EXPLORER
Journal of Computer Science and Information Technology
E-ISSN 2774-4647
Website: https://journal.fkpt.org/index.php/Explorer DOI: https://doi.org/10.47065/explorer.v6i2.2793

Decision Support System for Smartphone Recommendations Based on Consumer Purchasing Power Using the AHP-PROMETHEE Method

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Abstract-The selection of smartphones that match consumer preferences and purchasing power is often challenging due to the large number of alternatives with varying specifications and prices. This research aims to develop a Decision Support System for smartphone recommendations using the Analytical Hierarchy Process (AHP) and Preference Ranking Organization Method for Enrichment Evaluation (PROMETHEE) methods at R Ponsel Store. The AHP method was used to determine the priority weights of criteria based on the results of consumer preference questionnaires, while the PROMETHEE method was applied to rank smartphone alternatives. Data collection was conducted through observation, interviews, and literature studies. The criteria used include price, RAM, ROM, camera, processor, battery, and other supporting specifications. The results showed that the Consistency Ratio (CR) value was 0.035, indicating that the criteria comparison matrix was consistent. Based on the ranking results using the PROMETHEE method, the Redmi Note 14 8/256 achieved the highest net flow value of 0.042, making it the best alternative. The developed system is capable of assisting consumers in obtaining smartphone recommendations that better match their preferences and purchasing power.

Keywords: Decision Support System, Smartphone, AHP, PROMETHEE, Consumer Purchasing Power

1. INTRODUCTION

The rapid development of information technology has become a significant driving force for the global smartphone industry [1],[2]. Smartphone manufacturers continue to compete in offering various devices with diverse specifications, advanced features, and increasingly varied price ranges [3]. As a result, the smartphone market is currently filled with products from different price categories, ranging from entry-level to flagship devices, aimed at consumers with different levels of purchasing power [4]. This condition provides advantages for consumers because more alternative options are available. however, on the other hand, it also makes the decision-making process more complex, especially when consumers must match the desired specifications with their purchasing power limitations [5].

At R Ponsel Store, consumers often face difficulties in selecting smartphones due to the wide variety of available models with different price ranges. In addition, consumers' limited purchasing power makes price the primary criterion in this research, which complicates and prolongs the decision-making process, especially for consumers with limited knowledge of smartphone technical specifications. The smartphone recommendation process by salespersons is still carried out manually and depends on the experience and knowledge of each salesperson. Generally, salespersons only ask about the consumer's desired price range and then provide recommendations based on popular brands, promotional products, or products that need to be sold quickly. These recommendations are still general in nature and are not based on an analysis that specifically considers consumer purchasing power. As a result, consumers sometimes obtain smartphones that are less suitable for their purchasing power and expectations, which may lead to dissatisfaction after purchase.

A Decision Support System (DSS) is a system capable of providing solutions to problems and facilitating the evaluation process by offering a more objective basis for decision-making [6],[7]. By processing data into information and considering various relevant factors in the decision-making process, a DSS is implemented systematically and structurally [8]. A DSS is able to provide alternative solutions and assist in analyzing both structured and unstructured problems [9]. Therefore, a DSS can be used to support decision-making processes for both individuals and organizations such as companies and institutions [10].

This research applies a combination of the AHP and PROMETHEE methods. The AHP method is used to determine the weights of each assessment criterion, including the price criterion, which represents consumer purchasing power more objectively [11]. AHP is widely used in Decision Support Systems, particularly in functional hierarchical structures that utilize human perception as the main input, and it is considered capable of producing accurate weights for each assessment criterion [12],[13]. The AHP method is known as a simple, transparent, efficient, and reliable approach in multicriteria decision-making analysis [14]. Although AHP is effective for determining criterion weights based on their level of importance, the PROMETHEE method is considered superior in the process of ranking alternatives [15]. Therefore, the PROMETHEE method is used to rank smartphone alternatives based on the criterion weights determined using the AHP method.

