

DECISION SUPPORT SYSTEM FOR TREE SELECTION FOR RESTORATION OF FIRE LAND USING ANALYTIC HIERARCHY PROCESS (AHP) METHOD AND SIMPLE MULTI ATTRIBUTE RATING TECHNIQUE EXPLOITING RANKS (SMARTER) METHODS

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ABSTRACT

Utilization or use of forest and land areas that are not in accordance with conservation principles can cause critical land to occur. Critical land is a land that inside or outside the forest area that has been damaged, so that it can cause loss or decrease in its function. The lack of knowledge of some people on critical land and the selection of inappropriate plant types sometimes makes the condition of burnt land increasingly become one of the obstacles for the Forest and Land Rehabilitation Program (RHL). Statistical data analysis can be used in the data processing process to become valuable information for the system. Applying statistical analysis methods in making decisions in selecting statistical data that has several criteria. This research is focused on the application of the Analytic Hierarchy Process (AHP) method method to see a comparison of criteria. The SMARTER (Simple Multi Attribute Rating Technique Exploiting-Rank) method is very suitable to be used to overcome the many alternatives that will be given to different soil samples later. In short, each final weight that affects the alternative is calculated with the results of the alternative assessment, so that the utility value of each alternative is obtained. From the research of the Analytic Hierarchy Process (AHP) method and Simple Multi Attribute Rating Technique Exploiting-Rank (SMARTER) method, the results of the Balangeran vegetation are obtained as the main recommendation with the greatest utility value, namely 1.321668.

Keywords : Land Restoration, Institute for Environmental Research and Development, Decision support systems, AHP, SMARTER

1. Introduction

Utilization or use of forest and land areas that are not in accordance with conservation principles can cause critical land to occur. Critical land is a land that within or without the forest land area that has been barren forest, so that it can cause decrease in its function (Ministry of Forestry, 2009).

The lack of knowledge of some people about critical land and the selection of inappropriate plant types sometimes makes the condition of burnt land increasingly become one of the obstacles for the Forest and Land Rehabilitation Program (RHL) as an effort to reduce critical land..

Ecologically, fires cause loss of aboveground vegetation, loss of nutrients through smoke, decreased decomposition of forest litter, soil becomes more compact, soil infiltration is low, nutrients become more easily leached due to increased runoff, and causes high erosion and sedimentation. (Filho et al. 2013; Saharjo 2016)

Statistical data analysis can be used in the data processing process to become valuable information for the system. In order for this data processing effort to be carried out effectively and achieve the expected goals, a very careful strategy formulation is needed. Applying statistical analysis methods in decision making in selecting statistical data that has several criteria. This research is focused on the application of the Analytic Hierarchy Process (AHP) method method to see a comparison of criteria. AHP has many advantages in explaining the decision-making process, because it can decompose complex decision processes into simpler decisions and are easier to handle. In AHP decision making with many criteria is subjective.

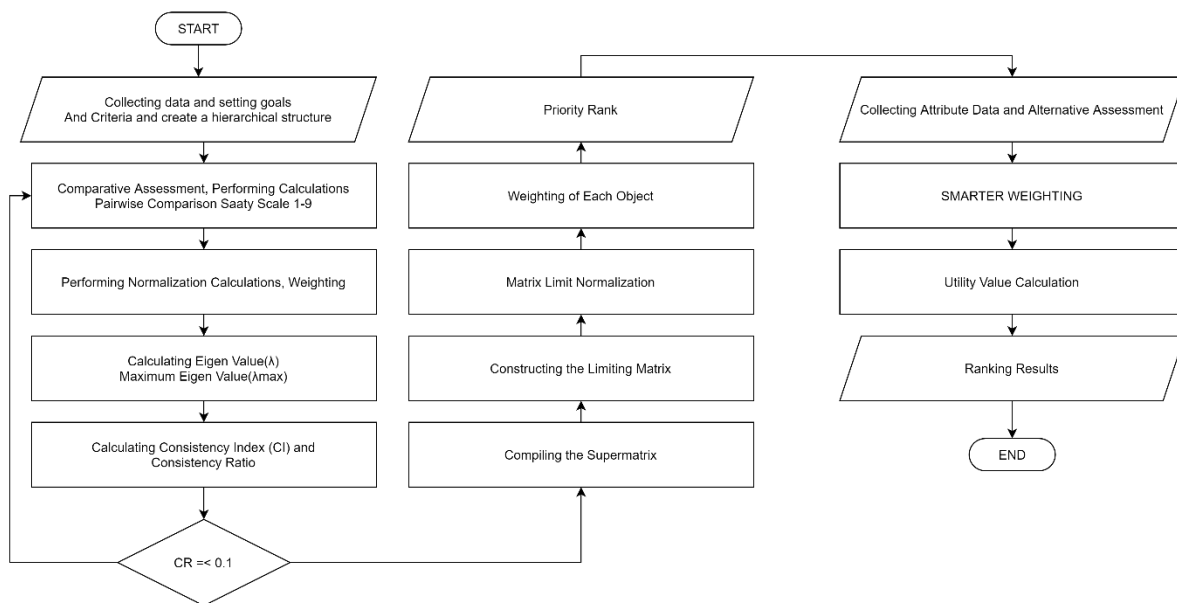
The SMARTER (Simple Multi Attribute Rating Technique Exploiting-Rank) algorithm is simple to edited when the influence of the number of categories increases changing the number of alternatives will not change the decision of the original number of alternatives and it is useful when new alternatives are added (Ward & Hutton, 1994), this is very advantageous because each region or each burned area has a different sample of land, so the sample of trees or alternatives used will of course vary. Therefore the SMARTER (Simple Multi Attribute Rating Technique Exploiting-Rank) method is very suitable to be used to overcome the many alternatives that will be given to different soil samples later..

