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Decision Support System for Selecting Rescuer Candidates for Basarnas Special Group Using SMART And BORDA

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Abstract *– The National Search and Rescue Agency (also known as BASARNAS) is a government agency responsible for offering search and rescue services in the event of an accident or disaster. At BASARNAS there is a special team, the BASARNAS Special Group (BSG). BSG performs rescues during national and international disasters or accidents. BSG itself consists of selected people, namely BSG candidates from all search and rescue office rescuers in Indonesia. BSG candidates themselves are still calculated manually so that it can affect the time efficiency of SAR personnel in making selections, this research was conducted at the Medan Class A Search and Rescue Office. To ensure that BSG candidates are accurate and processed quickly, a decision support system is needed. This time the researchers utilized the Simple Multi Attribute Rating Technique (SMART) and BORDA methods to determine BSG candidates. With the criteria used, namely fitness (K1), physical health (K2), mental health (K3) and creativity (K4). Then the alternatives used are 25 alternatives which include 20 skilled rescuers and 5 beginner rescuers. and the results can be saved in the form of a PDF file. The results of calculations using the SMART and BORDA methods found that among skilled rescuers, Rescuer-T15 is a suitable candidate to become a BSG candidate by obtaining a total score of 6049.25 and among novice rescuers, Rescuer-P5 obtained the highest score of 756.00.*

Keywords – DSS, Rescuer, BSG, SMART, BORDA

I. INTRODUCTION

Human safety is the top priority in every rescue operation carried out by the Badan SAR Nasional on land, sea and air. This is because human safety is the most fundamental human value and is the ultimate goal of every SAR action. The concept of SAR encompasses various tasks involving the search, assistance, and rescue of individuals who are at high risk due to circumstances like being misplaced or in peril during events such as aviation incidents, maritime accidents, or natural calamities. Badan SAR Nasional or BASARNAS is a non-ministerial government agency responsible for providing SAR or Search and Rescue services in disaster or accident situations[1]. Medan Class A Search and Rescue Office is one of the organizations in the formal environment of the government apparatus and is responsible to the Head of the BASARNAS. This office makes a considerable contribution to the search and rescue of missing people and materials in the province of North Sumatra[2].

Rescuers are officers responsible for rescuing and helping disaster victims in various terrains, including land, sea and air. Rescuers are specially trained and skilled in rescue techniques and strategies, and are equipped with adequate equipment and tools to deal with different disaster situations. They also have the ability to communicate with various related parties in order to coordinate and handle disasters effectively[3].

At the Badan SAR Nasional there are *Basarnas Special Group* (BSG) personnel, BSG itself consists of BASARNAS rescuer personnel selected from all over Indonesia. BSG refers to a distinguished group within BASARNAS that possesses exceptional expertise in a range of specialized areas, including *Medical First Responder* (MFR), *High Angle Rescue Technique* (HART), *Jungle Rescue*, *Water Rescue*, *Heli Rescue*, *Collapsed Structure Search and Rescue* (CSSR), as well as Parachuting. The selection process for BSG Candidate Rescuers relies on multiple criteria, which are currently assessed and documented manually. However, this manual approach often leads to inaccurate calculations, resulting in the inconsistent determination of all rescuers, including both experienced and novice individuals. To get rescuers who are suitable to be BSG candidates with consistent, accurate calculations, and processed through computing speed and can emphasize statements about the quality of rescuers who are candidates, it is necessary to have a decision support system that can determine rescuers.

To resolve the problems above, it is necessary to build a *Decision Support System* (DSS), DSS is a system used to assist decision making by collecting, analyzing, and processing information to produce the best alternative decisions[4]. In this study, the SMART (*Simple Multi Attribute Rating Technique*) and BORDA methods will be applied. To determine the ranking of rescuer selection decisions. Some previous studies that are relevant research objects such as [5] Decision Support System for Selection of the Best Members of the Fire Department Using the *Analitycal Hierarchy Process* (AHP) Method and [6] *Analitycal Hierarchy Process* and BORDA Methods for Selection of School Operational Exemption Recipients.

This research aims to accelerate and improve the effectiveness and efficiency in selecting the right rescuer to be a BSG candidate at the center. In addition, this research also aims to provide solutions to problems that often arise in the rescuer selection process, such as subjectivity in decision making. By using the SMART and BORDA

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methods, it is hoped that an objective decision support system can be created and can help make more accurate and precise decisions in selecting BSG candidate rescuers at the Search and Rescue Office.