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The combination of the AHP and PROMETHEE methods has been widely applied in various fields [16]. Indriyani and Putri (2023) applied the AHP and PROMETHEE methods in the process of selecting the best quality watermelons that are suitable for sale and export, thus helping agents in determining fruit priorities based on the weighting and ranking results obtained objectively [17]. Meanwhile, Setiawan and Hartini (2022) used the AHP and PROMETHEE methods in the meat supplier selection process, thus helping catering businesses determine ordering priorities based on the highest-ranking suppliers [18]. Unlike previous studies, the combination of the AHP and PROMETHEE methods in this research is used to develop a Decision Support System for smartphone recommendations that focuses on consumer preferences and purchasing power. The price range or consumer purchasing power is applied as a filter in the smartphone selection process. Preference data are obtained directly from prospective consumers through a criteria comparison questionnaire, enabling the system to generate smartphone recommendations that are more suitable for consumer preferences and purchasing power at R Ponsel Store.

2. RESEARCH METHODOLOGY

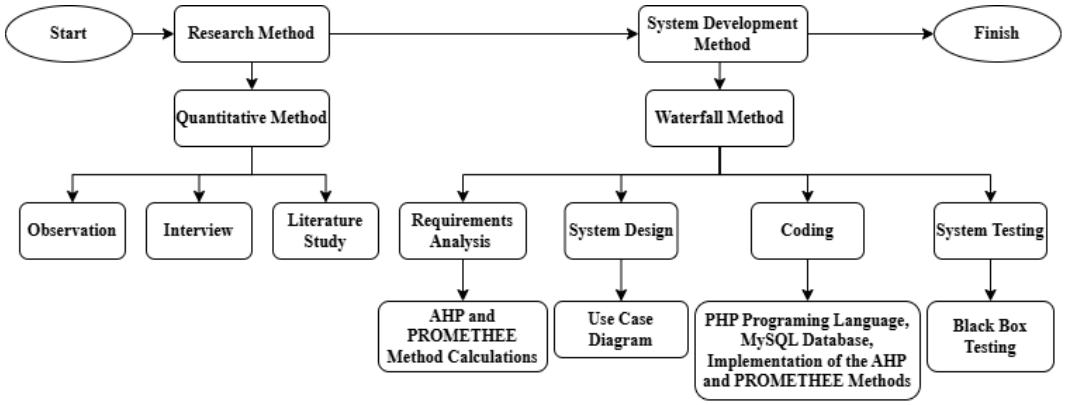

Figure 1. Research Stages

Figure 1 above illustrates the research stages, starting from the data collection process, criteria determination, weight calculation using the AHP method, ranking process using the PROMETHEE method, and ending with system implementation and testing.

2.1 Research Method

This research uses a quantitative approach to develop a Decision Support System for smartphone recommendations using the AHP and PROMETHEE methods based on consumer purchasing power at R Ponsel Store. Quantitative methods are research approaches that utilize numerical data and statistical analysis to produce objective, systematic, and measurable conclusions [19]. The data collection process was conducted through direct observation at R Ponsel Store, interviews with the store management, and literature studies related to the AHP and PROMETHEE methods.

2.2 System Development Method

This research applies the Waterfall model as a framework for system development. The Waterfall method is a structured development approach because each stage is carried out systematically and sequentially [20]. This method is applied after the quantitative research phase and consists of four main stages: requirements analysis followed by AHP and PROMETHEE calculations, system design using a Use Case Diagram, coding using PHP and MySQL along with the implementation of the AHP and PROMETHEE methods, and the final stage involving system testing using Black Box Testing before the system is declared complete.

2.3 Analytical Hierarchy Process (AHP) Method

a. Determining Criteria and Sub Criteria. The criteria and sub-criteria were obtained through interviews with the manager of R Ponsel Store, Akbar Pratama, S.Sos. The criteria data used in this research are presented in Table 1.

Table 1. Criteria

Code	Criteria

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C1	Processor (AnTuTu Score)
C2	RAM (GB)
C3	ROM (GB)
C4	Battery Capacity (mAh)
C5	Front Camera (MP)
C6	Rear Camera (MP)
C7	Screen Refresh Rate (Hz)
C8	Network
C9	Price

Table 1 above shows that there are nine criteria obtained from interview results. Furthermore, the sub criteria data used in this research can be seen in Table 2.