Based on the Total Soil Microbes above, the title of this research is "Tree Selection Decision Support System for Restoration of Fire-affected Land Using Analytic Hierarchy

Process (AHP) method and SMARTER (Simple Multi-Attribute Rating Technique Exploiting-Rank) Methods". This research was conducted to help provide system outputs in the form of recommendations that can be used as a means of supporting the Forestry Research and Development Agency and the South Kalimantan Forestry Service in choosing alternative plant vegetation to be planted on burned land..

2. Research Methodology

The steps taken in this research are:



Picture 1. Research Flowchart

2.1 Data Collection

The research materials used in this study were initial tree or vegetation data from the Banjarbaru Environmental and Forestry Research and Development Center (BP2LHK) and initial soil data in the form of soil physical properties, total soil microbes and soil chemical properties. The soil data provided is soil with peat soil type, namely peat land at KM. 17 in 2019.

The initial tree data obtained amounted to 10 recommendations from interviews with resource persons. The resource person in question is Mr. Prof. Dr, Acep Akbar. Tree data obtained as contained in the table 1.

Table 1. Tree Initial Data

No	Alternative	k1	k2	k3	k4	k5	k6	k7	k8	k9	k10
1	JELATUNG	300	200	0.2	1	3	90	5.5	175	90	7

2	BLANGERAN	280	185	0.22	1.4	8	80	5.5	180	100	7
3	MERAPAT	270	170	0.21	1.5	10	90	5.5	190	100	6
4	GERUNGUGNG	300	200	0.2	1.45	3	85	4.5	175	90	7
5	PUNAK	300	200	0.2	1.3	19	90	5.5	175	90	12
6	TERENTANG	300	200	0.21	1	19	90	5.5	190	90	13
7	GAHARU	280	180	0.2	1.35	19	85	4.5	175	90	13
8	EKALIPTUS	290	180	0.1	1	3	90	5.5	190	100	7
9	MERANTI	270	165	0.2	1.5	8	90	5.5	190	100	8
10	AKASIA	280	180	0.22	1.45	19	85	4.5	180	100	13

The soil preliminary data obtained is divided into 3 criteria, namely normal soil conditions, lightly burned soil conditions and heavily burned soil conditions as shown in table 2, table 3 and table 4

Table 2 The normal soil preliminary data

	Criteria	Normal	Unit
k1	Soil Water Content	288-300	%
k2	Water Binding Power	188-200	%
k3	Bulk Density	0.05-0.19	gr/cm ³
k4	Particle Density	1.15-1.27	gr/cm ³
k5	Permeability	14-21	cm/jam
k6	Total Pore Space	87-90	
k7	Acidity	6.5-7.5	pH
k8	Redox	188-200	m.v
k9	Electrical Conductivity	88-98	Ω
k10	Total Soil Microbes	13x10 ⁸	CFE/ml

Table 3 Light burning ground preliminary data

	Criteria	Light	Unit
k1	Soil Water Content	277-288	%
k2	Water Binding Power	177-188	%
k3	Bulk Density	0.2-0.21	gr/cm ³
k4	Particle Density	1.28-1.41	gr/cm ³
k5	Permeability	8.0-14	cm/jam

