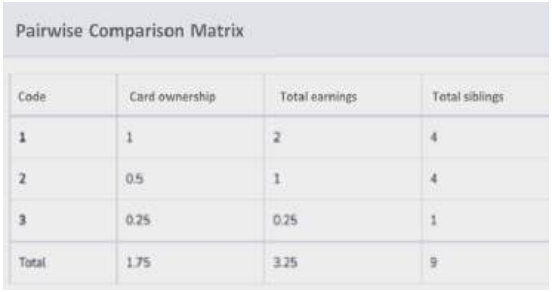


Fig. 5 Paired Comparison Matrix Display

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 earnings | 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 | 0.11 |

Fig. 6 AHP Normalization Matrix Display

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

Consistency Testing

| Code | Card ownership | Total earnings | 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

Calculation of CI and CR values to determine the consistency of the resulting 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 MOORA Method Process*

After calculating the AHP method, the next stage is the MOORA method calculation process to obtain results in the form of a sequence of students who deserve assistance. Alternative values function to input student grades which still consist of 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 into a scale of 1-5. Fig. 10 presents the system display for calculation results in normalization matrix.

MOORA Method

Student Grades

2022 Pilih

| | Card ownership | Total earnings | Total siblings |
|---|---|---|---|
| AHMAD FAUZUL MUTTAQIN | 4 | 10 | 2 |
| AMELIA HAFIZHA | 10 | 3 | 4 |
| CINDY QURROTUL AYUN | 2 | 4 | 10 |
| FARIQ FADLI | 4 | 10 | 5 |
| ISNAINI AMINATUZ ZAHRA | 3 | 10 | 2 |
| MEDIYA NUR AFITA | 10 | 3 | 5 |
| NADYA PUJI LESTARI | 3 | 2 | 5 |
| ZUHROTUL LAILIYAH | 3 | 3 | 3 |

Fig. 9 Student Grade Conversion Display

Matrix Normalization

| | Card ownership | Total earnings | Total siblings |
|---|---|---|---|
| WEIGHT | 0.543752543752543 | 0.34499034499035 | 0.11029711029731 |
| AHMAD FAUZUL MUTTAQIN | 0.33374466231999 | 0.30275242098834 | 0.04621267487107 |
| AMELIA HAFIZHA | 0.33198105570999 | 0.09082572629650 | 0.09242533974215 |
| CINDY QURROTUL AYUN | 0.06637231135999 | 0.12110096839533 | 0.23106633743955 |
| FARIQ FADLI | 0.13274466231999 | 0.30275242098834 | 0.11055316871777 |
| ISNAINI AMINATUZ ZAHRA | 0.09955849673099 | 0.30275242098834 | 0.04621267487107 |
| MEDIYA NUR AFITA | 0.33198105570999 | 0.09082572629650 | 0.11055316871777 |
| NADYA PUJI LESTARI | 0.09955849673099 | 0.06055048419766 | 0.11055316871777 |
| ZUHROTUL LAILIYAH | 0.09955849673099 | 0.09082572629650 | 0.08881901230661 |
| FATKHUR ROHMAN ARDIANSYAH | 0.09955849673099 | 0.09082572629650 | 0.11055316871777 |
| HAULIK MUBAYYINAH | 0.09955849673099 | 0.06055048419766 | 0.09242533974215 |

Fig. 10 MOORA Normalization Matrix Display

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

Weighted Normalization Matrix

| | Card ownership | Total earnings | Total siblings |
|---|---|---|---|
| AHMAD FAUZUL MUTTAQIN | 0.07218024780069 | 0.10473730477822 | 0.00303712449737 |
| AMELIA HAFIZHA | 0.18045061953517 | 0.03142191433466 | 0.01039434899476 |
| CINDY QURROTUL AYUN | 0.03609012390334 | 0.04189492191288 | 0.02548963248899 |
| FARIQ FADLI | 0.07218024780069 | 0.10473730477822 | 0.01274281124345 |
| ISNAINI AMINATUZ ZAHRA | 0.05413518585452 | 0.10473730477822 | 0.00303712449737 |
| MEDIYA NUR AFITA | 0.18045061953517 | 0.03142191433466 | 0.01274281124345 |
| NADYA PUJI LESTARI | 0.05413518585452 | 0.02094746095644 | 0.01274281124345 |
| ZUHROTUL LAILIYAH | 0.05413518585452 | 0.03142191433466 | 0.00764588674609 |
| FATKHUR ROHMAN ARDIANSYAH | 0.05413518585452 | 0.03142191433466 | 0.01274281124345 |
| HAULIK MUBAYYINAH | 0.05413518585452 | 0.02094746095644 | 0.01039434899476 |
| KHOTWATIN HASANAH | 0.05413518585452 | 0.03142191433466 | 0.01274281124345 |

Fig. 11 Weighted Normalization Matrix Display

After carrying out the weighted normalization process, the next stage is to find the preference or optimization value. The optimization value results of the system process can be seen in Figure 12.


Fig. 12 Preference Value Display

The final stage is to sort 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.


Fig. 13 Student Ranking Display

### *E. Accuracy Testing*

From the data obtained using direct research at SVHS 5 Surakarta, there are 3 recapitulation data on the results of receiving SIP assistance, namely data for 2021, 2022 and 2023. In 2021 there were 73 students who received SIP assistance from the 86 students who registered, in 2022 there were 68 out of 79 students applied and in 2023 there will be 49 out of 54 students. From the calculations of the system developed, 70 students received aid in 2021, there is a difference of 3 received which does not match the facts. For 2022, 66 students were produced, 2 students were accepted without the facts. For 2023, 46 students were produced, 3 were not accepted according to facts. Accuracy values for each calculated value were obtained using a confusion matrix which can be presented in Table XI.

TABLE XI
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 the values in Table XI, 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:

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

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

## IV. CONCLUSION

The DSS developed in this research uses the AHP and MOORA methods. The system was developed on a web basis that is responsive so that it can appear well when called from a smartphone. The criteria used include ownership of a card or letter, Parental income and lot of siblings. In each criterion there are sub-criteria that have values to be processed in the AHP method. Sub-criteria for card or letter ownership include a SIP card, a prosperous family card or the family hope program, a certificate of indigence and not having a letter. Other sub-criteria are as presented in table 1. The weight of the AHP calculation results is used as a reference in MOORA calculations and produces recommendations for the order of students who are entitled to receive SIP assistance. To test the system being developed, a comparison was made between the results of system calculations using existing facts at SVHS 5 Surakarta in 2021, 2022 and 2023. From the accuracy test with revenue data from 2021 to 2023, the accuracy level was above 93.3%, so it can be concluded that the results calculations using the AHP and MOORA methods are accurate. The system being developed currently still enters student data manually, for further development it would be better if the system could upload student data simultaneously and directly so that there is no need to enter grades one by one. For further research, you can use one or two other methods so that you can compare the accuracy results obtained in this research.

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**Artikel setelah di review kedua**

# 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 to improve its education quality with the provision of scholarship programs, one of which is the Smart Indonesia Program (SIP). Despite the increasing number of students who show their interest in registration for SIP, yet the selection process still adopts a conventional method, a situation that undermines SIP selection team performance. Without adequate IT support, selection process for SIP scholarship candidates will be difficult, less objective and rather unfair. State Vocational High School (SVHS) 5 Surakarta was selected as a case study object for this research to establish the selection process and data collection from previous years. The research aims to produce a Decision Support System (DSS) to assist in nominating students who are deemed eligible for recommendation as the recipients of SIP scholarships. 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, total income of the household and number of siblings. Each of which is further broken down into several sub-criteria and has a value that will be used in AHP method process. Upon accuracy test by comparing data from 2021 to 2023, it is found that the accuracy test in 2021 was 92.9%, while in 2022 it reached 94.7% and the accuracy in 2023 recorded 92.3%. From the results of such system accuracy test, it can be concluded that AHP and MOORA methods can be used to produce recommendations for students who are entitled to receive SIP scholarships in objective manner based on the inputted criteria.**

***Keywords*— Decision Making; Recommendation; Smart Indonesia Program; AHP; MOORA.**

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## I. INTRODUCTION

Elementary and secondary education is an important thing in determining future life. However, due to financial obstacles, some parents have to stop the education of their children. Every country need to pay attention to the development of education sector, because good education is pivotal to create and improve a smart and skilled workforce [1]. The present education will determine the development of a nation in future. Education plays an important 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 aims to provide financial assistance or relief to students aged 6 to 21 years old. 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]. Indonesian government continuously strive 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 Smart Indonesia Program (SIP) [4]. Without adequate IT support, the process of selecting prospective SIP recipient students may be very difficult, not objective and lack of 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]. The aim of SIC is to help education access for students who, in spite of having quality, have underprivileged parental backgrounds, as well as to prevent and reduce the dropouts and to 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) Surakarta city has a vision of producing graduates with strong characters, employable skills and entrepreneurial spirit based on environmentally friendly technology. In 2005, SVHS 5 Surakarta was the first vocational school to successfully obtain an ISO 9001-2000 certificate and was also selected to be the guiding model school for all vocational schools and high schools in Central Java region. SVHS 5 Surakarta managed to achieve and implement ISO 9001-2015 certificate in 2017. The screening process for SIP recipients is carried out every year to the students of state schools across Indonesia. The process of selecting students who receive SIP is a fairly complicated process to carry out without adequate information system support [8]. This condition and system is also found at SVHS 5 Surakarta, which is selected as the object of case study in this research. SIP selection committee at SVHS 5 Surakarta faces great responsibilities and challenges in selecting students who are really entitled for and need SIP assistance. The use of standard applications to process and calculate the large numbers of SIP registrants as well as data consisting of piles of files becomes a factor that undermines the performance of selection team. The assessment and selection process takes a long process, meanwhile they must maintain high accuracy. This makes the process become susceptible to abuse of authority or data manipulation and prone to errors in data input. Mistaken results of selection process can cause students who deserve and need SIP scholarship may lose their rights.

In an era where information technology is all about, methods contained in DSS are decisive, ranging from simple methods to the complex ones. DSS is a semi-structurally 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 certain technology or systems [11]. DSS can be implemented in various fields to find solutions to various problems [12]. In this research, DSS was created using the AHP and MOORA method. AHP can organize information using a number of 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 influences the resolution of existing problems [14]. AHP method has advantage of creating a pairwise comparison matrix to determine the weight of each criterion and calculate the consistency value [15]. Moora method is a multi-objective optimization technique that can be used to solve various types of complex decision-making problems [16]. Moora method sorts (ranks) each attribute and alternatives based on specified criteria [17]. Moora method performs simple calculations of minimum and maximum values. This method will determine alternatives with good selectivity [18]. The process runs simultaneously that will produce two or more optimal levels [19]. The results of Moora approach are inconsistent results and contain some errors [20]. AHP method used in this research aims to calculate the weight of each criterion that has been determined before entered to set alternative rankings process. AHP can describe complex multi-factor or multi-criteria problems into a hierarchy [21]. Meanwhile, MOORA method is to establish student rankings when the weight of each criterion produced by AHP method is known.

Some previous studies relating to the selection of SIP assistance beneficiaries with DSS have been made. They include research by Manuhutu that developed a decision support system to select the beneficiaries of Smart Indonesia Program assistance using weighted product method. Here, five criteria are set including: student activeness, certificate of poverty, orphan status, parents' salary, and absenteeism. The prototype model was chosen to develop a web-based decision support system that uses PHP programming language and Bootstrap as a framework [22]. A journal detailing research results by Anggrawan also uses AHP and MOORA methods to provide recommendations for educational scholarship recipients. This research compared

the combined use of AHP and MOORA methods, and 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 organization, and compliance to the requirements. The results concluded that the use of 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 that prevents it from accessing via the internet [23]. Research by Asnimar compares decision tree algorithm to Naive Bayes to classify the recipients of educational scholarship aid. Ten attributes are used in the research to nominate prospective new STMIK AKBA students who are entitled to receive educational scholarships. They include: smart Indonesia card ownership, a graduate for a maximum of 2 years, report card, and student's average report card. This research produces a classification using a decision tree algorithm with an accuracy value of 44.12% and F1-Score of 34.48%, while Naïve Bayes algorithm accuracy value is 76.47% obtained based on data of diploma grades and average report cards. From these accuracy results, Naïve Bayes algorithm is better when used to classify scholarship recipients than decision tree algorithm [24].

Some previous researh also use AHP and Moora methods to recommend students who are deemed eligible to receive scholarships. Scholarship type and six criteria are not the requirements to get SIP assistance. The research concluded that AHP and Moora methods used in combination are more accurate than using Moora method only. The system was developed using VB.Net programming language which is desktop based, thus, it cannot be accessed using the internet. In the research, which also created a DSS to determine students who are eligible for SIP assistance, the weighted product method was used. SIP assistance focuses on students who are declared poor and as such no criteria of percentage of attendance, student status is required as found in previous researh.