Table 2. Sub Criteria

Code	Criteria	Sub Criteria	Weight
C8	Network	WiFi Only	1
		3G	2
		4G	3
		5G	4
C9	Price	< Rp 3 Million	3
		Rp 3 – 7 Million	2
		> Rp 7 Million	1

Table 2 above shows that only the network and price criteria have sub criteria.

b. Determining respondents from prospective consumers at R Ponsel Store. The respondent data used in this research is presented in Table 3 below.

Table 3. Respondent Data

Name	Purchasing Power
Meilani Safitri	Rp 1–5 Million
Edwar Sugianto	Rp 500 Thousand–2 Million
Rahma Ningse	Rp 2–4 Million
Sulaiman	Rp 800 Thousand–2 Million
Rosiah	Rp 3–8 Million

c. Building the Hierarchy. The AHP method uses a hierarchical structure to solve the problems being addressed [21]. The hierarchy construction process is carried out by defining the objective as the main goal of the system at the highest level [22]. The hierarchical structure in this research is shown in Figure 2 below.

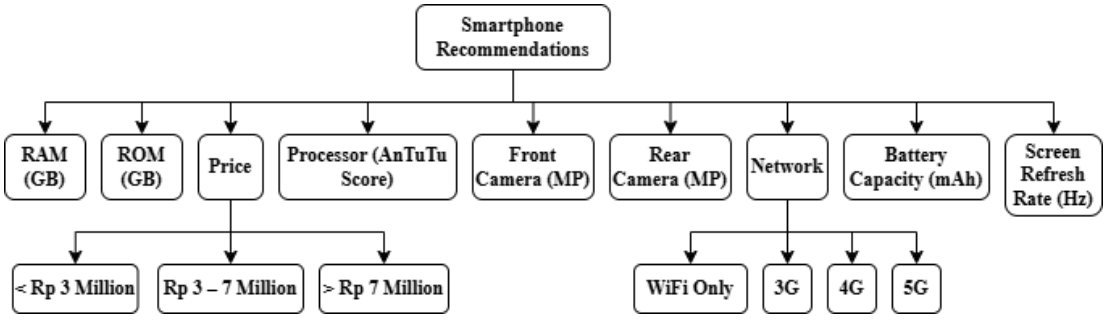

Figure 2. Hierarchy Construction Process

Based on Figure 2 above, it can be seen that the main objective of the system is to provide smartphone recommendations based on the results of a criteria comparison questionnaire conducted by consumers at R Ponsel Store. The second level consists of the criteria used as the basis for comparison, while the third level contains the sub-criteria of each criterion used in the evaluation process.

d. Criteria Assessment. Criteria assessment is carried out using pairwise comparisons based on the Saaty scale defined in the AHP method [23]. The comparison is carried out by considering the elements according to the decision maker's considerations, then the values obtained are entered into a pairwise

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comparison matrix to produce the priority weight of each criterion [24]. This is why AHP is very suitable for this research, as the research uses a questionnaire filled directly by consumers, which produces values in the form of criteria comparisons. Thus, the criterion weights are influenced by consumer preferences.

e. Normalization of the Comparison Matrix. The normalization process is carried out by dividing each comparison value (x) by the total value of each matrix column ($\sum x$).

$$\frac{x}{\sum x} \quad (1)$$

f. Calculating Priority Weights (w). The priority weight values are obtained by dividing the total normalized values of each matrix row ($\sum Row$) by the number of columns in the matrix ($n_{Columns}$).

$$w = \frac{\sum Row}{n_{Columns}} \quad (2)$$

g. Calculating Eigen Value (λ). The eigen value is obtained by multiplying the total value of each column in the comparison matrix ($\sum x$) by the priority weight (w).

$$\lambda = \sum x \ . w \quad (3)$$

h. Calculating Maximum Value ($\lambda\ max$). The maximum value is obtained by summing all eigen values (λ).