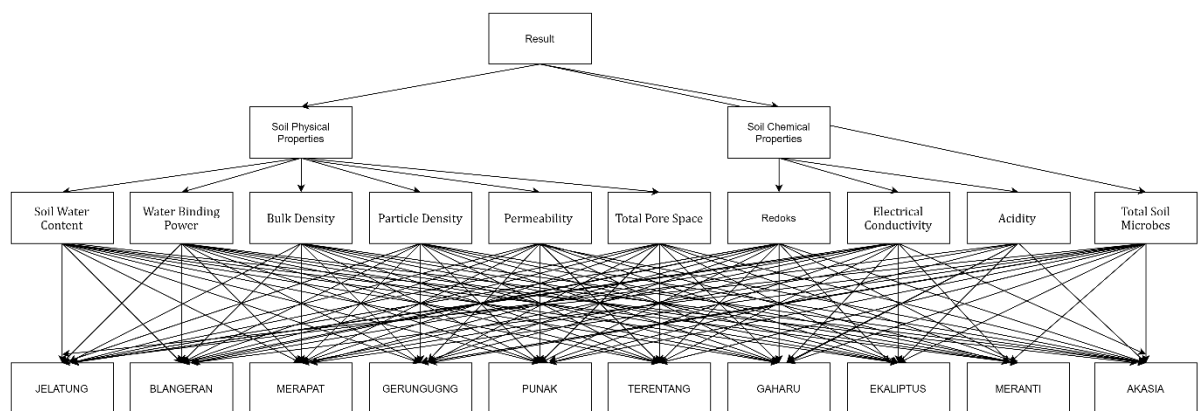
k6	Total Pore Space	83-86	
k7	Acidity	5-6.5	pH
k8	Redox	174-187	m.v
k9	Electrical Conductivity	99-109	Ω
k10	Total Soil Microbes	6×10^8	CFE/ml

Table 4 Heavy burning ground preliminary data

	Criteria	Heavy	Unit
k1	Soil Water Content	265-277	%
k2	Water Binding Power	165-177	%
k3	Bulk Density	0.22-0.23	gr/cm ³
k4	Particle Density	1.42-1.55	gr/cm ³
k5	Permeability	2-7.5	cm/jam
k6	Total Pore Space	80-82	
k7	Acidity	3-4.9	pH
k8	Redox	160-173	m.v
k9	Electrical Conductivity	110-120	Ω
k10	Total Soil Microbes	3×10^8	CFE/ml

2.2 Creating a Hierarchical Structure

Create a hierarchical structure that begins with a general goal followed by criteria, sub-criteria and alternative choices that you want to rank



Picture 2. Hierarchical Structure

2.3 Comparative Rating

Criteria and alternatives were carried out by pairwise comparisons. In many cases, a scale of 1 to 9 is the best scale for expressing opinions. The value and definition of qualitative opinion of the Saaty comparison scale

2.4 Measuring Consistency

In pairwise comparison assessments, inconsistencies in the opinions/preferences given by the decision makers. The consistency of the paired assessment was evaluated by calculating the Consistency Ratio (CR). Saaty determined that if CR < 0.1, then the results of the assessment were said to be consistent. The formula for calculating are $CR = \frac{CI}{RI}$. Where, Index Consistency and RI = Random Consistency Index.

To calculate the CI, the Formula is $CI = \frac{\lambda_{max} - n}{(n-1)}$ where max = maximum value of eigen value of order n. The maximum eigen value is obtained by adding up the result of the comparison matrix multiplication with the main eigenvector (priority vector) and dividing by the number of elements.

Table 5. Weighting Results

Description	WEIGHT		
	Criteria	Subcriteria	FINAL
Soil Water Content	0.633346	0.416945	0.264071
Water Binding Power	0.633346	0.293147	0.185664
Bulk Density	0.633346	0.035608	0.022552
Particle Density	0.633346	0.102183	0.064717
Permeability	0.633346	0.071672	0.045393
Total Pore Space	0.633346	0.080444	0.050949
Acidity	0.106156	0.633346	0.067234
Redox	0.106156	0.260498	0.027654
Electrical Conductivity	0.106156	0.106156	0.011269
Total Soil Microbes	0.260498	-	0.260498

2.5 Weight Ranking

Provide a rating for each criterion and sub-criteria that has been calculated using the Analytic Hierarchy Process. The results of the weight ranking as contained in table 6