## II. Material And Methods

### A. Data Acquisition

This stage is a phase for collecting data needed for research to develop DSS. Data used in this research includes primary and secondary data. Primary data is data obtained directly from the agency or institution that becomes the subject of research, in this case SVHS 5 Surakarta. Data was collected from internal interviews with stakeholders to obtain values of the criteria. Secondary data is a collection of data that is needed as input to build a computational model and functions as test data when carrying out classification process and to obtain output in the form of system prediction results. The collected data is information about students who apply for SIP assistance. Data obtained from the next data collection stage is used to set criteria needed and used in alternative assessment. For the developed system, 3 three criteria have been established, and for criteria and values they are presented in table 1.

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 amoount | < 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 develop is DSS to produce recommendations for the recipients of SIP assistance. This DSS will be applied to recommend recipients eligible for SIP assistance at SVHS 5 Surakarta. Block diagram of the developed system is presented in Fig. 1.

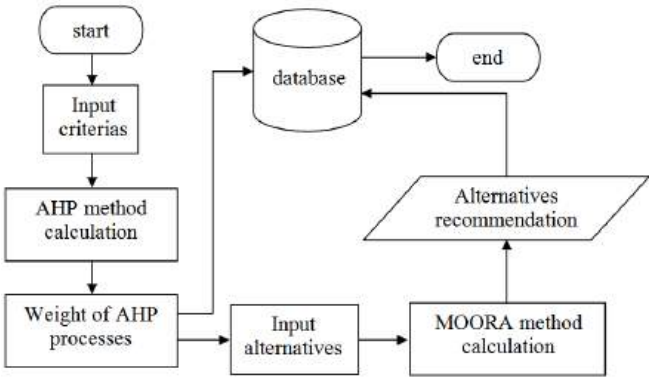


Fig. 1 System architecture

### 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 [25]. AHP is an approach aiming to deal with complex systems and the decisions so taken are based on relevant options considered from previous alternatives [26]. The process of calculating and creating a matrix with AHP method is presented in the form of a flowchart as presented in Fig. 2.

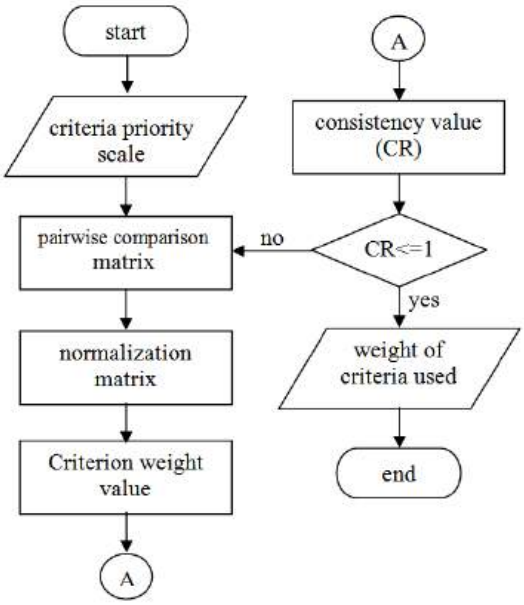


Fig. 2 AHP method process flowchart [27]

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

12) Define problem and determine the desired solution.
13) Create a hierarchical structure initiated with a general objective, followed by criteria, sub-criteria and alternative options that have been set in order.
14) Determine each criteria 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 [28].
15) Value of each column is divided by 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 weight vector.

16) 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 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 inconsistent and must be corrected, if the result is less than or equal to 0.01 then the value is consistent or correct [29].

*D. MOORA Method Process*

MOORA method which was first introduced by Brauers and Zavadskas 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 [30]. MOORA method working process is to run processes simultaneously to optimize two or more conflicting criteria. MOORA method is flexible and easy to understand and separates the subjective part of evaluation process into decision weight criteria with several decision making attributes [31]. The calculation process flow in generating alternative rankings with MOORA is presented in Fig. 3.

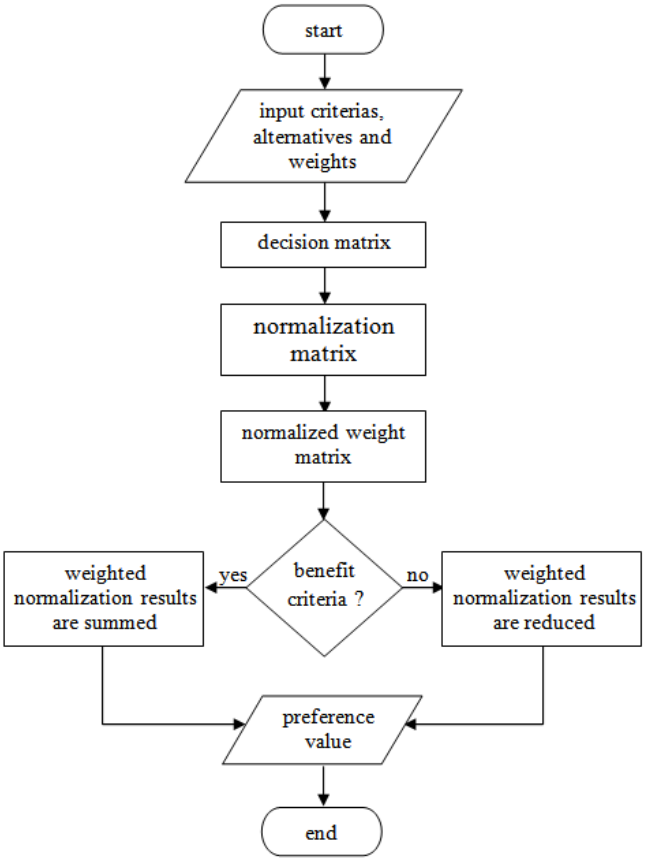


Fig. 3 Alternative Ranking Calculation In MOORA Method [32]

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

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

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

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

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

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

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

12) Determine preference values: Order from the best alternative with the highest yi value to the alternative with the lowest yi value [33]:

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

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. Result 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 Comparision 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 explained that a value of 3 in row C-1 and column C-2 comparison means that total earnings are slightly more important than card/letter ownership. In row C-1 column C-3 the comparison value is 5, meaning that sibling amount is more important than Card/letter ownership. Likewise, a value of 3 in row C-2 column C-3 means that sibling amount is slightly more important than 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 criteria:
(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 on the average or weighted value.

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

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

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

5) Calculate the Consistency Ratio (CR)

After getting the t value, the next stage is finding the CI value.

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

Based on existing provisions, a CR value < 10% or 0.1 is said to be consistent. And if <10% or 0.10 means it is inconsistent, then the repetition is repeated starting from

the second step and so on until the data becomes consistent.

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

*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 consistent AHP.

TABLE V
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 VI) with the assessment results for each existing alternative.

TABLE VI
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 VII.

TABLE VII
NORMALIZATIOON 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 AHP method with the normalized matrix.

TABLE VIII

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 adding up all the criteria values (columns) in 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.

6) Sorting Preference Values: Sort the preference values in descending order (from large to small) to obtain priorities or recommendations for alternatives that are entitled to receive SIP assistance. The alternative order of eligible for the SIP scholarship is presented in Table IX.

TABLE IX
ALTERNATIVE RANGKING

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

*C. Implementation AHP Method Process*

Implementation is the stage for implementing the system according to 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 that will be used and calculations to determine which students are entitled to receive SIP assistance. Student scores in applying for SIP assistance are used as consideration to determine the student's eligibility to receive assistance. The information page for student grades can be seen in Fig. 4.


Fig. 4 Student Assessment Page

The initial stage in the AHP method is determining the pairwise comparison matrix. In the developed system, a pairwise comparison 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 MOORA Method Process*

After calculating the AHP method, the next stage is the MOORA method calculation process to obtain results in the form of a sequence of students who deserve assistance. Alternative values function to input student grades which still consist of 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 into a scale of 1-5. Fig. 10 presents the system display for calculation results in 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, next stage is weighted normalization stage. The calculation process is to multiply the normalization results with criteria weights that have been obtained from previous stages of 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 | 0.007645867460697 |
| 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 carrying out the weighted normalization process, the next stage is to find the preference or optimization value. The optimization value results of the system process can be seen 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 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 using direct research at SVHS 5 Surakarta, there are 3 recapitulation data on the results detailing the number of students receiving SIP assistance, namely data for 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 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 studiers failed because of unmatched facts. For 2022, 66 students were produced, 2 students were accepted without facts verification. For 2023, 46 students were produced, 3 students fail to meet fact verification. The accuracy of each value calculated from a confusion matrix is presented in Table XI.

TABLE XI
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 XI, 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:

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

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

## IV. CONCLUSION

The DSS developed in this research uses AHP and MOORA methods. The system was developed on a web basis and responsive that makes it can appear from a call of a smartphone. 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 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 recommendation letter whether having such letter or not. Other sub-criteria are as presented in table 1. The weight value obtained from AHP calculation results is used as a reference in MOORA calculations and produces recommendations for the order of students who are entitled to receive SIP assistance. To test the system being developed, a comparison was made between the results of system calculations using existing facts at SVHS 5 Surakarta in 2021, 2022 and 2023. From the accuracy test with total income data from 2021 to 2023, the accuracy level was above 93.3%, so it can be concluded that the results of calculations using AHP and MOORA methods are accurate. Under the system currently developed, data of students is entered manually. For further development it would be better if the system has ability to upload student data simultaneously and directly and no data entry in one-by-one manner will be necessary. For further research, you can use one or two other methods from which the accuracy results shown in this research can be compared.

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**Artikel setelah di review ketiga**

# 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 to improve its education quality with the provision of scholarship programs, one of which is the Smart Indonesia Program (SIP). Despite the increasing number of students who show their interest in registration for SIP, yet the selection process still adopts a conventional method, a situation that undermines SIP selection team performance. Without adequate IT support, selection process for SIP scholarship candidates will be difficult, less objective and rather unfair. State Vocational High School (SVHS) 5 Surakarta was selected as a case study object for this research to establish the selection process and data collection from previous years. The research aims to produce a Decision Support System (DSS) to assist in nominating students who are deemed eligible for recommendation as the recipients of SIP scholarships. 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, total income of the household and number of siblings. Each of which is further broken down into several sub-criteria and has a value that will be used in AHP method process. Upon accuracy test by comparing data from 2021 to 2023, it is found that the accuracy test in 2021 was 92.9%, while in 2022 it reached 94.7% and the accuracy in 2023 recorded 92.3%. From the results of such system accuracy test, it can be concluded that AHP and MOORA methods can be used to produce recommendations for students who are entitled to receive SIP scholarships in objective manner based on the inputted criteria.**

***Keywords*— Decision Making; Recommendation; Smart Indonesia Program; AHP; MOORA.**

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## I. INTRODUCTION

Elementary and secondary education is an important thing in determining future life. However, due to financial obstacles, some parents have to stop the education of their children. Every country need to pay attention to the development of education sector, because good education is pivotal to create and improve a smart and skilled workforce [1]. The present education will determine the development of a nation in future. Education plays an important 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 aims to provide financial assistance or relief to students aged 6 to 21 years old. 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]. Indonesian government continuously strive 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 Smart Indonesia Program (SIP) [4]. Without adequate IT support, the process of selecting prospective SIP recipient students may be very difficult, not objective and lack of 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]. The aim of SIC is to help education access for students who, in spite of having quality, have underprivileged parental backgrounds, as well as to prevent and reduce the dropouts and to 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) Surakarta city has a vision of producing graduates with strong characters, employable skills and entrepreneurial spirit based on environmentally friendly technology. In 2005, SVHS 5 Surakarta was the first vocational school to successfully obtain an ISO 9001-2000 certificate and was also selected to be the guiding model school for all vocational schools and high schools in Central Java region. SVHS 5 Surakarta managed to achieve and implement ISO 9001-2015 certificate in 2017. The screening process for SIP recipients is carried out every year to the students of state schools across Indonesia. The process of selecting students who receive SIP is a fairly complicated process to carry out without adequate information system support [8]. This condition and system is also found at SVHS 5 Surakarta, which is selected as the object of case study in this research. SIP selection committee at SVHS 5 Surakarta faces great responsibilities and challenges in selecting students who are really entitled for and need SIP assistance. The use of standard applications to process and calculate the large numbers of SIP registrants as well as data consisting of piles of files becomes a factor that undermines the performance of selection team. The assessment and selection process takes a long process, meanwhile they must maintain high accuracy. This makes the process become susceptible to abuse of authority or data manipulation and prone to errors in data input. Mistaken results of selection process can cause students who deserve and need SIP scholarship may lose their rights.