i. Calculating the Consistency Index (CI). The CI value is obtained using the following formula, where n is the number of columns in the matrix:

$$\frac{\lambda \max - n}{n - 1} \quad (4)$$

j. Calculating the Consistency Ratio (CR). The result is obtained by dividing the CI value by the Index Ratio (IR). If the CR value is greater than 0.1 (10%), the judgment must be revised. However, if CR ≤ 0.1 (10%), then the pairwise comparison results in the criteria matrix are considered consistent and acceptable [25].

$$CR = \frac{CI}{IR} \quad (5)$$

2.4 Preference Ranking Organization Method for Enrichment Evaluation (PROMETHEE) Method

a. Determining Alternatives. In this research, smartphones are used as alternatives. R Ponsel Store has 80 smartphone models, and 10 models were selected as the research sample.

Table 4. Smartphones Data

Code	Smartphone	Price
A1	POCO C65 6/128	Rp 1.299.000
A2	Redmi Note 14 8/256	Rp 2.599.000
A3	OPPO A5 Pro 8/256	Rp 3.499.000
A4	vivo V50 Lite 8/256	Rp 3.999.000
A5	Redmi Pad Pro	Rp 4.299.000
A6	ZTE Blade A35	Rp 898.000
A7	OPPO Reno13 F 5G 12/256	Rp 5.999.000
A8	Samsung Galaxy A56 5G	Rp 6.199.000
A9	Apple iPhone 16	Rp 14.999.000
A10	Apple iPhone 16 Pro Max	Rp 22.499.000

b. Alternative Assessment. Each alternative is evaluated based on the predetermined sub-criteria weights. Furthermore, the alternatives are filtered according to prices that match the consumer's purchasing power.

c. Calculating Value Differences. The difference in values between alternatives is calculated using the following formula:

$$An - Am \quad (6)$$

Where An represents the value of the first alternative and Am represents the value of the second alternative.

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d. Calculating the Preference Index. The preference index values between alternatives are calculated and then multiplied by the priority weights (w) obtained from the AHP calculation. The preference index formula is presented in Equation (7).

$$H(d) = \begin{cases} 0 \; jika \; \leq 0 \\ 1 \; jika \; > 0 \end{cases} \quad (7)$$

Where $H(d)$ represents the function of the difference in criterion values between alternatives.

e. Calculating the Total Preference Index Value. This process is carried out by summing the preference index values in each row of the matrix.

f. Calculating the Multicriteria Preference Index.

g. Calculating the Leaving Flow Value. The leaving flow value is obtained using the following formula:

$$\varphi^{+}(a) = \frac{1}{n-1} \Sigma_{X \in A} \, \varphi(a, x) \quad (8)$$

h. Calculating the Entering Flow Value. The result is obtained using the following formula:

$$\varphi^{-}(a) = \frac{1}{n-1} \; \Sigma_{X \in A} \, \varphi(a, x) \quad (9)$$

i. Calculating the Net Flow Value. The result is obtained using the following formula:

$$\varphi = \varphi^{+}(a) - \varphi^{-}(a) \quad (10)$$

Description:
$\varphi^{+}(a)$ = Positive Flow value for alternative a
$\varphi^{-}(a)$ = Negative Flow value for alternative a

j. Alternative Ranking. The ranking process is carried out based on the Net Flow values obtained from the previous calculations.

3. RESULTS AND DISCUSSION

In determining smartphone recommendations based on consumer purchasing power, this research uses two methods, namely AHP and PROMETHEE. The initial stage involves calculating the criterion weights using the AHP method. After the weights are obtained, smartphone alternatives are filtered based on consumer purchasing power. Furthermore, the smartphone ranking process is carried out using the PROMETHEE method.

3.1 Implementation of the AHP Method

At this stage, the criteria to be used are first determined before the calculation process is carried out. The calculation steps using the AHP method are as follows:

a. Determining the criteria and sub-criteria along with their weights based on research conducted at R Ponsel Store, as shown in Table 1 and Table 2 previously.

b. The criteria comparison matrix was obtained from the criteria comparison questionnaire completed by the respondents and previously presented in Table 3. In this calculation process, one respondent, namely Meilani Safitri, was used as the sample. Based on the questionnaire results completed by the respondent, the matrix values obtained are shown in Table 5 below.