A. Decision Support System

In essence, the Decision Support System (DSS) is specifically developed to aid every step of the decision-making process. This includes tasks such as problem definition, selection of pertinent data, determining the appropriate approach for decision-making, and evaluating different alternatives. A decision support system is essentially an information system that supplies data, information, and modeling capabilities for data manipulation[7]. This system is used to assist decision making in semi-structured situations, where no one knows exactly how decisions should be made. Decision support systems aim to increase the effectiveness of decisions with computational speed that can increase productivity and decision quality so as to assist managers in making decisions[8].

B. Rescuer

A rescuer is an officer who works at the Indonesian Badan SAR Nasional (BASARNAS). The main task of a rescuer is to perform rescue or first aid on victims of natural disasters or accidents at sea, air and land. They are also trained in rescue techniques which include rescuing people trapped under collapsed buildings, stranded on remote islands, lost in forests or mountains, and many more. Rescuers themselves are equipped with modern rescue equipment and communication tools to help them in their rescue missions[9]. Some of the equipment includes diving equipment, land rescue equipment, and other supporting equipment such as vehicles, medical equipment, and others[10].

C. Basarnas Special Group

Basarnas Special Group personnel consist of selected BASARNAS personnel, known as BSG. A team of rescuers is assembled through a rigorous selection process that involves individuals from diverse work units within Basarnas. BSG is educated and trained to have special abilities in the field of search and rescue. Basarnas Special Group was formed to assist and accelerate the implementation of SAR operations in aviation, shipping, disaster and other disasters that are national in scale, or have a high level of difficulty.

D. Simple Multi Attribute Rating Technique Method (SMART)

The SMART Method is a technique for multi-attribute decision-making, which assists decision makers in selecting the most suitable alternative among several options. In this method, each decision maker is required to choose an alternative that aligns with the predetermined objectives[11].

According to [12], [13] The steps used for solving the Simple Multi Attribute Rating Technique (SMART) method are as follows:

1. Determine Criteria and Weights
   In order to establish the criteria employed in this decision-making system, it is necessary to obtain data from knowledgeable parties who possess expertise in the specific problem that needs to be addressed [14].
2. Then normalization is carried out. The formula used for weight normalization is as below:
   $$w_i = \frac{w'_i}{\sum_{j=1}^{m} w_j} \quad (1)$$
   Description:
   w_i : normalized criterion weight for the i-th criteria
   w'_i : weight of the i-th criteria
   w_j : j-th criteria weight
   j : 1,2,3, ... , m number of criteria
3. Calculate each utility value for each criterion respectively.
   $$u_i(a_i) = \frac{c_{max} - c_{min}}{c_{max} - c_{min}} \text{ x } 100 \quad (2)$$
   If Criteria is worth *benefit*
   $$u_i(a_i) = \frac{c_{out} - c_{min}}{c_{max} - c_{min}} \text{ x } 100 \quad (3)$$
   If Criteria is worth *cost*
   Description:
   $u_i(a_i)$: utility value of the i-th criteria for the i-th alternative
   c_{max} : maximum criteria score
   c_{min} : minimum criteria score
   c_{out} : i-th criteria value
4. Determining the Final Grade
   The final value is calculated by aggregating the collective outcomes of the utility value and the normalized weight value of the criteria.
   $$u(a_i) = \sum_{j=1}^{m} w_j * u_j(a_i) \quad (4)$$
   Description:
   $u(a_i)$: total value for the i-th alternative
   w_j : normalized jth criterion weight value
   $u_j(a_i)$: utility value of the jth criterion for the i-th alternative
5. Ranking
   After calculating the final value, the results are then arranged in descending order, with the alternative having the highest final value considered as the best alternative [15].

E. BORDA Method

BORDA method does not take into account the subjective views of the decision makers, which greatly influence the group's decision[16]. The Borda method is utilized to assess the complexity of the voting system election[17]. The Borda method is a method used in decision making for single winner and multiple winner elections, where voters rank the candidates based on the choice of data[18].

According to [16] The stages of solving a case using the Borda method are as follows:

1. In the decision-making process, each decision maker assigns a value of n-1 to the top-ranked alternative, a value of n-2 to the second-ranked alternative, and so on, with a value of 0 assigned to the least preferred alternative.
2. The alternative that obtains the highest cumulative score is declared as the winner.
3. For example: there are 3 alternatives with 9 voters

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Alternative: 2, 1, 0
4 sample where A > B > C A: 4x2+3x0+2x0 = 8 votes
3 sample where B > C > A B: 4x1+3x2+2x1 = 12 votes
2 sample where C > B > A C: 4x0+3x1+2x2 = 7 votes
Note: rank 1 is given a value of 2, rank 2 is given a value of 1, and rank 3 is given a value of 0. Where n = 3. The result is B as the winner.