In an era where information technology is all about, methods contained in DSS are decisive, ranging from simple methods to the complex ones. DSS is a semi-structurally 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 certain technology or systems [11]. DSS can be implemented in various fields to find solutions to various problems [12]. In this research, DSS was created using the AHP and MOORA method. AHP can organize information using a number of 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 influences the resolution of existing problems [14]. AHP method has advantage of creating a pairwise comparison matrix to determine the weight of each criterion and calculate the consistency value [15]. Moora method is a multi-objective optimization technique that can be used to solve various types of complex decision-making problems [16]. Moora method sorts (ranks) each attribute and alternatives based on specified criteria [17]. Moora method performs simple calculations of minimum and maximum values. This method will determine alternatives with good selectivity [18]. The process runs simultaneously that will produce two or more optimal levels [19]. The results of Moora approach are inconsistent results and contain some errors [20]. AHP method used in this research aims to calculate the weight of each criterion that has been determined before entered to set alternative rankings process. AHP can describe complex multi-factor or multi-criteria problems into a hierarchy [21]. Meanwhile, MOORA method is to establish student rankings when the weight of each criterion produced by AHP method is known.

Some previous studies relating to the selection of SIP assistance beneficiaries with DSS have been made. They include research by Manuhutu that developed a decision support system to select the beneficiaries of Smart Indonesia Program assistance using weighted product method. Here, five criteria are set including: student activeness, certificate of poverty, orphan status, parents' salary, and absenteeism. The prototype model was chosen to develop a web-based decision support system that uses PHP programming language and Bootstrap as a framework [22]. Research by Asnimar compares decision tree algorithm to Naive Bayes to classify the recipients of educational scholarship aid. Ten attributes are used in the research to nominate prospective

new STMIK AKBA students who are entitled to receive educational scholarships. They include: smart Indonesia card ownership, a graduate for a maximum of 2 years, report card, and student's average report card. This research produces a classification using a decision tree algorithm with an accuracy value of 44.12% and F1-Score of 34.48%, while Naïve Bayes algorithm accuracy value is 76.47% obtained based on data of diploma grades and average report cards. From these accuracy results, Naïve Bayes algorithm is better when used to classify scholarship recipients than decision tree algorithm [23].

A journal detailing research results by Anggrawan also uses AHP and MOORA methods to provide recommendations for educational scholarship recipients. This research compared the combined use of AHP and MOORA methods, and 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 organization, and compliance to the requirements. The results concluded that the use of 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 that prevents it from accessing via the internet [24]. This research concluded that AHP and Moora methods used in combination are more accurate than using Moora method only.

Anggrawan's research is applied in universities and has different criteria when applied in schools. Scholarship type discussed is not for SIP assistance so that the criteria used are not a requirement to apply for SIP assistance. The system developed also still uses desktop-based programming so that it cannot be accessed using internet. Our research conducted to apply for SIP assistance with the criteria that have been used by SVHS 5 Surakarta. The problem Problem statement in our research is to evaluate developed DSS results by calculating the accuracy levels, precision and recall.

## II. Material And Methods

From previous research results which also discussed DSS for scholarship recipient selection that not using AHP and MOORA methods , it produced a lower level of accuracy. DSS using the AHP and TOPSIS methods produced performance with an accuracy of 56.72% for achievement scholarship recommendations, and 65.21% for bidikmisi scholarship recipients 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]. Choice to using AHP and MOORA methods in our research was based on Anggrawan's research results which also used the same method and produced an accuracy of 94.7%.

### *A. Data Acquisition*

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

The collected data is information about students who apply for SIP assistance. Data obtained from the next data collection stage is used to set criteria needed and used in alternative assessment. For the developed system, 3 three criteria have been established, and for criteria and values they are presented in table 1. Each criterion has several choices for system input and has a value according to the choices that have been made. Each value will affect the process in the AHP method.

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 amoount | < 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 develop is DSS to produce recommendations for the recipients of SIP assistance. This DSS will be applied to recommend recipients eligible for SIP assistance at SVHS 5 Surakarta. Block diagram of the developed system is presented in Fig. 1.

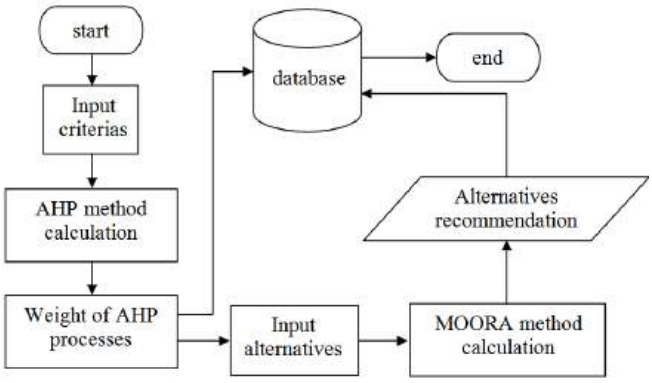


Fig. 1 System architecture

### 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.

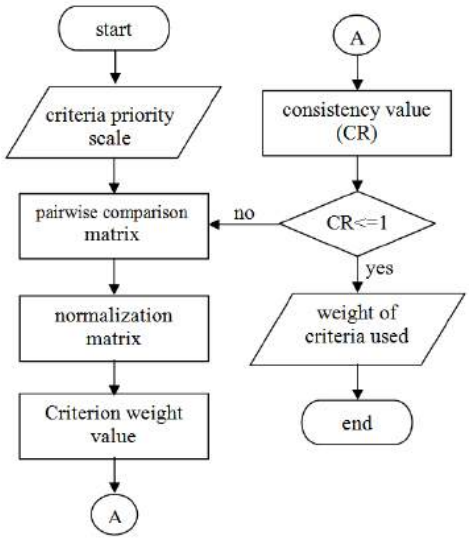


Fig. 2 AHP method process flowchart [29]

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

17) Define problem and determine the desired solution.
18) Create a hierarchical structure initiated with a general objective, followed by criteria, sub-criteria and alternative options that have been set in order.
19) Determine each criteria 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].
20) Value of each column is divided by 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 weight vector.

21) 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 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 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

MOORA method which was first introduced by Brauers and Zavadskas 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]. MOORA method working process is to run processes simultaneously to optimize two or more conflicting criteria. MOORA method is flexible and easy to understand and separates the subjective part of 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.

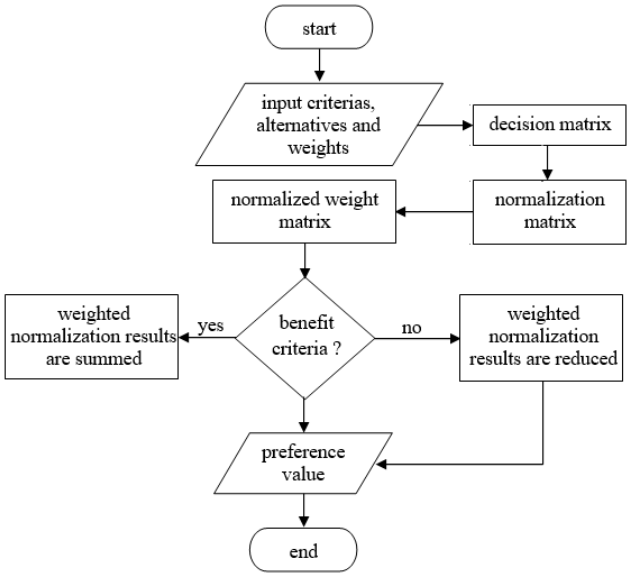


Fig. 3 Alternative Ranking Calculation In MOORA Method [34]

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

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

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

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

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

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

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

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

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

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. Result 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 Comparision 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 explained that a value of 3 in row C-1 and column C-2 comparison means that total earnings are slightly more important than card/letter ownership. In row C-1 column C-3 the comparison value is 5, meaning that sibling amount is more important than Card/letter ownership. Likewise, a value of 3 in row C-2 column C-3 means that sibling amount is slightly more important than 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 criteria:
(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 on the average or weighted value.

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

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

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

5) Calculate the Consistency Ratio (CR)

After getting the t value, the next stage is finding the CI value.

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

Based on existing provisions, a CR value < 10% or 0.1 is said to be consistent. And if <10% or 0.10 means it is inconsistent, then the repetition is repeated starting from the second step and so on until the data becomes consistent.

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

*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 consistent AHP.

TABLE V
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 VI) with the assessment results for each existing alternative.

TABLE VI
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 VII.

TABLE VII
NORMALIZATIOON 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 AHP method with the normalized matrix.

TABLE VIII
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 adding up all the criteria values (columns) in 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.

6) Sorting Preference Values: Sort the preference values in descending order (from large to small) to obtain priorities or recommendations for alternatives that are entitled to receive SIP assistance. The alternative order of eligible for the SIP scholarship is presented in Table IX.

TABLE IX
ALTERNATIVE RANGKING

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

*C. Implementation AHP Method Process*

Implementation is the stage for implementing the system according to 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 that will be used and calculations to determine which students are entitled to receive SIP assistance. Student scores in applying for SIP assistance are

used as consideration to determine the student's eligibility to receive assistance. The information page for student grades can be seen 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 in the AHP method is determining the pairwise comparison matrix. In the developed system, a pairwise comparison 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 MOORA Method Process*

After calculating the AHP method, the next stage is the MOORA method calculation process to obtain results in the form of a sequence of students who deserve assistance. Alternative values function to input student grades which still consist of 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 into a scale of 1-5. Fig. 10 presents the system display for calculation results in 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, next stage is weighted normalization stage. The calculation process is to multiply the normalization results with criteria weights that have been obtained from previous stages of 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 carrying out the weighted normalization process, the next stage is to find the preference or optimization value. The optimization value results of the system process can be seen 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 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 using direct research at SVHS 5 Surakarta, there are 3 recapitulation data on the results detailing the number of students receiving SIP assistance, namely data for 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 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 studiers failed because of unmatched facts. For 2022, 66 students were produced, 2 students were accepted without facts verification. For 2023, 46 students were produced, 3 students fail to meet fact verification. The accuracy of each value calculated from a confusion matrix is presented in Table XI.

TABLE XI
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 XI, 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:

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

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

## IV. CONCLUSION

The DSS developed in this research uses AHP and MOORA methods. The system was developed on a web basis and responsive that makes it can appear from a call of a smartphone. 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 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 recommendation letter whether having such letter or not. Other sub-criteria are as presented in table 1. The weight value obtained from AHP calculation results is used as a reference in MOORA calculations and produces recommendations for the order of students who are entitled to receive SIP assistance. To test the system being developed, a comparison was made between the results of system calculations using existing facts at SVHS 5 Surakarta

in 2021, 2022 and 2023. From the accuracy test with total income data from 2021 to 2023, the accuracy level was above 93.3%, so it can be concluded that the results of calculations using AHP and MOORA methods are accurate. The percentage results of accuracy level produced in this research are included in very good classification category, so that AHP and MOORA methods are suitable for use to assist a decision making process in 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 a system has the ability to upload student data simultaneously or retrieve data from an external system. For further research, one or two other methods can be used as a comparison of the accuracy results shown in this research.

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**Artikel setelah di review keempat**

# 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 to improve its education quality with the provision of scholarship programs, one of which is the Smart Indonesia Program (SIP). Students' interest in obtaining SIP is increasing, but selection process still uses conventional methods. Without adequate IT support, selection process for SIP scholarship candidates will be difficult, less objective and rather unfair. State Vocational High School (SVHS) 5 Surakarta was selected as a case study object for this research to establish the selection process and data collection from previous years. The research aims to produce a Decision Support System (DSS) to assist in nominating students who are deemed eligible for recommendation as the recipients of SIP scholarships. 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, total income of the household and number of siblings. Each of which is further broken down into several sub-criteria and has a value that will be used in AHP method process. Upon accuracy test by comparing data from 2021 to 2023, it is found that the accuracy test in 2021 was 92.9%, while in 2022 it reached 94.7% and the accuracy in 2023 recorded 92.3%. From the results of such system accuracy test, it can be concluded that AHP and MOORA methods can be used to produce recommendations for students who are entitled to receive SIP scholarships in objective manner based on the inputted criteria.**

***Keywords*— Decision Making; Recommendation; Smart Indonesia Program; AHP; MOORA.**

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## I. INTRODUCTION

Elementary and secondary education is an important thing in determining future life. However, due to financial obstacles, some parents have to stop the education of their children. Every country need to pay attention to the development of education sector, because good education is pivotal to create and improve a smart and skilled workforce [1]. The present education will determine the development of a nation in future. Education plays an important 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 aims to provide financial assistance or relief to students aged 6 to 21 years old. 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]. Indonesian government continuously strive 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 Smart Indonesia Program (SIP) [4]. Without adequate IT support, the process of selecting prospective SIP recipient students may be very difficult, not objective and lack of 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]. The aim of SIC is to help education access for students who, in spite of having quality, have underprivileged parental backgrounds, as well as to prevent and reduce the dropouts and to 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) Surakarta city has a vision of producing graduates with strong characters, employable skills and entrepreneurial spirit based on environmentally friendly technology. In 2005, SVHS 5 Surakarta was the first vocational school to successfully obtain an ISO 9001-2000 certificate and was also selected to be the guiding model school for all vocational schools and high schools in Central Java region. SVHS 5 Surakarta managed to achieve and implement ISO 9001-2015 certificate in 2017. The screening process for SIP recipients is carried out every year to the students of state schools across Indonesia. The process of selecting students who receive SIP is a fairly complicated process to carry out without adequate information system support [8]. This condition and system is also found at SVHS 5 Surakarta, which is selected as the object of case study in this research. SIP selection committee at SVHS 5 Surakarta faces great responsibilities and challenges in selecting students who are really entitled for and need SIP assistance. The use of standard applications to process and calculate the large numbers of SIP registrants as well as data consisting of piles of files becomes a factor that undermines the performance of selection team. The assessment and selection process takes a long process, meanwhile they must maintain high accuracy. This makes the process become susceptible to abuse of authority or data manipulation and prone to errors in data input. Mistaken results of selection process can cause students who deserve and need SIP scholarship may lose their rights.