Table 5. Criteria Comparison

Criteria	C1	C2	C3	C4	C5	C6	C7	C8	C9
C1	1	6,00	4,00	4,00	5,00	5,00	6,00	3,00	2,00
C2	0,17	1	1,00	2,00	3,00	2,00	2,00	1,00	0,50
C3	0,25	1,00	1	2,00	3,00	2,00	2,00	1,00	0,50
C4	0,25	0,50	0,50	1	2,00	2,00	1,00	0,50	0,33
C5	0,20	0,33	0,33	0,50	1	1,00	0,33	0,33	0,33
C6	0,20	0,50	0,50	0,50	1,00	1	0,33	0,33	0,33
C7	0,17	0,50	0,50	1,00	3,00	3,00	1	1,00	0,50
C8	0,33	1,00	1,00	2,00	3,00	3,00	1,00	1	0,50
C9	0,50	2,00	2,00	3,00	3,00	3,00	2,00	2,00	1
Total	**3,067**	**12,833**	**10,833**	**16,000**	**24,000**	**22,000**	**15,667**	**10,167**	**6,000**

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c. Matrix normalization is performed based on the values in Table 5 of the criteria comparison to obtain the priority weights. The normalization is considered correct if the total sum of each column equals one. The results of the matrix normalization can be seen in Table 6 below.

Table 6. Matrix Normalization

Criteria	C1	C2	C3	C4	C5	C6	C7	C8	C9	Row Total	Priority Weight	Eigen Value
C1	0,326	0,468	0,369	0,250	0,208	0,227	0,383	0,295	0,333	2,860	**0,318**	0,974
C2	0,054	0,078	0,092	0,125	0,125	0,091	0,128	0,098	0,083	0,875	**0,097**	1,247
C3	0,082	0,078	0,092	0,125	0,125	0,091	0,128	0,098	0,083	0,902	**0,100**	1,086
C4	0,082	0,039	0,046	0,063	0,083	0,091	0,064	0,049	0,056	0,572	**0,064**	1,017
C5	0,065	0,026	0,031	0,031	0,042	0,045	0,021	0,033	0,056	0,350	**0,039**	0,933
C6	0,065	0,039	0,046	0,031	0,042	0,045	0,021	0,033	0,056	0,378	**0,042**	0,925
C7	0,054	0,039	0,046	0,063	0,125	0,136	0,064	0,098	0,083	0,709	**0,079**	1,234
C8	0,109	0,078	0,092	0,125	0,125	0,136	0,064	0,098	0,083	0,911	**0,101**	1,029
C9	0,163	0,156	0,185	0,188	0,125	0,136	0,128	0,197	0,167	1,443	**0,160**	0,962
Total	**1,000**	**1,000**	**1,000**	**1,000**	**1,000**	**1,000**	**1,000**	**1,000**	**1,000**	**9,000**	**1,000**	

The row total is obtained by summing all values in each row. For example, the calculation for C1 is $0{,}326 + 0{,}468 + 0{,}369 + 0{,}250 + 0{,}208 + 0{,}227 + 0{,}383 + 0{,}295 + 0{,}333 = 2{,}860$. The same calculation process is carried out up to C9.

The priority weight is obtained by dividing the total value of each row by the number of matrix columns. For example, the calculation for C1 is $\frac{2{,}860}{9} = 0{,}974$, and the same process is performed up to C9.

The eigen value is obtained by multiplying the total value of each column in the comparison matrix by the priority weight. For example, the calculation for C1 is $3{,}067 \times 0{,}318 = 0{,}974$, and the same calculation process is carried out up to C9.

d. The maximum value is obtained by summing all eigen values. The calculation is as follows: $0{,}974 + 1{,}247 + 1{,}086 + 1{,}017 + 0{,}933 + 0{,}925 + 1{,}234 + 1{,}029 + 0{,}962 = 9{,}408$.
e. The Consistency Index (CI) value is obtained by subtracting the maximum value from the number of columns, then dividing the result by the number of columns minus one. The calculation is as follows: $CI = \frac{(9{,}408 - 9)}{(9-1)} = 0{,}051$.
f. The Consistency Ratio (CR) value is obtained by dividing the CI value by the Index Ratio (IR) value. Since the number of criteria is 9, the IR value used is 1.45. The calculation is as follows: $CR = \frac{0{,}51}{1{,}45} = 0{,}035$. The result indicates that the comparison matrix is consistent because the CR value is ≤ 0.1.