F. Research & Development Method (R&D)

The R&D method is a research approach employed to develop products and assess their effectiveness through testing [19]. The stages carried out in the Research and Development method begin with researching and analyzing the needs or problems to be researched and then formulating a research plan by formulating problems, determining objectives, determining problem boundaries, conducting literature studies, and carrying out data collection with certain techniques[20].

G. Unified Modelling Language (UML)

UML (Unified Modeling Language) offers a set of language and modeling concepts, along with a user-friendly graphical notation, to facilitate the modeling of diverse application domains. It enables the specification, design, visualization, and documentation of software systems. The outcome of utilizing UML for modeling is a graphical representation comprising different diagrams that provide various perspectives of the system [21].

II. RESEARCH METHODOLOGY

A. Researh and Development Method (R&D)

In this research, the author collected data by interview, observation, and literature study. The explanation of the data sources is as follows:

1. Interview
   In this case the author conducted interviews with several employees of the Medan Class A Search and Rescue Office, such as the Head of General Subdivision, Head of Operations, Head of Resources, Advanced Rescuer, Advanced Staffing Analyst and Rescuer Supervisor regarding the criteria that determine the selection of rescuers.
2. Observation
   In this case the author makes direct observations at the Medan Class A Search and Rescue Office to obtain information.
3. Literature Study
   The data collection approach involved examining and investigating relevant books, online sources, journals and theses to identify the most suitable rescuers.

B. System Requirements Analysis

This stage is an analysis of system requirements by collecting data. This stage produces *user requirements* or *user desires* in making the system.

C. Design

At this stage aims to provide an overview of the appearance that will be done along with an overview of the stages that will be done. In the design stage the author uses UML (*Unified Model Language*) as system modeling, the UML used is: *Use Case Diagram*. In the design stage the author also describes the database design and interface design using Microsoft Visio 2019 which will later become a reference in making program code.

D. Program Design

Program code generation refers to the process of converting a design into a programming language that can be understood and executed by a computer. In this research, the author will make program code using the CSS programming language for the user interface with the Visual Studio Code text editor and the Hypertext Preprocessor programming language for implementing algorithms into the database using the local server XAMPP.

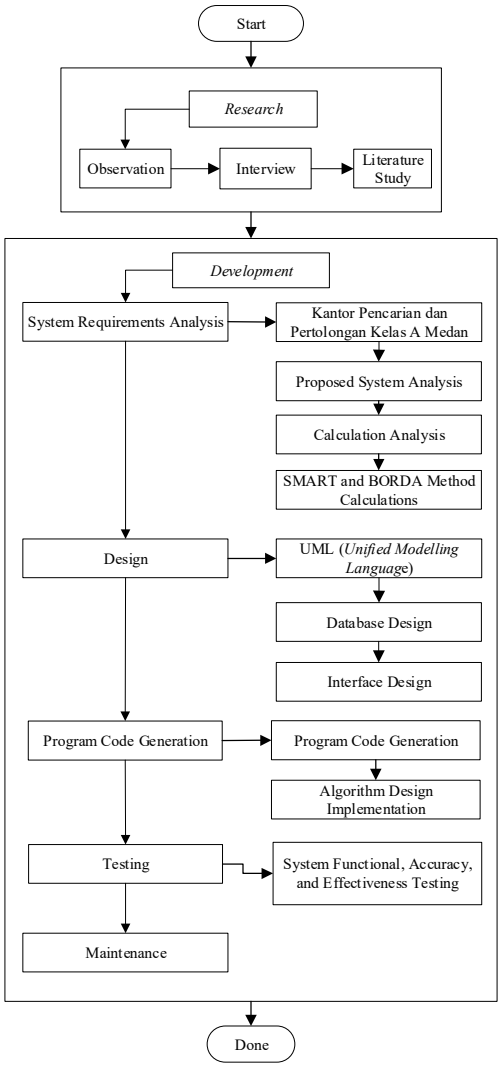

Fig1. R&D Method

E. Testing Techniques

At this stage, what is done for testing is testing the program to test the system completely according to the needs and find errors or bugs that may occur. At this stage the author will test the accuracy of system calculations with manual calculations to see the level of accuracy[22]. The product effectiveness testing stage is also carried out to see

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the success rate of a product or system that has been built[23].

F. Maintenance

At this stage, the system will be implemented to users and later the system will be carried out a maintenance process.