In an era where information technology is all about, methods contained in DSS are decisive, ranging from simple methods to the complex ones. DSS is a semi-structurally 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 certain technology or systems [11]. DSS can be implemented in various fields to find solutions to various problems [12]. In this research, DSS was created using the AHP and MOORA method. AHP can organize information using a number of 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 influences the resolution of existing problems [14]. AHP method has advantage of creating a pairwise comparison matrix to determine the weight of each criterion and calculate the consistency value [15]. Moora method is a multi-objective optimization technique that can be used to solve various types of complex decision-making problems [16]. Moora method sorts (ranks) each attribute and alternatives based on specified criteria [17]. Moora method performs simple calculations of minimum and maximum values. This method will determine alternatives with good selectivity [18]. The process runs simultaneously that will produce two or more optimal levels [19]. The results of Moora approach are inconsistent results and contain some errors [20]. AHP method used in this research aims to calculate the weight of each criterion that has been determined before entered to set alternative rankings process. AHP can describe complex multi-factor or multi-criteria problems into a hierarchy [21]. Meanwhile, MOORA method is to establish student rankings when the weight of each criterion produced by AHP method is known.

Some previous studies relating to the selection of SIP assistance beneficiaries with DSS have been made. They include research by Manuhutu that developed a decision support system to select the beneficiaries of Smart Indonesia Program assistance using weighted product method. Here, five criteria are set including: student activeness, certificate of poverty, orphan status, parents' salary, and absenteeism. The prototype model was chosen to develop a web-based decision support system that uses PHP programming language and Bootstrap as a framework [22]. Research by Asnimar compares decision tree algorithm to Naive Bayes to classify the recipients of educational scholarship aid. Ten attributes are used in the research to nominate prospective

new STMIK AKBA students who are entitled to receive educational scholarships. They include: smart Indonesia card ownership, a graduate for a maximum of 2 years, report card, and student's average report card. This research produces a classification using a decision tree algorithm with an accuracy value of 44.12% and F1-Score of 34.48%, while Naïve Bayes algorithm accuracy value is 76.47% obtained based on data of diploma grades and average report cards. From these accuracy results, Naïve Bayes algorithm is better when used to classify scholarship recipients than decision tree algorithm [23].

A journal detailing research results by Anggrawan also uses AHP and MOORA methods to provide recommendations for educational scholarship recipients. This research compared the combined use of AHP and MOORA methods, and 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 organization, and compliance to the requirements. The results concluded that the use of 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 that prevents it from accessing via the internet [24]. This research concluded that AHP and Moora methods used in combination are more accurate than using Moora method only.

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

## II. Material And Methods

From previous research results which also discussed DSS for scholarship recipient selection that not using AHP and MOORA methods , it produced a lower level of accuracy. DSS using the AHP and TOPSIS methods produced performance with an accuracy of 56.72% for achievement scholarship recommendations, and 65.21% for bidikmisi scholarship recipients 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, an accuracy using AHP-TOPSIS and SAW methods had a lower level of accuracy compared to using AHP-MOORA method. Choice to using AHP and MOORA methods in our research was based on Anggrawan's research results which also used the same method and produced an accuracy of 94.7%.

### *A. Data Acquisition*

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

The collected data is information about students who apply for SIP assistance. Data obtained from the next data collection stage is used to set criteria needed and used in alternative assessment. For the developed system, 3 three criteria have been established, and for criteria and values they are presented in table 1. Each criterion has several choices for system input and has a value according to the choices that have been made. Each value will affect the process in the AHP method.

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 amoount | < 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 develop is DSS to produce recommendations for the recipients of SIP assistance. This DSS will be applied to recommend recipients eligible for SIP assistance at SVHS 5 Surakarta. Block diagram of the developed system is presented in Fig. 1.

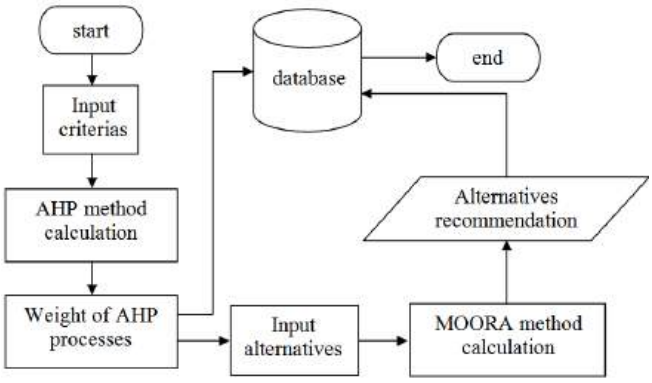


Fig. 1 System architecture

### 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.

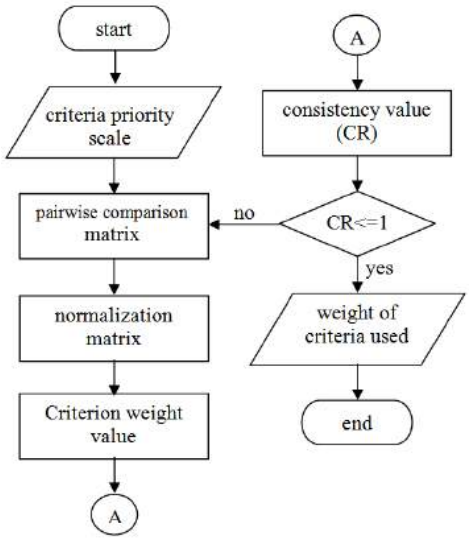


Fig. 2 AHP method process flowchart [29]

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

22) Define problem and determine the desired solution.
23) Create a hierarchical structure initiated with a general objective, followed by criteria, sub-criteria and alternative options that have been set in order.
24) Determine each criteria 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].
25) Value of each column is divided by 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 weight vector.

26) 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 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 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

MOORA method which was first introduced by Brauers and Zavadskas 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]. MOORA method working process is to run processes simultaneously to optimize two or more conflicting criteria. MOORA method is flexible and easy to understand and separates the subjective part of 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.

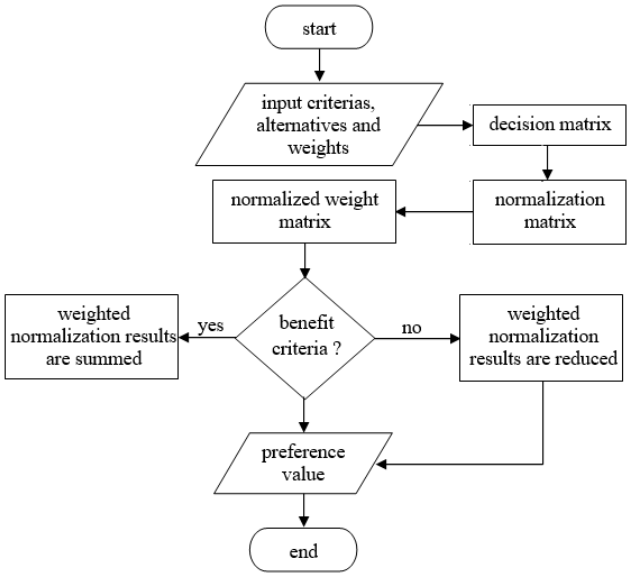


Fig. 3 Alternative Ranking Calculation In MOORA Method [34]

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

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

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

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

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

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

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

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

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

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. Result 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 Comparision 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 explained that a value of 3 in row C-1 and column C-2 comparison means that total earnings are slightly more important than card/letter ownership. In row C-1 column C-3 the comparison value is 5, meaning that sibling amount is more important than Card/letter ownership. Likewise, a value of 3 in row C-2 column C-3 means that sibling amount is slightly more important than 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 criteria:
(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 on the average or weighted value.

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

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

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

5) Calculate the Consistency Ratio (CR)

After getting the t value, the next stage is finding the CI value.

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

Based on existing provisions, a CR value < 10% or 0.1 is said to be consistent. And if <10% or 0.10 means it is inconsistent, then the repetition is repeated starting from the second step and so on until the data becomes consistent.

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

*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 consistent AHP.

TABLE V
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 VI) with the assessment results for each existing alternative.

TABLE VI
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 VII.

TABLE VII
NORMALIZATIOON 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 AHP method with the normalized matrix.

TABLE VIII
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 adding up all the criteria values (columns) in 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.

6) Sorting Preference Values: Sort the preference values in descending order (from large to small) to obtain priorities or recommendations for alternatives that are entitled to receive SIP assistance. The alternative order of eligible for the SIP scholarship is presented in Table IX.

TABLE IX
ALTERNATIVE RANGKING

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

*C. Implementation AHP Method Process*

Implementation is the stage for implementing the system according to 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 that will be used and calculations to determine which students are entitled to receive SIP assistance. Student scores in applying for SIP assistance are used as consideration to determine the student's eligibility to

receive assistance. The information page for student grades can be seen 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 in the AHP method is determining the pairwise comparison matrix. In the developed system, a pairwise comparison 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 MOORA Method Process*

After calculating the AHP method, the next stage is the MOORA method calculation process to obtain results in the form of a sequence of students who deserve assistance. Alternative values function to input student grades which still consist of 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 into a scale of 1-5. Fig. 10 presents the system display for calculation results in 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, next stage is weighted normalization stage. The calculation process is to multiply the normalization results with criteria weights that have been obtained from previous stages of AHP process.

Weighted Normalization Matrix

| Name | Card ownership | Total income | Total siblings |
|---|---|---|---|
| AHMAD FAUZUL MUTTAQIN | 0.072180247060669 | 0.104773730477822 | 0.005097124497380 |
| AMELIA HAFIZNA | 0.18045061951517 | 0.031421191433466 | 0.01019424899476 |
| CINDY QURROTUL AYUN | 0.026090123030334 | 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 carrying out the weighted normalization process, the next stage is to find the preference or optimization value. The optimization value results of the system process can be seen 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 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 using direct research at SVHS 5 Surakarta, there are 3 recapitulation data on the results detailing the number of students receiving SIP assistance, namely data for 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 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 studiers failed because of unmatched facts. For 2022, 66 students were produced, 2 students were accepted without facts verification. For 2023, 46 students were produced, 3 students fail to meet fact verification. The accuracy of each value calculated from a confusion matrix is presented in Table XI.

TABLE XI
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 XI, 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. 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.

TABLE XII
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 XII, average precision is 96.3% and 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.

## IV. Conclusion

The DSS developed in this research uses AHP and MOORA methods. The system was developed on a web basis and responsive that makes it can appear from a call of a smartphone. 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 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 recommendation letter whether having such letter or not. Other sub-criteria are as presented in table 1. The weight value obtained from AHP calculation results is used as a reference in MOORA calculations and produces recommendations for the order of students who are entitled to receive SIP assistance. To test the system being developed, a comparison was made between the results of system calculations using existing facts at SVHS 5 Surakarta in 2021, 2022 and 2023. From the accuracy test with total income data from 2021 to 2023, the accuracy level was above 93.3%, so it can be concluded that the results of calculations using AHP and MOORA methods are accurate. The percentage results of accuracy level produced in this research are included in very good classification category, so that AHP and MOORA methods are suitable for use to assist a decision making process in 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 a system has the ability to upload student data simultaneously or retrieve data from an external system. For further research, one or two other methods can be used as a comparison of the accuracy results shown in this research.