3.2 Implementation of the PROMETHEE Method

At this stage, the PROMETHEE method is used to rank the alternatives based on the AHP weights obtained previously. The calculation steps using the PROMETHEE method are as follows:

a. Determining smartphones as alternatives along with their criterion values based on research conducted at R Ponsel Store. The alternatives are then filtered according to consumer purchasing power. In this calculation, Meilani Safitri was selected as the sample with a purchasing power range of Rp1 million–Rp5 million. Furthermore, normalization is performed on the criterion values that have sub criteria. The filtered smartphone data along with their values can be seen in Table 7 below.

Table 7. Smartphone Criterion Values

Code	Smartphone	C1	C2	C3	C4	C5	C6	C7	C8	C9
A1	POCO C65 6/128	262438	6	128	5000	8	50	90	3	3
A2	Redmi Note 14 8/256	358794	8	256	5500	20	108	120	3	3
A3	OPPO A5 Pro 8/256	248971	8	256	5800	8	50	120	4	2
A4	vivo V50 Lite 8/256	349440	8	256	6500	32	50	120	3	2
A5	Redmi Pad Pro	609002	8	256	10000	8	8	120	1	2

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Journal of Computer Science and Information Technology
E-ISSN 2774-4647
Website: https://journal.fkpt.org/index.php/Explorer
DOI: https://doi.org/10.47065/explorer.v6i2.2793

b. Calculating the value differences between each alternative. The results of the value difference calculations can be seen in Table 8 below.

Table 8. Alternative Difference Values

Code	C1	C2	C3	C4	C5	C6	C7	C8	C9
A1, A2	-96356	-2	-128	-500	-12	-58	-30	0	0
A1, A3	13467	-2	-128	-800	0	0	-30	-1	1
…	…	…	…	…	…	…	…	…	…
A5, A3	360031	0	0	4200	0	-42	0	-3	0
A5, A4	259562	0	0	3500	-24	-42	0	-2	0

c. Calculating the preference index based on the obtained difference values, then multiplying them by the AHP weights. Furthermore, the values in each row are summed. The preference index results can be seen in Table 9 below.

Table 9. Preference Index

Code	C1	C2	C3	C4	C5	C6	C7	C8	C9	Total
A1, A2	0	0	0	0	0	0	0	0	0	**0**
A1, A3	0,317761	0	0	0	0	0	0	0	0,160379	**0,47814**
…	…	…	…	…	…	…	…	…	…	…
A5, A3	0,317761	0	0	0,063549	0	0	0	0	0	**0,381311**
A5, A4	0,317761	0	0	0,063549	0	0	0	0	0	**0,381311**

d. Calculating the multicriteria preference index, then summing the values in each row and column. The results of the multicriteria preference index can be seen in Table 10 below.

Table 10. Multicriteria Preference Index

Code	C1	C2	C3	C4	C5	Total
A1	0,000	0,000	0,053	0,018	0,034	**0,105**
A2	0,082	0,000	0,062	0,058	0,038	**0,240**
A3	0,049	0,018	0,000	0,011	0,016	**0,094**
A4	0,077	0,011	0,047	0,000	0,020	**0,156**
A5	0,073	0,042	0,042	0,042	0,000	**0,200**
Total	**0,281**	**0,072**	**0,204**	**0,129**	**0,108**	

e. Calculating the leaving flow value using Equation (8). The results of the leaving flow calculation can be seen in Table 11 below.

Table 11. Leaving Flow Values

Code	Value
A1	0,026
A2	0,060
A3	0,024
A4	0,039
A5	0,050

f. Calculating the entering flow value using Equation (9). The results of the entering flow calculation can be seen in Table 12 below.