G. SMART and BORDA Method Algorithms

The SMART (Simple Multi Attribute Rating Technique) and BORDA method algorithms can be seen in the figure below:

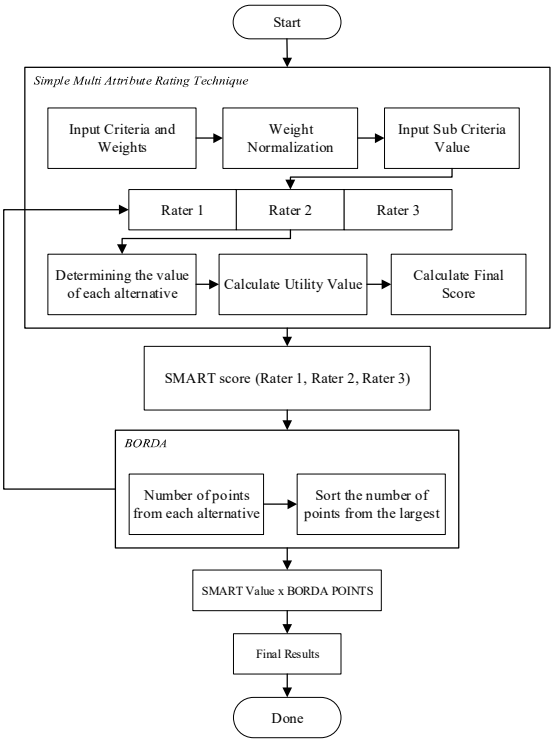

Fig 2. SMART and BORDA Method Algorithms

III. RESULTS AND DISCUSSION

The implementation of this system is carried out using two methods, namely weighting criteria using the SMART method, scoring with the BORDA method, and ranking with SMART scores and BORDA points.

A. Criteria and Weights

The criteria used in this decision support system are as follows:

Table 1. Criteria and Weights

No	Code	Criteria	Weight
1	K1	Fitness	35
2	K2	Physical Health	30
3	K3	Mental Health	25
4	K4	Creativity	20
Total			100

Determination of table 1 on the weight of the criteria obtained from BASARNAS. From table 1, it can be seen that there are 4 criteria that will be used as a benchmark for assessing BSG candidates in this study. And each criterion is shortened in letters and numbers such as K1 in table 1.

B. Normalization

After obtaining the weight value for each criterion, then the normalization calculation is carried out, normalization is carried out by dividing the weight value of the criteria by the total weight.

Table 3. Normalization

No	Code	Weight Normalization	Total
1	K1	35/100	0,35
2	K2	25/100	0,25
3	K3	25/100	0,25
4	K4	15/100	0,15

C. Sub-Criteria Score

Table 2. Sub-Criteria

No	Criteria	Sub-Criteria	Value
1	Fitness	Very Masterful	12
		Mastering	6
		Not Mastering	4
		Very Poorly Mastered	2
2	Physical Health	Very Good	12
		Good	6
		Not Good	4
		Not Very Good	2
3	Mental Health	Very Good	12
		Good	6
		Not Good	4
		Not Very Good	2
4	Creativity	Very Creative	12
		Creative	6
		Not Creative	4
		Very Uncreative	2

D. Utility Value

The data used has two job titles, Rescuer-T is Skilled Rescuer, and Rescuer-P is Beginner Rescuer. As there are 3 raters, only one will be assessed to calculate the utility value, the following table is a fraction of the overall BSG candidate data:

Table 4. BSG Candidate Data

No	Sample	K1	K2	K3	K4
1	Rescuer-T 1	12	6	6	6
2	Rescuer-T 2	12	6	12	6
3	Rescuer-T 3	12	12	12	6
…	…..	…	…	…	…
25	Rescuer-P 5	12	6	4	2

Table 4 is a change in the number of BSG candidate assessments. From these changes, we can see the maximum value and minimum value that will then be determined.

Table 5. Minimum and Maximum Values

Value Category	K1	K2	K3	K4
Minimum Value	2	2	4	2
Maximum Value	12	12	12	12

After obtaining the maximum and minimum values, the utility value is calculated with alternative values using the theory with the benefit equation as below.

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$$u_{(Rescuer-T1)}(K1) = \frac{(12-2)}{(12-2)} x100 = 100 \qquad u_{(Rescuer-T2)}(K1) = \frac{(12-2)}{(12-2)} x100 = 100$$

$$u_{(Rescuer-T\ )}(K2) = \frac{(6-2)}{(12-2)} x100 = 40 \qquad u_{(Rescuer-T2)}(K2) = \frac{(6-2)}{(12-2)} x100 = 40$$

$$u_{(Rescuer-T1)}(K3) = \frac{(6-4)}{(12-4)} x100 = 25 \qquad u_{(Rescuer-T2)}(K3) = \frac{(12-4)}{(12-4)} x100 = 100$$