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**Artikel setelah di review kelima**

# nuhuMulti Criteria Decision Making Method For Developing Smart Indonesia Program Scholarship Recipient Candidate System

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***Abstract*— The Government of Indonesia is continuously to improve its education quality with the provision of scholarship programs, one of which is the Smart Indonesia Program (SIP). Students' interest in obtaining SIP is increasing, but selection process still uses conventional methods. Without adequate IT support, selection process for SIP scholarship candidates will be difficult, less objective and rather unfair. State Vocational High School (SVHS) 5 Surakarta was selected as a case study object for this research to establish the selection process and data collection from previous years. The research aims to produce a Decision Support System (DSS) to assist in nominating students who are deemed eligible for recommendation as the recipients of SIP scholarships. 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, total income of the household and number of siblings. Each of which is further broken down into several sub-criteria and has a value that will be used in AHP method process. Upon accuracy test by comparing data from 2021 to 2023, it is found that the accuracy test in 2021 was 92.9%, while in 2022 it reached 94.7% and the accuracy in 2023 recorded 92.3%. From the results of such system accuracy test, it can be concluded that AHP and MOORA methods can be used to produce recommendations for students who are entitled to receive SIP scholarships in objective manner based on the inputted criteria.**

***Keywords*— Decision Making; Recommendation; Smart Indonesia Program; AHP; MOORA.**

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## I. INTRODUCTION

Elementary and secondary education is an important thing in determining future life. However, due to financial obstacles, some parents have to stop the education of their children. Every country need to pay attention to the development of education sector, because good education is pivotal to create and improve a smart and skilled workforce [1]. The present education will determine the development of a nation in future. Education plays an important 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 aims to provide financial assistance or relief to students aged 6 to 21 years old. 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]. Indonesian government continuously strive 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 Smart Indonesia Program (SIP) [4]. Without adequate IT support, the process of selecting prospective SIP recipient students may be very difficult, not objective and lack of 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]. The aim of SIC is to help education access for students who, in spite of having quality, have underprivileged parental backgrounds, as well as to prevent and reduce the dropouts and to 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) Surakarta city has a vision of producing graduates with strong characters, employable skills and entrepreneurial spirit based on environmentally friendly technology. In 2005, SVHS 5 Surakarta was the first vocational school to successfully obtain an ISO 9001-2000 certificate and was also selected to be the guiding model school for all vocational schools and high schools in Central Java region. SVHS 5 Surakarta managed to achieve and implement ISO 9001-2015 certificate in 2017. The screening process for SIP recipients is carried out every year to the students of state schools across Indonesia. The process of selecting students who receive SIP is a fairly complicated process to carry out without adequate information system support [8]. This condition and system is also found at SVHS 5 Surakarta, which is selected as the object of case study in this research. SIP selection committee at SVHS 5 Surakarta faces great responsibilities and challenges in selecting students who are really entitled for and need SIP assistance. The use of standard applications to process and calculate the large numbers of SIP registrants as well as data consisting of piles of files becomes a factor that undermines the performance of selection team. The assessment and selection process takes a long process, meanwhile they must maintain high accuracy. This makes the process become susceptible to abuse of authority or data manipulation and prone to errors in data input. Mistaken results of selection process can cause students who deserve and need SIP scholarship may lose their rights.

In an era where information technology is all about, methods contained in DSS are decisive, ranging from simple methods to the complex ones. DSS is a semi-structurally 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 certain technology or systems [11]. DSS can be implemented in various fields to find solutions to various problems [12]. In this research, DSS was created using the AHP and MOORA method. AHP can organize information using a number of 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 influences the resolution of existing problems [14]. AHP method has advantage of creating a pairwise comparison matrix to determine the weight of each criterion and calculate the consistency value [15]. Moora method is a multi-objective optimization technique that can be used to solve various types of complex decision-making problems [16]. Moora method sorts (ranks) each attribute and alternatives based on specified criteria [17]. Moora method performs simple calculations of minimum and maximum values. This method will determine alternatives with good selectivity [18]. The process runs simultaneously that will produce two or more optimal levels [19]. The results of Moora approach are inconsistent results and contain some errors [20]. AHP method used in this research aims to calculate the weight of each criterion that has been determined before entered to set alternative rankings process. AHP can describe complex multi-factor or multi-criteria problems into a hierarchy [21]. Meanwhile, MOORA method is to establish student rankings when the weight of each criterion produced by AHP method is known. By combining AHP and MOORA methods, a solution will be generate consisting of more objective and comprehensive recommendations for SIP recipients.

Some previous studies relating to the selection of SIP assistance beneficiaries with DSS have been made. They include research by Manuhutu that developed a decision support system to select the beneficiaries of Smart Indonesia Program assistance using weighted product method. Here, five criteria are set including: student activeness, certificate of poverty, orphan status, parents' salary, and absenteeism. The prototype model was chosen to develop a web-based decision support system that uses PHP programming language and Bootstrap as a framework [22]. Research by

Asnimar compares decision tree algorithm to Naive Bayes to classify the recipients of educational scholarship aid. Ten attributes are used in the research to nominate prospective new STMIK AKBA students who are entitled to receive educational scholarships. They include: smart Indonesia card ownership, a graduate for a maximum of 2 years, report card, and student's average report card. This research produces a classification using a decision tree algorithm with an accuracy value of 44.12% and F1-Score of 34.48%, while Naïve Bayes algorithm accuracy value is 76.47% obtained based on data of diploma grades and average report cards. From these accuracy results, Naïve Bayes algorithm is better when used to classify scholarship recipients than decision tree algorithm [23].

A journal detailing research results by Anggrawan also uses AHP and MOORA methods to provide recommendations for educational scholarship recipients. This research compared the combined use of AHP and MOORA methods, and 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 organization, and compliance to 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 that prevents it from accessing via the internet [24].

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

## II. Material And Methods

From previous research results which also discussed DSS for scholarship recipient selection that not using AHP and MOORA methods , it produced a lower level of accuracy. DSS using the AHP and TOPSIS methods produced performance with an accuracy of 56.72% for achievement scholarship recommendations, and 65.21% for bidikmisi scholarship recipients 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, an accuracy using AHP-TOPSIS and SAW methods had a lower level of accuracy compared to using AHP-MOORA method. Choice to using AHP and MOORA methods in our research was based on Anggrawan's research results which also used the same method and produced an accuracy of 94.7%.

### *A. Data Acquisition*

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

The collected data is information about students who apply for SIP assistance. Data obtained from the next data collection stage is used to set criteria needed and used in alternative assessment. For the developed system, 3 three criteria have been established, and for criteria and values they are presented in table 1. Each criterion has several choices for system input and has a value according to the choices that have been made. Each value will affect the process in the AHP method.

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 amoount | < 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 develop is DSS to produce recommendations for the recipients of SIP assistance. This DSS will be applied to recommend recipients eligible for SIP assistance at SVHS 5 Surakarta. Block diagram of the developed system is presented in Fig. 1.

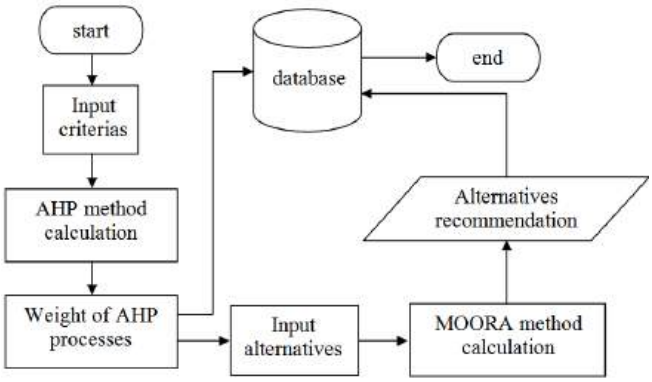


Fig. 1 System architecture

### 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.

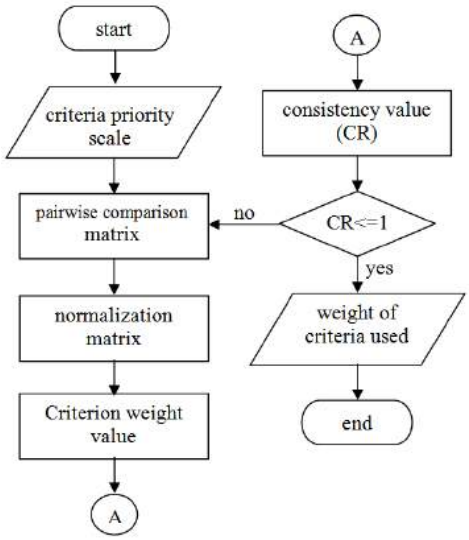


Fig. 2 AHP method process flowchart [29]

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

27) Define problem and determine the desired solution.
28) Create a hierarchical structure initiated with a general objective, followed by criteria, sub-criteria and alternative options that have been set in order.
29) Determine each criteria 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].
30) Value of each column is divided by 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 weight vector.

31) 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 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 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

MOORA method which was first introduced by Brauers and Zavadskas 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]. MOORA method working process is to run processes simultaneously to optimize two or more conflicting criteria. MOORA method is flexible and easy to understand and separates the subjective part of 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.

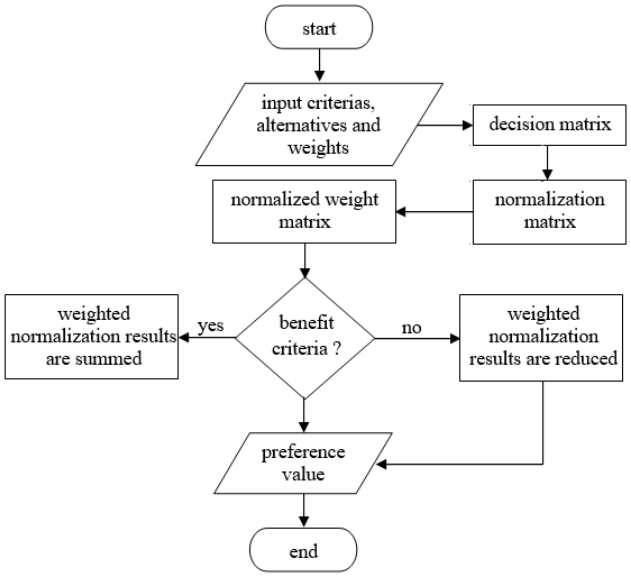


Fig. 3 Alternative Ranking Calculation In MOORA Method [34]

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

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

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

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

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

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

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

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

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

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. Result 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 Comparision 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 explained that a value of 3 in row C-1 and column C-2 comparison means that total earnings are slightly more important than card/letter ownership. In row C-1 column C-3 the comparison value is 5, meaning that sibling amount is more important than Card/letter ownership. Likewise, a value of 3 in row C-2 column C-3 means that sibling amount is slightly more important than 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 criteria:
(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 on the average or weighted value.

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

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

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

5) Calculate the Consistency Ratio (CR)

After getting the t value, the next stage is finding the CI value.

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

Based on existing provisions, a CR value < 10% or 0.1 is said to be consistent. And if <10% or 0.10 means it is inconsistent, then the repetition is repeated starting from the second step and so on until the data becomes consistent.

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

*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 consistent AHP.

TABLE V
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 VI) with the assessment results for each existing alternative.

TABLE VI
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 VII.

TABLE VII
NORMALIZATIOON 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 AHP method with the normalized matrix.

TABLE VIII
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 adding up all the criteria values (columns) in 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.

6) Sorting Preference Values: Sort the preference values in descending order (from large to small) to obtain priorities or recommendations for alternatives that are entitled to receive SIP assistance. The alternative order of eligible for the SIP scholarship is presented in Table IX.

TABLE IX
ALTERNATIVE RANGKING

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

*C. Implementation AHP Method Process*

Implementation is the stage for implementing the system according to 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 that will be used and calculations to determine which students are entitled to receive SIP assistance. Student scores in applying for SIP assistance are used as consideration to determine the student's eligibility to receive assistance. The information page for student grades can be seen 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 in the AHP method is determining the pairwise comparison matrix. In the developed system, a pairwise comparison 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 MOORA Method Process*

After calculating the AHP method, the next stage is the MOORA method calculation process to obtain results in the form of a sequence of students who deserve assistance. Alternative values function to input student grades which still consist of 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 into a scale of 1-5. Fig. 10 presents the system display for calculation results in 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, next stage is weighted normalization stage. The calculation process is to multiply the normalization results with criteria weights that have been obtained from previous stages of 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 carrying out the weighted normalization process, the next stage is to find the preference or optimization value. The optimization value results of the system process can be seen 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 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 using direct research at SVHS 5 Surakarta, there are 3 recapitulation data on the results detailing the number of students receiving SIP assistance, namely data for 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 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 studiers failed because of unmatched facts. For 2022, 66 students were produced, 2 students were accepted without facts verification. For 2023, 46 students were produced, 3 students fail to meet fact verification. The accuracy of each value calculated from a confusion matrix is presented in Table XI.