Table 12. Entering Flow Values

Code	Value
A1	0,070
A2	0,018
A3	0,051
A4	0,032
A5	0,027

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E-ISSN 2774-4647
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g. Calculating the net flow value using Equation (10), then performing ranking based on the obtained net flow values. The net flow values and ranking results can be seen in Table 13 below.

Table 13. Net Flow Values and Rankings

Code	Value	Rangking
A1	-0,044	5
A2	0,042	1
A3	-0,027	4
A4	0,007	3
A5	0,023	2

Table 13 shows that the Redmi Note 14 8/256 (A2) smartphone obtained the highest net flow value because it has the most suitable combination of specifications and price according to consumer preferences and purchasing power.

3.3 Use Case Diagram

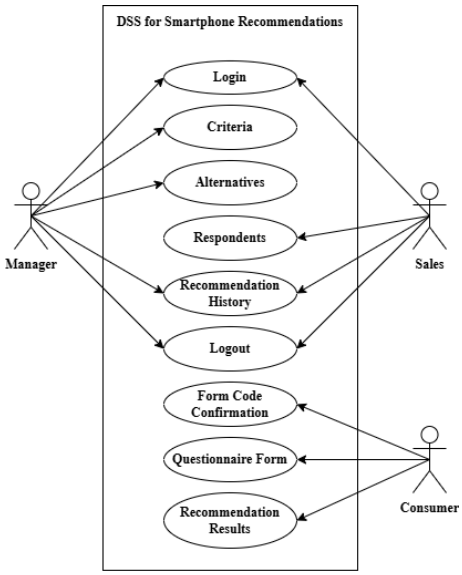

Figure 3. Use Case Diagram

Figure 3 above illustrates the Use Case Diagram of the Decision Support System (DSS) for smartphone recommendations, which involves three main actors: the Manager, Sales, and Consumer.

3.4 System Implementation

In this research, the system pages presented focus only on the main features related to the decision-making process and smartphone recommendation results, so that the discussion remains more focused on the research aspects.

a. Respondent Page

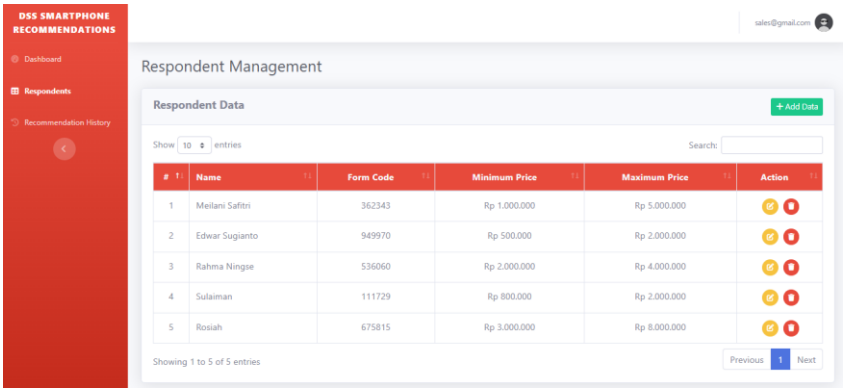

Figure 4. Respondent Page

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E-ISSN 2774-4647
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Figure 4 shows the display of the respondent data management page. After respondent data is added, the system automatically generates a form code and provides empty values for AHP criteria comparisons, which are then used as a questionnaire.

b. Form Code Confirmation Page

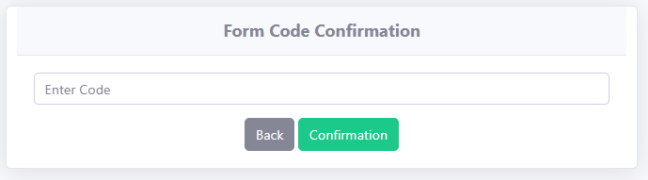

Figure 5. Form Code Confirmation Page

Figure 5 shows the form code confirmation page in the system. This page is used to enter the available form code so that users can access the questionnaire page.

c. Questionnaire Page

Figure 6. Questionnaire Page

Figure 6 shows the questionnaire page in the system. This page allows users to fill in or modify the criteria comparison values according to their individual preferences.

d. Recommendation Results Page

Figure 7. Recommendation Results

Figure 7 above shows the recommendation results page in the system. This page allows users to view smartphone recommendations based on the results of the previously completed criteria comparison questionnaire.