$$u_{(Rescuer-T\ )}(K4) = \frac{(6-2)}{(12-2)} x100 = 40 \qquad u_{(Rescuer-T2)}(K4) = \frac{(6-2)}{(12-2)} x100 = 40$$

$$u_{(Rescuer-T3)}(K1) = \frac{(12-2)}{(12-2)} x100 = 100 \qquad u_{(Rescuer-P5)}(K1) = \frac{(12-2)}{(12-2)} x100 = 100$$

$$u_{(Rescuer-T3)}(K2) = \frac{(12-2)}{(12-2)} x100 = 100 \qquad u_{(Rescuer-P5)}(K2) = \frac{(6-2)}{(12-2)} x100 = 40$$

$$u_{(Rescuer-T3)}(K3) = \frac{(12-4)}{(12-4)} x100 = 100 \qquad u_{(Rescuer-P\ )}(K3) = \frac{(4-4)}{(12-4)} x100 = 0$$

$$u_{(Rescuer-T3)}(K4) = \frac{(6-2)}{(12-2)} x100 = 40 \qquad u_{(Rescuer-P5)}(K4) = \frac{(2-2)}{(12-2)} x100 = 0$$

Table 6. Utility Value Result

No	Sample	K1	K2	K3	K4
1	Rescuer-T 1	100	40	25	40
2	Rescuer-T 2	100	40	100	40
3	Rescuer-T 3	100	100	100	40
…	…..	…	…	…	…
25	Rescuer-P 5	100	40	20	0

E. Final Grade Determination

To determine the final score, the normalized value is multiplied by the utility value as below.

Table 7. Results of the Final Value of Rater I

No	Sample	K1	K2	K3	K4
1	Rescuer-T 1	0,35x100=35	0,25x40=10	0,25x25=6,25	0,15x40=6
2	Rescuer-T 2	0,35x100=35	0,25x40=10	0,25x100=25	0,15x40=6
3	Rescuer-T 3	0,35x100=35	0,25x100=25	0,25x100=25	0,15x40=6
…	…..	…	…	…	…
25	Rescuer-P 5	0,35x100=35	0,25x40=10	0,25x0=0	0,15x0=0

Table 8. Rating Results of Rater I

No	Sampel	K1	K2	K3	K4	SMART Value
1	Rescuer-T 1	35	10	6,25	6	57,25
2	Rescuer-T 2	35	10	25	6	76,00
3	Rescuer-T 3	35	25	25	6	91,00
4	Rescuer-T 4	14	10	6,25	3	33,25
5	Rescuer-T 5	14	10	6,25	6	36,25
6	Rescuer-T 6	35	25	6,25	6	72,25
7	Rescuer-T 7	35	25	6,25	15	81,25
8	Rescuer-T 8	14	10	6,25	3	33,25
9	Rescuer-T 9	35	10	6,25	3	54,25
10	Rescuer-T 10	35	0	6,25	6	47,25
11	Rescuer-T 11	14	10	25	6	55,00
12	Rescuer-T 12	35	5	6,25	6	52,25
13	Rescuer-T 13	14	10	25	3	52,00
14	Rescuer-T 14	35	25	6,25	6	72,25
15	Rescuer-T 15	35	25	25	15	100,00
16	Rescuer-T 16	14	10	25	15	64,00
17	Rescuer-T 17	14	25	6,25	3	48,25
18	Rescuer-T 18	35	10	6,25	3	54,25
19	Rescuer-T 19	35	5	6,25	6	52,25
20	Rescuer-T 20	35	10	6,25	3	54,25
21	Rescuer-P 1	14	5	6,25	0	25,25
22	Rescuer-P 2	7	10	6,25	3	26,25
23	Rescuer-P 3	0	10	6,25	3	19,25
24	Rescuer-P 4	14	25	0	0	39,00
25	Rescuer-P 5	35	10	0	0	45,00

F. Poin BORDA

The SMART value that has been obtained is multiplied by BORDA points with the Tournament Style with the highest rank getting the largest value with the number n or the number of alternatives, the next rank will get n-1, n-2 and so on.

Table 9. Results of BORDA Points Rater I

No	Sample	SMART Value	Point BORDA	Total
1	Rescuer-T15	100,00	25	2500,00
2	Rescuer-T3	91,00	24	2184,00
3	Rescuer-T7	81,25	23	1868,75
…	…..	…	…	…
25	Rescuer-P3	19,25	1	19,25

G. SMART and BORDA Calculation Results for All Assessors

The total of the SMART and BORDA multiplication, summed by several raters, gives the final score, which can determine who is eligible to become a BSG candidate.