TABLE XI
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 XI, 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. 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. There was a decrease in precision in 2023 compared to 2022. This could be due to regulatory changes regarding requirements or priorities for granting SIP. Other reason include a less objective selection process during interviews or data manipulation.

TABLE XII
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 XII, average precision is 96.3% and 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 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 MOORA method and resulted an accuracy rate of 5.61% [37]. From the comparison with these two previous research, it can be concluded that 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 developed on a web basis and responsive that makes it can appear from a call of a smartphone. 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 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 recommendation letter whether having such letter or not. Other sub-criteria are as presented in table 1. The weight value obtained from AHP calculation results is used as a reference in MOORA calculations and produces recommendations for the order of students who are entitled to receive SIP assistance. To test the system being developed, a comparison was made between the results of system calculations using existing facts at SVHS 5 Surakarta in 2021, 2022 and 2023. From the accuracy test with total income data from 2021 to 2023, the accuracy level was above 93.3%, so it can be concluded that the results of calculations using AHP and MOORA methods are accurate. The percentage results of accuracy level produced in this research are included in very good classification category, so that AHP and MOORA methods are suitable for use to assist a decision making process in 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 a system has the ability to upload student data simultaneously or retrieve data from an external system. For further research, one or two other methods can be used as a comparison of the accuracy results shown in this research.


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Artikel revisi yang terakhir

# 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 to improve its education quality with the provision of scholarship programs, one of which is the Smart Indonesia Program (SIP). Students' interest in obtaining SIP is increasing, but selection process still uses conventional methods. Without adequate IT support, selection process for SIP scholarship candidates will be difficult, less objective and rather unfair. State Vocational High School (SVHS) 5 Surakarta was selected as a case study object for this research to establish the selection process and data collection from previous years. The research aims to produce a Decision Support System (DSS) to assist in nominating students who are deemed eligible for recommendation as the recipients of SIP scholarships. 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, total income of the household and number of siblings. Each of which is further broken down into several sub-criteria and has a value that will be used in AHP method process. Upon accuracy test by comparing data from 2021 to 2023, it is found that the accuracy test in 2021 was 92.9%, while in 2022 it reached 94.7% and the accuracy in 2023 recorded 92.3%. From the results of such system accuracy test, it can be concluded that AHP and MOORA methods can be used to produce recommendations for students who are entitled to receive SIP scholarships in objective manner based on the inputted criteria.**

***Keywords*— Decision Making; Recommendation; Smart Indonesia Program; AHP; MOORA.**

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## I. INTRODUCTION

Elementary and secondary education is an important thing in determining future life. However, due to financial obstacles, some parents have to stop the education of their children. Every country need to pay attention to the development of education sector, because good education is pivotal to create and improve a smart and skilled workforce [1]. The present education will determine the development of a nation in future. Education plays an important 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 aims to provide financial assistance or relief to students aged 6 to 21 years old. 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]. Indonesian government continuously strive 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 Smart Indonesia Program (SIP) [4]. Without adequate IT support, the process of selecting prospective SIP recipient students may be very difficult, not objective and lack of 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]. The aim of SIC is to help education access for students who, in spite of having quality, have underprivileged parental backgrounds, as well as to prevent and reduce the dropouts and to 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) Surakarta city has a vision of producing graduates with strong characters, employable skills and entrepreneurial spirit based on environmentally friendly technology. In 2005, SVHS 5 Surakarta was the first vocational school to successfully obtain an ISO 9001-2000 certificate and was also selected to be the guiding model school for all vocational schools and high schools in Central Java region. SVHS 5 Surakarta managed to achieve and implement ISO 9001-2015 certificate in 2017. The screening process for SIP recipients is carried out every year to the students of state schools across Indonesia. The process of selecting students who receive SIP is a fairly complicated process to carry out without adequate information system support [8]. This

condition and system is also found at SVHS 5 Surakarta, which is selected as the object of case study in this research. SIP selection committee at SVHS 5 Surakarta faces great responsibilities and challenges in selecting students who are really entitled for and need SIP assistance. The use of standard applications to process and calculate the large numbers of SIP registrants as well as data consisting of piles of files becomes a factor that undermines the performance of selection team. The assessment and selection process takes a long process, meanwhile they must maintain high accuracy. This makes the process become susceptible to abuse of authority or data manipulation and prone to errors in data input. Mistaken results of selection process can cause students who deserve and need SIP scholarship may lose their rights.

In an era where information technology is all about, methods contained in DSS are decisive, ranging from simple methods to the complex ones. DSS is a semi-structurally 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 certain technology or systems [11]. DSS can be implemented in various fields to find solutions to various problems [12]. In this research, DSS was created using the AHP and MOORA method. AHP can organize information using a number of 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 influences the resolution of existing problems [14]. AHP method has advantage of creating a pairwise comparison matrix to determine the weight of each criterion and calculate the consistency value [15]. Moora method is a multi-objective optimization technique that can be used to solve various types of complex decision-making problems [16]. Moora method sorts (ranks) each attribute and alternatives based on specified criteria [17]. Moora method performs simple calculations of minimum and maximum values. This method will determine alternatives with good selectivity [18]. The process runs simultaneously that will produce two or more optimal levels [19]. The results of Moora approach are inconsistent results and contain some errors [20]. AHP method used in this research aims to calculate the weight of each criterion that has been determined before entered to set alternative rankings process. AHP can describe complex multi-factor or multi-criteria problems into a hierarchy [21]. Meanwhile, MOORA method is to establish student rankings when the weight of each criterion produced by AHP method is known. By combining AHP and MOORA methods, a solution will be generate consisting of more objective and comprehensive recommendations for SIP recipients.

Some previous studies relating to the selection of SIP assistance beneficiaries with DSS have been made. They include research by Manuhutu that developed a decision support system to select the beneficiaries of Smart Indonesia Program assistance using weighted product method. Here, five criteria are set including: student activeness, certificate of poverty, orphan status, parents' salary, and absenteeism. The prototype model was chosen to develop a web-based decision support system that uses PHP programming language and Bootstrap as a framework [22]. Research by Asnimar compares decision tree algorithm to Naive Bayes to classify the recipients of educational scholarship aid. Ten attributes are used in the research to nominate prospective new STMIK AKBA students who are entitled to receive educational scholarships. They include: smart Indonesia card ownership, a graduate for a maximum of 2 years, report card, and student's average report card. This research produces a classification using a decision tree algorithm with an accuracy value of 44.12% and F1-Score of 34.48%, while Naïve Bayes algorithm accuracy value is 76.47% obtained based on data of diploma grades and average report cards. From these accuracy results, Naïve Bayes algorithm is better when used to classify scholarship recipients than decision tree algorithm [23].

A journal detailing research results by Anggrawan also uses AHP and MOORA methods to provide recommendations for educational scholarship recipients. This research compared the combined use of AHP and MOORA methods, and 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 organization, and compliance to 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 that prevents it from accessing via the internet [24].

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

## II. Material And Methods

From previous research results which also discussed DSS for scholarship recipient selection that not using AHP and MOORA methods , it produced a lower level of accuracy. DSS using the AHP and TOPSIS methods produced performance with an accuracy of 56.72% for achievement scholarship recommendations, and 65.21% for bidikmisi scholarship recipients 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, an accuracy using AHP-TOPSIS and SAW methods had a lower level of accuracy compared to using AHP-MOORA method. Choice to using AHP and MOORA methods in our research was based on Anggrawan's research results which also used the same method and produced an accuracy of 94.7%.

### *A. Data Acquisition*

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

The collected data is information about students who apply for SIP assistance. Data obtained from the next data collection stage is used to set criteria needed and used in alternative assessment. For the developed system, 3 three criteria have been established, and for criteria and values they are presented in table 1. Each criterion has several choices for system input and has a value according to the choices that have been made. Each value will affect the process in the AHP method.

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 amoount | < 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 develop is DSS to produce recommendations for the recipients of SIP assistance. This DSS will be applied to recommend recipients eligible for SIP assistance at SVHS 5 Surakarta. Block diagram of the developed system is presented in Fig. 1.

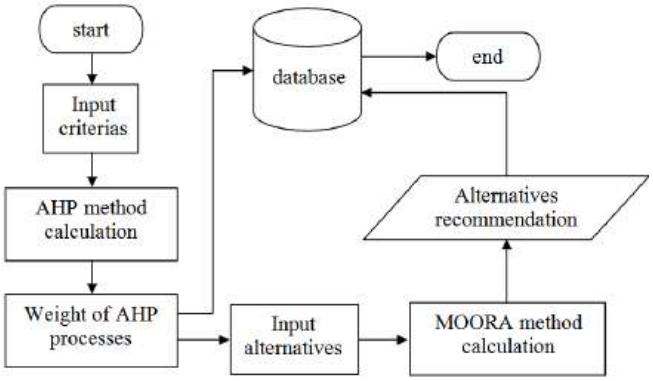


Fig. 1 System architecture

### *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.

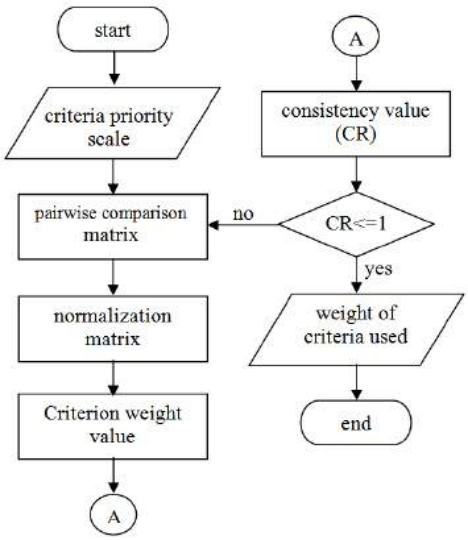


Fig. 2 AHP method process flowchart [29]

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

32) Define problem and determine the desired solution.
33) Create a hierarchical structure initiated with a general objective, followed by criteria, sub-criteria and alternative options that have been set in order.
34) Determine each criteria 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].
35) Value of each column is divided by 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 weight vector.

36) 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 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 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*

MOORA method which was first introduced by Brauers and Zavadskas 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]. MOORA method working process is to run processes simultaneously to optimize two or more conflicting criteria. MOORA method is flexible and easy to understand and separates the subjective part of 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.

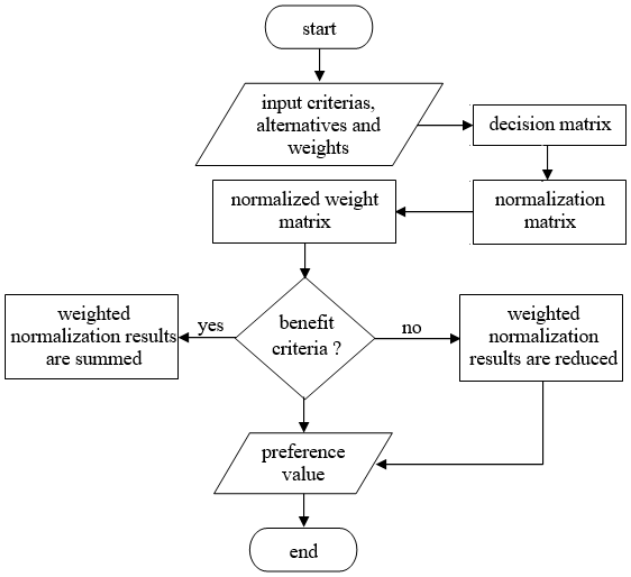


Fig. 3 Alternative Ranking Calculation In MOORA Method [34]

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

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

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

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

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

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

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

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

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

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. Result and Discussion

### F. 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 Comparision 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 explained that a value of 3 in row C-1 and column C-2 comparison means that total earnings are slightly more important than card/letter ownership. In row C-1 column C-3 the comparison value is 5, meaning that sibling amount is more important than Card/letter ownership. Likewise, a value of 3 in row C-2 column C-3 means that sibling amount is slightly more important than 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 criteria:
(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 on the average or weighted value.

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

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

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

5) Calculate the Consistency Ratio (CR)

   After getting the t value, the next stage is finding the CI value.

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

Based on existing provisions, a CR value < 10% or 0.1 is said to be consistent. And if <10% or 0.10 means it is inconsistent, then the repetition is repeated starting from the second step and so on until the data becomes consistent.

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

### G. 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 consistent AHP.

TABLE V
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 VI) with the assessment results for each existing alternative.