Table 5. Weight Ranking

Description	Weight
Soil Physical Properties	0.633346 c1
Total Soil Microbes	0.260498 c2
Soil Chemical Properties	0.106156 c3

The results of the ranking of the weights of the Soil sub-criteria as contained in table 7

Table 7. Ranking Sub-criteria weight

Description	Weight
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Soil Water Content	0.264071	c1
Total Soil Microbes	0.260498	c2
Water Binding Power	0.185664	c3
Acidity	0.067234	c4
Particle Density	0.064717	c5
Total Pore Space	0.050949	c6
Permeability	0.045393	c7
Redox	0.027654	c8
Bulk Density	0.022552	c9
Electrical Conductivity	0.011269	c10

2.6 Attribute Weighting with SMARTER

The weighting procedure is considered disproportionate where each weight given must reflect the distance and priority of each criterion correctly. To overcome this, the SMARTER method uses the Rank Order Centroid (ROC) weighting formula.

In general, the ROC weighting can be formulated as follows :

$$W_k = \frac{1}{k} \sum_{i=1}^k \left(\frac{1}{i}\right)$$

explanation:

W = Weighting Value

K = Number of criteria

i = Alternative value

Table 8. The results of the initial weighting with the SMARTER method

attribute	Weight			
Heavy	0.61	1	1/2	1/3
Light	0.28	0	1/2	1/3
Normal	0.11	0	0	1/3

The weight of each attribute that has been determined will be calculated with each weight of the pre-determined sub-criteria using the Analytic Hierarchy Process (AHP) method which was previously also ranked and calculated with the ROC in Table 8. so the final weight will be obtained which will be used for ranking. end of each alternative. As shown in table 9

Table 9 AHP weight that has been calculated with ROC

criteria	Description	criteria	Subcriteria	Final
c1	Soil Water Content	0.633346	0.408333	0.258616
c2	Total Soil Microbes	0.260498	-	0.260498
c3	Water Binding Power	0.633346	0.241667	0.153059
c4	Acidity	0.106156	0.611111	0.064873
c5	Particle Density	0.633346	0.158333	0.10028
c6	Total Pore Space	0.633346	0.102778	0.065094

c7	Permeability	0.633346	0.061111	0.038704
c8	Redox	0.106156	0.277778	0.029488
c9	Bulk Density	0.633346	0.027778	0.017593
c10	Electrical Conductivity	0.106156	0.111111	0.011795

2.7 Alternative Assessment

Provide an assessment on all criteria for each alternative. The assessment is obtained by interviewing relevant sources or experts. The assessment is given referring to the resistance of alternative vegetation to soil conditions with soil attributes, namely normal soil, lightly burned soil and heavily burned soil.

Table 9. Assessment of alternatives

	c1	c2	c3	c4	c5	c6	c7	c8	c9	c10
A1	1	1	2	1	3	1	2	2	1	2
A2	2	2	3	2	2	3	2	2	2	2
A3	3	3	2	3	2	1	2	1	2	2
A4	1	1	2	3	3	2	3	2	1	2
A5	1	1	2	2	1	1	2	2	1	1
A6	1	1	2	1	1	1	2	1	1	1
A7	2	2	2	2	1	2	3	2	1	1
A8	2	2	1	1	3	1	2	1	2	2
A9	3	3	2	3	2	1	2	1	2	2
A10	2	2	3	3	1	2	3	2	2	1
Nilai										
MAX	3	3	3	3	3	3	3	3	3	3

2.8 Utility Calculation

Calculating utility against each alternative. Calculation of the utility value of the equation by using the equation.

$$v(x) = \sum_{i=1}^n w_i v_i(x)$$

Explanation :

W_i = The weight that affects from the i dimension to the overall value of the evaluation.

V_i = Evaluation object on dimension i

n = Number of different value dimensions

The results of the assessment given will be calculated by weight. As shown in the table 10