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Website: https://journal.fkpt.org/index.php/Explorer DOI: https://doi.org/10.47065/explorer.v6i2.2793

e. Recommendation History Page

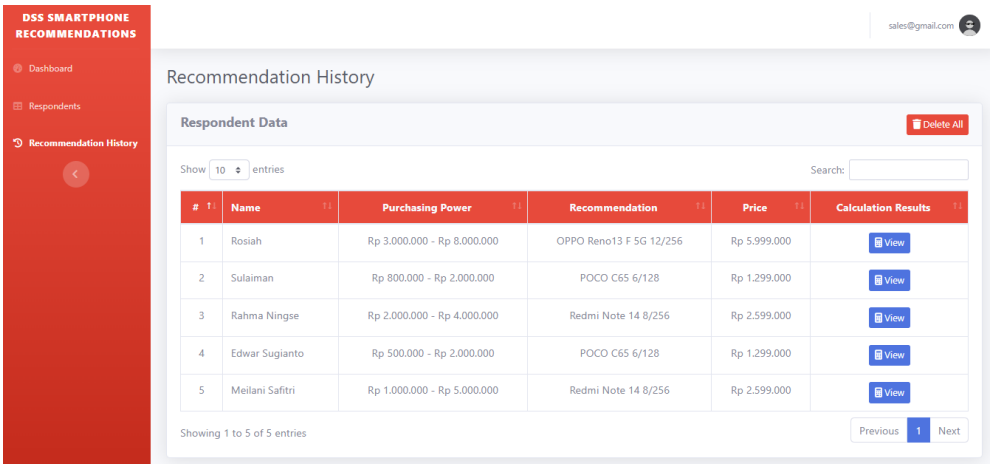

Figure 8. Recommendation History Page

Figure 8 shows the recommendation history page, which is used to display each consumer's smartphone recommendation results based on the system's calculation process.

3.5 System Testing

Table 14. Black Box Testing

#	Tested Page	Expected Result	Final Result
1	Login	Display login form so users can access the system	Valid
2	Criteria	Add, edit, and delete criteria data	Valid
3	Alternatives	Add, edit, and delete alternative data	Valid
4	Respondents	Add, edit, and delete respondent data	Valid
5	Form Code Confirmation	Validate respondent form code	Valid
6	Questionnaire Form	Edit criteria comparison values	Valid
7	Recommendation Results	View smartphone recommendation page	Valid
8	Recommendation History	View each consumer's smartphone recommendation results	Valid
9	Calculation Results	View manual calculation results	Valid

Table 14 above shows the results of system testing using the Black Box Testing method to ensure that all system functions run properly and meet the required specifications.

4. CONCLUSION

This research successfully developed a Decision Support System for smartphone recommendations based on consumer purchasing power using a combination of the AHP and PROMETHEE methods. The AHP method is used to determine the priority weights of each evaluation criterion, while the PROMETHEE method is used to rank smartphone alternatives based on the obtained weights. The criteria used include processor, RAM, ROM, battery capacity, front camera, rear camera, screen refresh rate, network, and price. The test results show a Consistency Ratio (CR) value of 0.035, indicating that the comparison matrix is consistent and can be used in the decision-making process. Based on the calculation results using respondent data from Meilani Safitri with a purchasing power range of Rp1 million–Rp5 million, the Redmi Note 14 8/256 smartphone obtained the highest net flow value of 0.042, making it the best alternative. These results indicate that the system is able to provide smartphone recommendations that are more aligned with consumer preferences and purchasing power. In addition, the system can assist store staff, especially salespersons, in providing product recommendations in a more effective, measurable, and personalized manner. This research still uses a limited number of smartphone alternatives so that the recommendation results can be further developed by adding alternative variations and assessment criteria.

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