TABLE VI
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 VII.

TABLE VII
NORMALIZATIOON 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 AHP method with the normalized matrix.

TABLE VIII
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 adding up all the criteria values (columns) in 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.

6) Sorting Preference Values: Sort the preference values in descending order (from large to small) to obtain priorities or recommendations for alternatives that are entitled to receive SIP assistance. The alternative order of eligible for the SIP scholarship is presented in Table IX.

TABLE IX
ALTERNATIVE RANGKING

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

*H. Implementation AHP Method Process*

Implementation is the stage for implementing the system according to 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 that will be used and calculations to determine which students are entitled to receive SIP assistance. Student scores in applying for SIP assistance are used as consideration to determine the student's eligibility to receive assistance. The information page for student grades can be seen in Fig. 4.


Fig. 4 Student Assessment Page

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

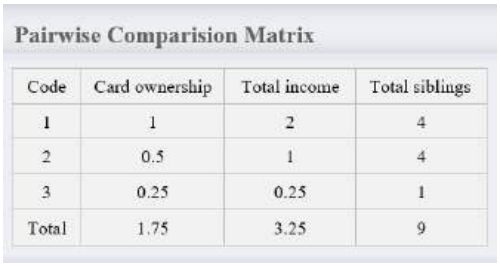


Fig. 5 Paired Comparison Matrix Display

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

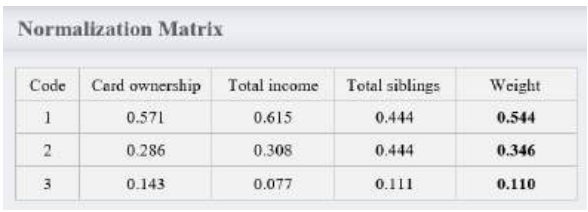


Fig. 6 AHP Normalization Matrix Display

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

## *I. Implementation MOORA Method Process*

After calculating the AHP method, the next stage is the MOORA method calculation process to obtain results in the form of a sequence of students who deserve assistance. Alternative values function to input student grades which still consist of 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 into a scale of 1-5. Fig. 10 presents the system display for calculation results in 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, next stage is weighted normalization stage. The calculation process is to multiply the normalization results with criteria weights that have been obtained from previous stages of 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 | 0.007645686746069 |
| 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 carrying out the weighted normalization process, the next stage is to find the preference or optimization value. The optimization value results of the system process can be seen 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 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 | 0.12367454831 15 |
| 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

### *J. Accuracy Testing*

From the data obtained using direct research at SVHS 5 Surakarta, there are 3 recapitulation data on the results detailing the number of students receiving SIP assistance, namely data for 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 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 studiers failed because of unmatched facts. For 2022, 66 students were produced, 2 students were accepted without facts verification. For 2023, 46 students were produced, 3 students fail to meet fact verification. The accuracy of each value calculated from a confusion matrix is presented in Table XI.

TABLE XI
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 XI, 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. 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. There was a decrease in precision in 2023 compared to 2022. This could be due to regulatory changes regarding requirements or priorities for granting SIP. Other reason include a less objective selection process during interviews or data manipulation.

TABLE XII
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 XII, average precision is 96.3% and 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 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 MOORA method and resulted an accuracy rate of 5.61% [37]. From the comparison with these two previous research, it can be concluded that 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 developed on a web basis and responsive that makes it can appear from a call of a smartphone. 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 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 recommendation letter whether having such letter or not. Other sub-criteria are as presented in table 1. The weight value obtained from AHP calculation results is used as a

reference in MOORA calculations and produces recommendations for the order of students who are entitled to receive SIP assistance. To test the system being developed, a comparison was made between the results of system calculations using existing facts at SVHS 5 Surakarta in 2021, 2022 and 2023. From the accuracy test with total income data from 2021 to 2023, the accuracy level was above 93.3%, so it can be concluded that the results of calculations using AHP and MOORA methods are accurate. The percentage results of accuracy level produced in this research are included in very good classification category, so that AHP and MOORA methods are suitable for use to assist a decision making process in 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 a system has the ability to upload student data simultaneously or retrieve data from an external system. For further research, one or two other methods can be used as a comparison of the accuracy results shown in this research.

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**Artikel jurnal final**

# 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 to improve its education quality with the provision of scholarship programs, one of which is the Smart Indonesia Program (SIP). Students' interest in obtaining SIP is increasing, but selection process still uses conventional methods. Without adequate IT support, selection process for SIP scholarship candidates will be difficult, less objective and rather unfair. State Vocational High School (SVHS) 5 Surakarta was selected as a case study object for this research to establish the selection process and data collection from previous years. The research aims to produce a Decision Support System (DSS) to assist in nominating students who are deemed eligible for recommendation as the recipients of SIP scholarships. 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, total income of the household and number of siblings. Each of which is further broken down into several sub-criteria and has a value that will be used in AHP method process. Upon accuracy test by comparing data from 2021 to 2023, it is found that the accuracy test in 2021 was 92.9%, while in 2022 it reached 94.7% and the accuracy in 2023 recorded 92.3%. From the results of such system accuracy test, it can be concluded that AHP and MOORA methods can be used to produce recommendations for students who are entitled to receive SIP scholarships in objective manner based on the inputted criteria.**

***Keywords*— Decision Making; Recommendation; Smart Indonesia Program; AHP; MOORA.**

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## I. INTRODUCTION

Elementary and secondary education is an important thing in determining future life. However, due to financial obstacles, some parents have to stop the education of their children. Every country need to pay attention to the development of education sector, because good education is pivotal to create and improve a smart and skilled workforce [1]. The present education will determine the development of a nation in future. Education plays an important 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 aims to provide financial assistance or relief to students aged 6 to 21 years old. 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]. Indonesian government continuously strive 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 Smart Indonesia Program (SIP) [4]. Without adequate IT support, the process of selecting prospective SIP recipient students may be very difficult, not objective and lack of 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]. The aim of SIC is to help education access for students who, in spite of having quality, have underprivileged parental backgrounds, as well as to prevent and reduce the dropouts and to 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) Surakarta city has a vision of producing graduates with strong characters, employable skills and entrepreneurial spirit based on environmentally friendly technology. In 2005, SVHS 5 Surakarta was the first vocational school to successfully obtain an ISO 9001-2000 certificate and was also selected to be the guiding model school for all vocational schools and high schools in Central Java region. SVHS 5 Surakarta

managed to achieve and implement ISO 9001-2015 certificate in 2017. The screening process for SIP recipients is carried out every year to the students of state schools across Indonesia. The process of selecting students who receive SIP is a fairly complicated process to carry out without adequate information system support [8]. This condition and system is also found at SVHS 5 Surakarta, which is selected as the object of case study in this research. SIP selection committee at SVHS 5 Surakarta faces great responsibilities and challenges in selecting students who are really entitled for and need SIP assistance. The use of standard applications to process and calculate the large numbers of SIP registrants as well as data consisting of piles of files becomes a factor that undermines the performance of selection team. The assessment and selection process takes a long process, meanwhile they must maintain high accuracy. This makes the process become susceptible to abuse of authority or data manipulation and prone to errors in data input. Mistaken results of selection process can cause students who deserve and need SIP scholarship may lose their rights.

In an era where information technology is all about, methods contained in DSS are decisive, ranging from simple methods to the complex ones. DSS is a semi-structurally 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 certain technology or systems [11]. DSS can be implemented in various fields to find solutions to various problems [12]. In this research, DSS was created using the AHP and MOORA method. AHP can organize information using a number of 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 influences the resolution of existing problems [14]. AHP method has advantage of creating a pairwise comparison matrix to determine the weight of each criterion and calculate the consistency value [15]. Moora method is a multi-objective optimization technique that can be used to solve various types of complex decision-making problems [16]. Moora method sorts (ranks) each attribute and alternatives based on specified criteria [17]. Moora method performs simple calculations of minimum and maximum values. This method will determine alternatives with good selectivity [18]. The process runs simultaneously that will produce two or more optimal levels [19]. The results of Moora approach are inconsistent results and contain some errors [20]. AHP method used in this research aims to calculate the weight of each criterion that has been determined before entered to set alternative rankings process. AHP can describe complex multi-factor or multi-criteria problems into a hierarchy [21]. Meanwhile, MOORA method is to establish student rankings when the weight of each criterion produced by AHP method is known. By combining AHP and MOORA methods, a solution will be generate consisting of more objective and comprehensive recommendations for SIP recipients.

Some previous studies relating to the selection of SIP assistance beneficiaries with DSS have been made. They include research by Manuhutu that developed a decision support system to select the beneficiaries of Smart Indonesia Program assistance using weighted product method. Here, five criteria are set including: student activeness, certificate of poverty, orphan status, parents' salary, and absenteeism. The prototype model was chosen to develop a web-based decision support system that uses PHP programming language and Bootstrap as a framework [22]. Research by Asnimar compares decision tree algorithm to Naive Bayes to classify the recipients of educational scholarship aid. Ten attributes are used in the research to nominate prospective new STMIK AKBA students who are entitled to receive educational scholarships. They include: smart Indonesia card ownership, a graduate for a maximum of 2 years, report card, and student's average report card. This research produces a classification using a decision tree algorithm with an accuracy value of 44.12% and F1-Score of 34.48%, while Naïve Bayes algorithm accuracy value is 76.47% obtained based on data of diploma grades and average report cards. From these accuracy results, Naïve Bayes algorithm is better when used to classify scholarship recipients than decision tree algorithm [23].

A journal detailing research results by Anggrawan also uses AHP and MOORA methods to provide recommendations for educational scholarship recipients. This research compared the combined use of AHP and MOORA methods, and 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 organization, and compliance to 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 that prevents it from accessing via the internet [24].

Anggrawan's research is applied in universities and has different criteria when applied in schools. Scholarship type discussed is not for SIP assistance so that the criteria used are not a requirement to apply for SIP assistance. The system developed also still uses desktop-based programming so that it cannot be accessed using internet. Our research conducted to apply for SIP assistance with the criteria that have been used by SVHS 5 Surakarta. Our

research objective is to develop a DSS to provide recommendations for students who are eligible to receive SIP scholarships and to evaluate a system by calculating accuracy grade of the method used.

## II. Material And Methods

From previous research results which also discussed DSS for scholarship recipient selection that not using AHP and MOORA methods , it produced a lower level of accuracy. DSS using the AHP and TOPSIS methods produced performance with an accuracy of 56.72% for achievement scholarship recommendations, and 65.21% for bidikmisi scholarship recipients 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, an accuracy using AHP-TOPSIS and SAW methods had a lower level of accuracy compared to using AHP-MOORA method. Choice to using AHP and MOORA methods in our research was based on Anggrawan's research results which also used the same method and produced an accuracy of 94.7%.

### *A. Data Acquisition*

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

The collected data is information about students who apply for SIP assistance. Data obtained from the next data collection stage is used to set criteria needed and used in alternative assessment. For the developed system, 3 three criteria have been established, and for criteria and values they are presented in table 1. Each criterion has several choices for system input and has a value according to the choices that have been made. Each value will affect the process in the AHP method.

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 amoount | < 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 develop is DSS to produce recommendations for the recipients of SIP assistance. This DSS will be applied to recommend recipients eligible for SIP assistance at SVHS 5 Surakarta. Block diagram of the developed system is presented in Fig. 1.

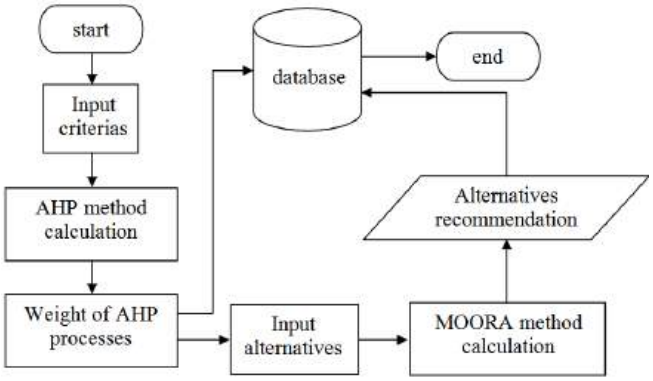


Fig. 1 System architecture

### *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.

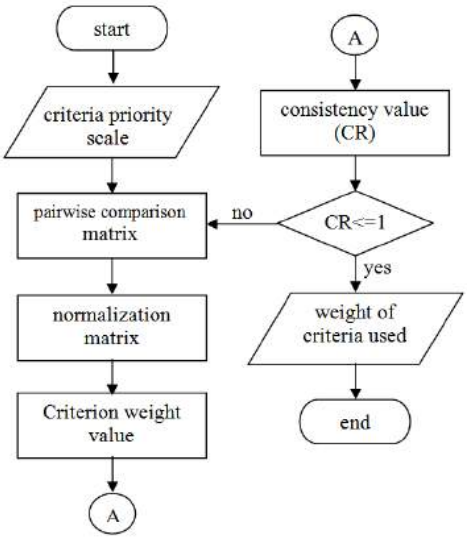


Fig. 2 AHP method process flowchart [29]

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

37) Define problem and determine the desired solution.
38) Create a hierarchical structure initiated with a general objective, followed by criteria, sub-criteria and alternative options that have been set in order.
39) Determine each criteria 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].
40) Value of each column is divided by 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 weight vector.