Table 10. Ranking Result

Rank	Sample	Rater I	Rater II	Rater III	Total
1	Rescuer-T15	2500,00	1518,00	2031,25	6049,25
2	Rescuer-T3	2184,00	1584,00	2031,25	5799,25
3	Rescuer-T7	1868,75	1086,75	1770,00	4725,50
4	Rescuer-T2	1672,00	795,00	992,25	3459,25
5	Rescuer-T6	1445,00	514,50	573,75	2533,25
6	Rescuer-T19	903,00	679,25	675,75	2258,00
7	Rescuer-T14	1517,25	47,00	636,00	2200,25
8	Rescuer-T1	1030,50	231,00	840,75	2102,25
9	Rescuer-T4	1012,00	133,00	715,50	1860,50
10	Rescuer-T17	920,00	482,50	332,50	1735,00
11	Rescuer-T10	1039,50	88,50	425,25	1553,25
12	Rescuer-T16	1216,00	126,00	210,00	1552,00
13	Rescuer-T20	868,00	390,00	273,00	1531,00
14	Rescuer-T9	759,50	59,00	661,50	1480,00
15	Rescuer-T12	722,00	108,00	627,00	1457,00
16	Rescuer-T11	935,00	189,00	285,00	1409,00
17	Rescuer-T13	572,00	570,00	73,75	1215,75
18	Rescuer-T18	813,75	210,00	105,00	1128,75
19	Rescuer-T5	480,00	217,50	189,00	886,50
20	Rescuer-P5	360,00	144,00	252,00	756,00
21	Rescuer-T8	356,25	231,00	166,25	753,50
22	Rescuer-P4	273,00	27,75	144,00	444,75
23	Rescuer-P1	50,50	75,00	12,50	138,00
24	Rescuer-P2	78,75	17,50	3,00	99,25
25	Rescuer-P3	19,25	8,75	27,75	55,75

In this manual calculation, it is found that Rescuer-T15 deserves to be a BSG candidate with a total score of 6049.25 and Rescuer-P5 who got the highest score at the beginner level with a score of 756.00.

H. Usecase Diagram SMART & BORDA

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In the Use Case Diagram below, there are 4 actors who play a role in the course of the program.

The first actor is the admin, the admin can perform the login logout process, manage data such as criteria data, sub-criteria, weights, rater reminders, manage users and SMART & BORDA reports.

The second, third and fourth actors are Appraisers I, II, and III, in this system appraisers can log in, dashboard, view SMART&BORDA reports, and conduct assessments.

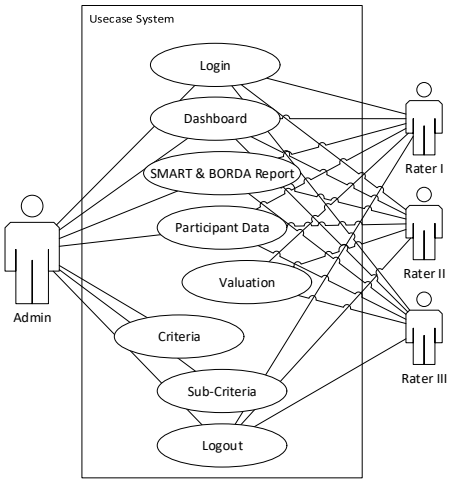

Fig 3. Usecase Diagram SMART&BORDA

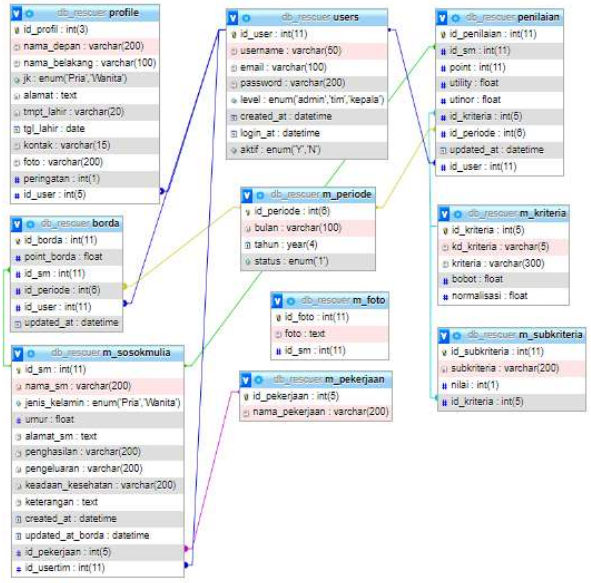

Fig4. Database Design

And this is the database design to create a PHP-based BSG candidate selection decision support system.

I. Implementation System

In making a web system, the author uses the PHP programming language and MySQL database. The following is a view of the web-based system.