41) 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 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 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*

MOORA method which was first introduced by Brauers and Zavadskas 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]. MOORA method working process is to run processes simultaneously to optimize two or more conflicting criteria. MOORA method is flexible and easy to understand and separates the subjective part of 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.

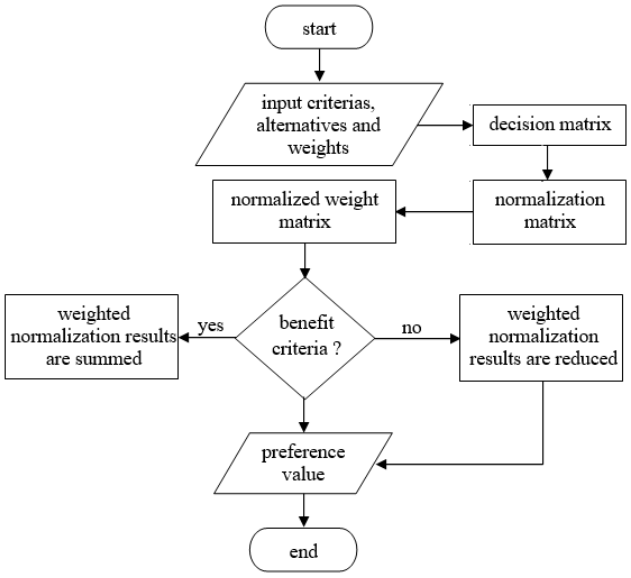


Fig. 3 Alternative Ranking Calculation In MOORA Method [34]

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

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

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

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

$$X_{ij} = \frac{x_{ij}}{\sqrt{\sum_{i}^{m=} x_{ij}^2}}$$

(5)

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

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

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

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

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. Result 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 Comparision 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 explained that a value of 3 in row C-1 and column C-2 comparison means that total earnings are slightly more important than card/letter ownership. In row C-1 column C-3 the comparison value is 5, meaning that sibling amount is more important than Card/letter ownership. Likewise, a value of 3 in row C-2 column C-3 means that sibling amount is slightly more important than 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 criteria:
(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 on the average or weighted value.

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

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

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

5) Calculate the Consistency Ratio (CR)

After getting the t value, the next stage is finding the CI value.

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

Based on existing provisions, a CR value < 10% or 0.1 is said to be consistent. And if <10% or 0.10 means it is inconsistent, then the repetition is repeated starting from the second step and so on until the data becomes consistent.

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

### 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 consistent AHP.

TABLE V
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 VI) with the assessment results for each existing alternative.

TABLE VI
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 VII.

TABLE VII
NORMALIZATIOON 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 AHP method with the normalized matrix.

TABLE VIII
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 adding up all the criteria values (columns) in 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.

6) Sorting Preference Values: Sort the preference values in descending order (from large to small) to obtain priorities or recommendations for alternatives that are entitled to receive SIP assistance. The alternative order of eligible for the SIP scholarship is presented in Table IX.

TABLE IX
ALTERNATIVE RANGKING

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

*C. Implementation AHP Method Process*

Implementation is the stage for implementing the system according to 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 that will be used and calculations to determine which students are entitled to receive SIP assistance. Student scores in applying for SIP assistance are used as consideration to determine the student's eligibility to receive assistance. The information page for student grades can be seen in Fig. 4.


Fig. 4 Student Assessment Page

The initial stage in the AHP method is determining the pairwise comparison matrix. In the developed system, a pairwise comparison 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 MOORA Method Process*

After calculating the AHP method, the next stage is the MOORA method calculation process to obtain results in the form of a sequence of students who deserve assistance. Alternative values function to input student grades which still consist of 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 into a scale of 1-5. Fig. 10 presents the system display for calculation results in 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, next stage is weighted normalization stage. The calculation process is to multiply the normalization results with criteria weights that have been obtained from previous stages of AHP process.

**Weighted Normalization Matrix**

| Name | Card ownership | Total income | Total siblings |
|---|---|---|---|
| AHMAD FAUZUL MUTTAQIN | 0.072180247006069 | 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 carrying out the weighted normalization process, the next stage is to find the preference or optimization value. The optimization value results of the system process can be seen 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 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 | 0.12367454831 15 |
| 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 using direct research at SVHS 5 Surakarta, there are 3 recapitulation data on the results detailing the number of students receiving SIP assistance, namely data for 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 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 studiers failed because of unmatched facts. For 2022, 66 students were produced, 2 students were accepted without facts verification. For 2023, 46 students were produced, 3 students fail to meet fact verification. The accuracy of each value calculated from a confusion matrix is presented in Table XI.

TABLE XI
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 XI, 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. 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. There was a decrease in precision in 2023 compared to 2022. This could be due to regulatory changes regarding requirements or priorities for granting SIP. Other reason include a less objective selection process during interviews or data manipulation.

TABLE XII
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 XII, average precision is 96.3% and 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 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 MOORA method and resulted an accuracy rate of 5.61% [37]. From the comparison with these two previous research, it can be concluded that 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 developed on a web basis and responsive that makes it can appear from a call of a smartphone. 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 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 recommendation letter whether having such letter or not. Other sub-criteria are as presented in table 1. The weight value obtained from AHP calculation results is used as a reference in MOORA calculations and produces recommendations for the order of students who are entitled to receive SIP assistance. To test the system being developed, a comparison was made between the results of system calculations using existing facts at SVHS 5 Surakarta in 2021, 2022 and 2023. From the accuracy test with total income data from 2021 to 2023, the accuracy level was above 93.3%, so it can be concluded that the results of calculations using AHP and MOORA methods are accurate. The percentage results of accuracy level produced in this research are included in very good classification category, so that AHP and MOORA methods are suitable for use to assist a decision making process in 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 a system has the ability to upload student data simultaneously or retrieve data from an external system. For further research, one or two other methods can be used as a comparison of the accuracy results shown in this research.

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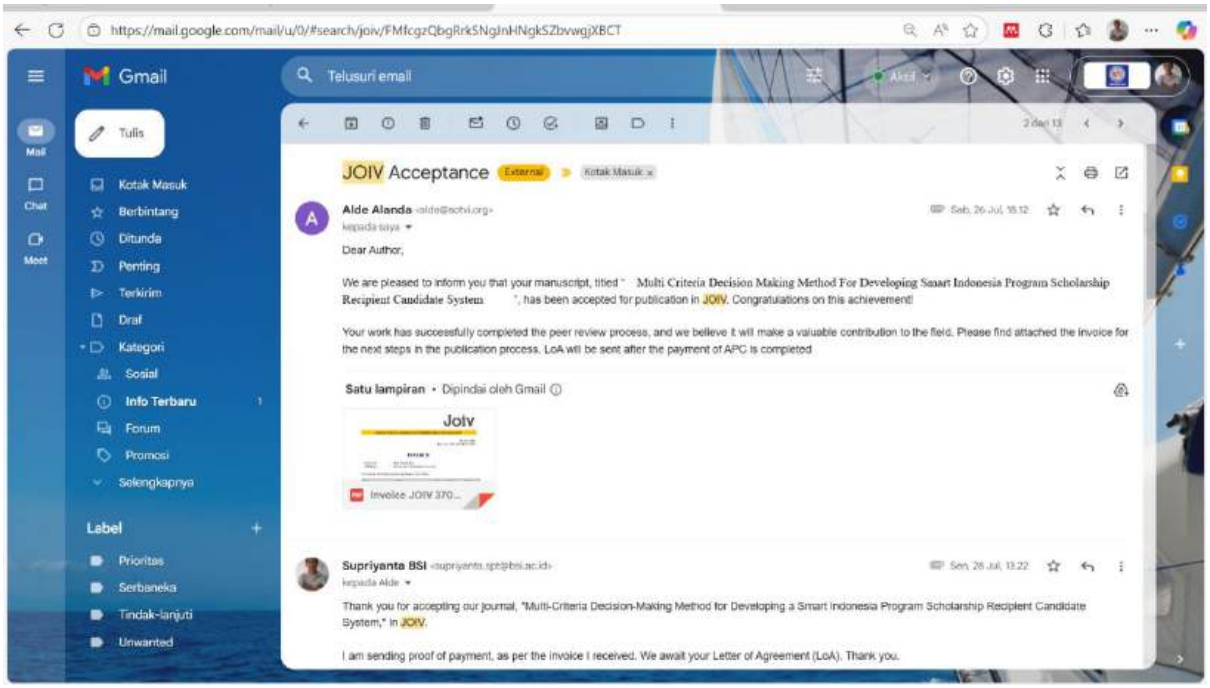

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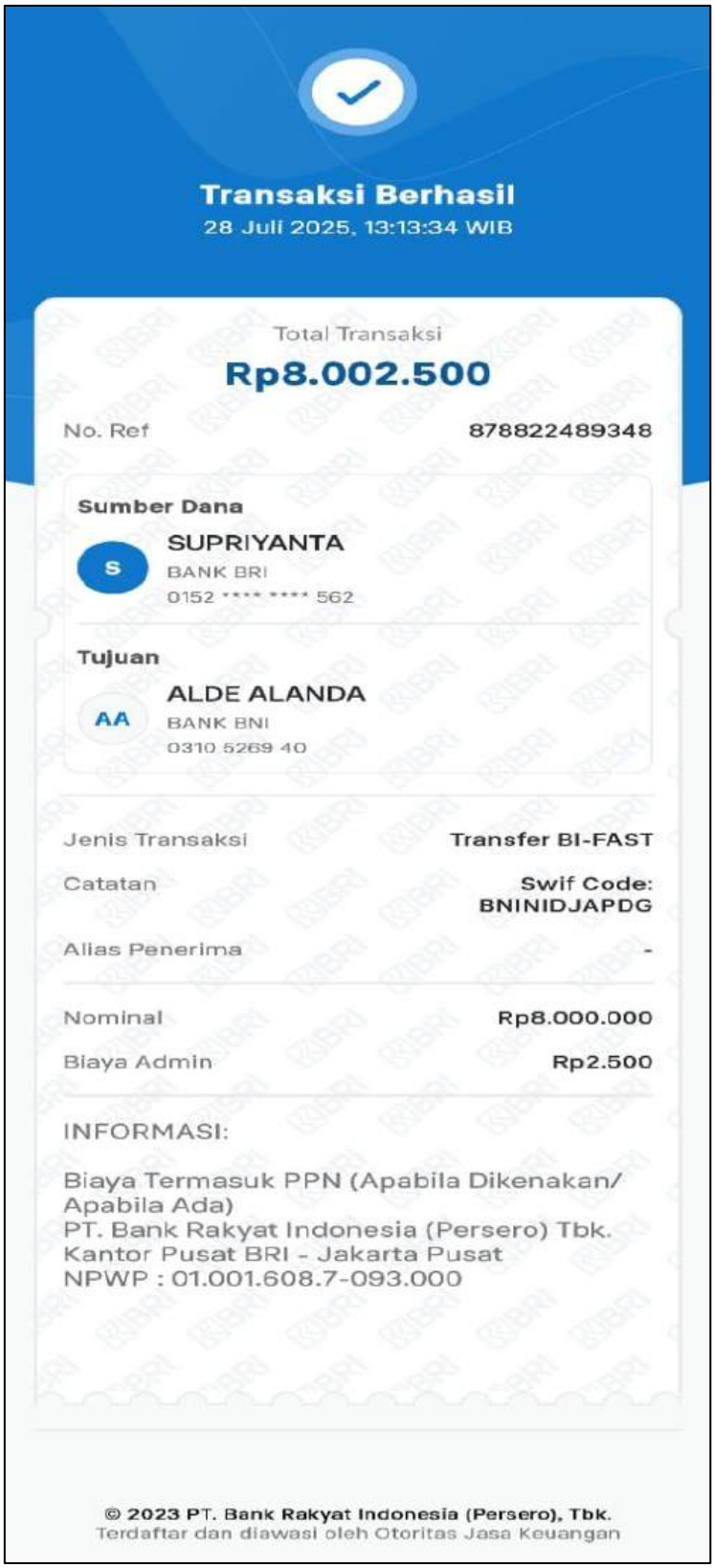

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