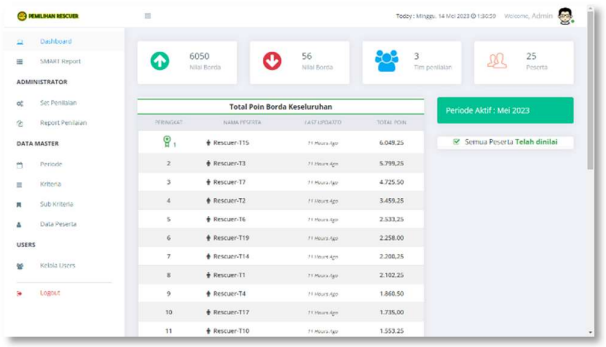

Fig 5. Dashboard Page

The dashboard page directly displays the assessment ranking from highest to lowest, there is also an assessment team and participants who become BSG candidates.

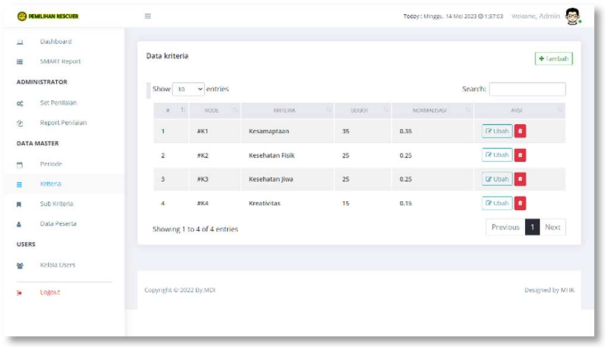

Fig 6. Criteria Page

On the criteria page there are CRUD functions, such as adding, editing and deleting. As well as the weights that have been input directly normalized with the overall weight.

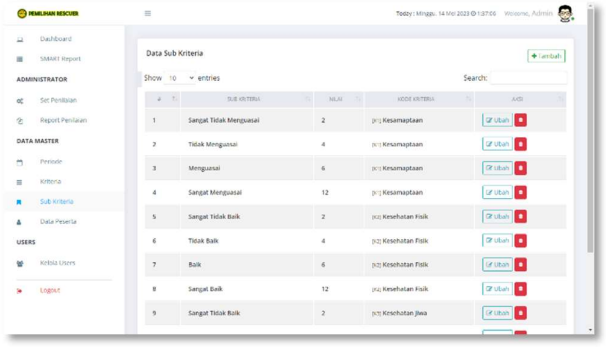

Fig 7. Sub-Criteria Page

On this page, you can create and assess several sub-criteria in Figure 7 above.

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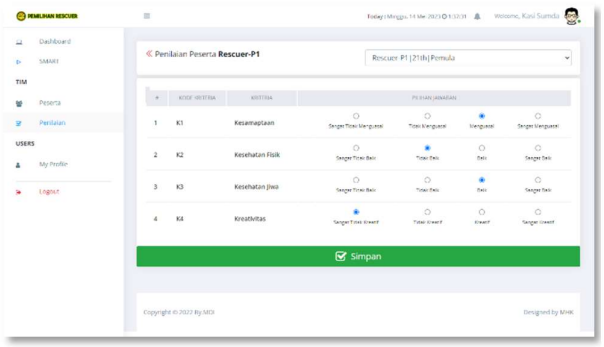

Fig 8. Valuation Page

This page is an assessment page, an example of an assessment as in Figure 8 above, the assessor only needs to click on the assessment criteria that match the participant.

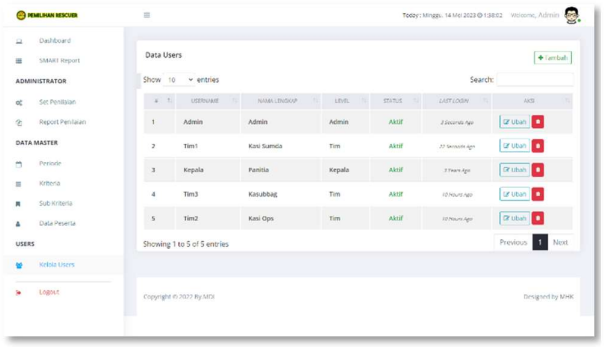

Fig 9. Manage Users Page

Admins are able to manage existing users such as assessors, able to change usernames, passwords and delete them.

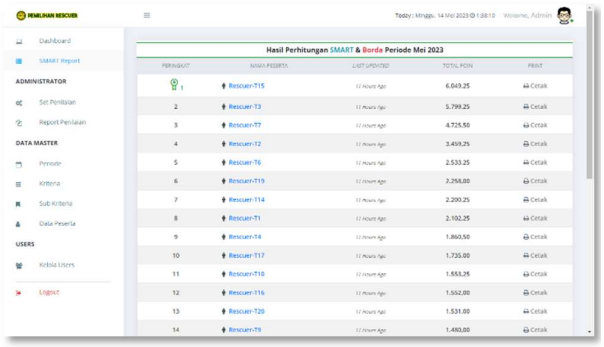

Fig 10. SMART and BORDA calculations

On the SMART Report menu, we can see the highest to lowest rankings. The rankings are obtained from the assessment by the assessment team.

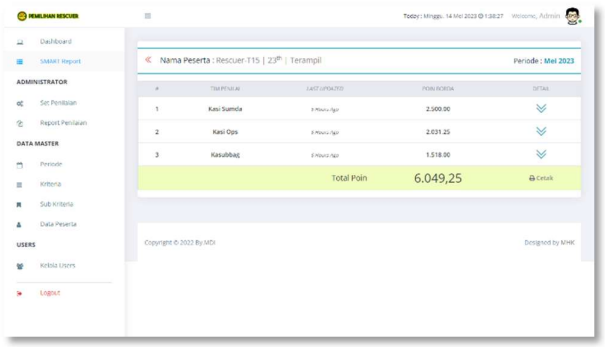

Fig 11. Total Per-Individual Page

Participants who click on their name on the SMART Report will appear like this, with details of assessors I, II, and III as in Figure 11 above.

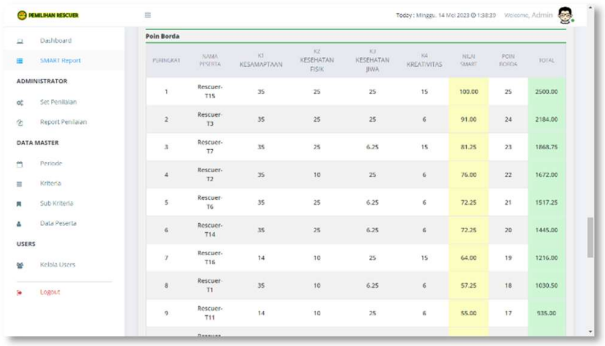

Fig 12. SMART Value x BORDA Point Page

When the SMART value is obtained, it will be multiplied by borda points according to the number n, the results are automatically ranked.

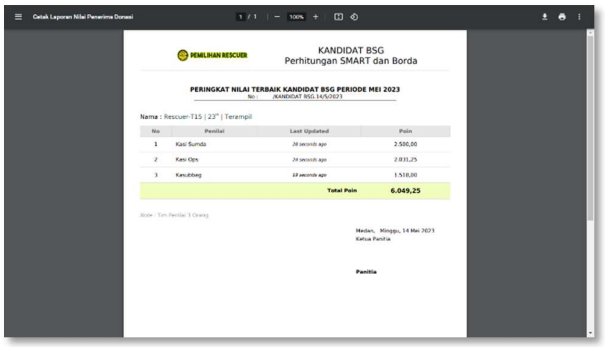

Fig13. Print Per-Individual Page

Print results for each individual can be seen in the image above.

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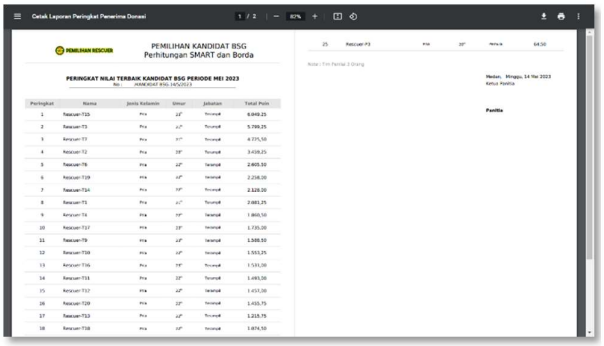

Fig 14. Print All Page

And this is the whole print page, the print results obtained are in PDF format. In this system calculation, it is also found that Rescuer-T15 deserves to be a BSG candidate with a total score of 6049.25 and Rescuer-P5 who got the highest score at the beginner level with a score of 756.00.

IV. CONCLUSION

The results of the use of the SMART and BORDA methods in the selection of Basarnas Special Group candidates based on criteria, namely, Kesamaptaan, Kesehatan Fisik, Kesehatan Jiwa and Kreatifitas. The final result obtained is that the best BSG candidate is obtained on predetermined criteria. Based on the overall results of manual and system calculations in the program above, Rescuer-T15 and Rescuer-P5 are the highest alternatives in skilled and beginner positions.

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