Table 10. Utility Calculation

	cr1	cr2	cr3	cr4	cr5	cr6	cr7	cr8	cr9	cr10
Alt1	0.0287	0.0289	0.0425	0.0072	0.0613	0.0072	0.0108	0.0082	0.0020	0.0033
Alt2	0.0718	0.0724	0.0935	0.0180	0.0279	0.0398	0.0108	0.0082	0.0049	0.0033
Alt3	0.1580	0.1592	0.0425	0.0396	0.0279	0.0072	0.0108	0.0033	0.0049	0.0033
Alt4	0.0287	0.0289	0.0425	0.0396	0.0613	0.0181	0.0237	0.0082	0.0020	0.0033
Alt5	0.0287	0.0289	0.0425	0.0180	0.0111	0.0072	0.0108	0.0082	0.0020	0.0013
Alt6	0.0287	0.0289	0.0425	0.0072	0.0111	0.0072	0.0108	0.0033	0.0020	0.0013
Alt7	0.0718	0.0724	0.0425	0.0180	0.0111	0.0181	0.0237	0.0082	0.0020	0.0013
Alt8	0.0718	0.0724	0.0170	0.0072	0.0613	0.0072	0.0108	0.0033	0.0049	0.0033
Alt9	0.1580	0.1592	0.0425	0.0396	0.0279	0.0072	0.0108	0.0033	0.0049	0.0033
Alt10	0.0718	0.0724	0.0935	0.0396	0.0111	0.0181	0.0237	0.0082	0.0049	0.0013
Max	0.1580	0.1592	0.0935	0.0396	0.0613	0.0398	0.0237	0.0180	0.0108	0.0072
	0.7184	0.7236	0.5017	0.2343	0.3120	0.1374	0.1462	0.0623	0.0342	0.0249

In calculating the utility value, the value is generated from the sum of the scores of each student and then multiplied by the value of the sub-criteria weighting, then the results are added up. For further calculation of the final value using the formula.

$$ni = \sum_{j=1}^n nwj uij$$

Explanation :

Wj = The weight of the i-th criterion

Uij = Utility value of the jth criterion for Alternative i

ni = Final score

Where the utility value is multiplied by the criterion weight value. As found in Table 11

Table 11. Utility value multiplied by Weight criteria

	cr1	cr2	cr3	cr4	cr5	cr6	cr7	cr8	cr9	cr10	NA
Alt1	0.040	0.040	0.085	0.031	0.196	0.053	0.074	0.132	0.057	0.132	0.838
Alt2	0.100	0.100	0.186	0.077	0.089	0.289	0.074	0.132	0.143	0.132	1.322
Alt3	0.220	0.220	0.085	0.169	0.089	0.053	0.074	0.053	0.143	0.132	1.236
Alt4	0.040	0.040	0.085	0.169	0.196	0.132	0.162	0.132	0.057	0.132	1.144
Alt5	0.040	0.040	0.085	0.077	0.036	0.053	0.074	0.132	0.057	0.053	0.645
Alt6	0.040	0.040	0.085	0.031	0.036	0.053	0.074	0.053	0.057	0.053	0.520
Alt7	0.100	0.100	0.085	0.077	0.036	0.132	0.162	0.132	0.057	0.053	0.932
Alt8	0.100	0.100	0.034	0.031	0.196	0.053	0.074	0.053	0.143	0.132	0.914
Alt9	0.220	0.220	0.085	0.169	0.089	0.053	0.074	0.053	0.143	0.132	1.236
Alt10	0.100	0.100	0.186	0.169	0.036	0.132	0.162	0.132	0.143	0.053	1.212

Final Value of Soil Moisture Content:

$$ni = \sum_{j=1}^n nwj uij$$

$$\begin{aligned}
 ni(A1) &= \sum_{j=1}^n nW(C) u(A1) \\
 &= 0.040+0.040+0.085+0.031+0.196+0.053+0.074+0.132+0.057+0.132 \\
 &= 0.838
 \end{aligned}$$

etc.

3. Results and Evaluation

3.1 Results

To decide which alternative is the best recommendation, it is decided by looking at the highest or greatest utility value. The value will be converted into percentage form by calculating the result value with the overall value or here the highest value of the alternative is used. From the calculations obtained 2.019881 as the maximum value or the highest value that can be obtained if success grows 100%. This value will be used as a reference for the overall value of the assessment and a comparison of the result values to get a percentage value.

In percentages, the formula for finding percentages is determined as follows:

$$\text{Percentage} = \frac{\text{Value of number of parts}}{\text{Value of sum of whole}} \times 100\%$$

The results of the calculations as contained in the table 12

Table 12, Ranking results

Code	Alternative	Final Score	Percentage
A2	BALANGERAN	1.321668	65%
A3	MERAPAT	1.236491	61%
A9	MERANTI	1.236491	61%
A10	AKASIA	1.211797	60%
A4	GERUNGGANG	1.14405	57%
A7	GAHARU	0.93208	46%
A8	EKALIPTUS	0.914325	45%
A1	JELUTUNG	0.838405	42%
A5	PUNAK	0.644897	32%
A6	TERENTANG	0.519796	26%
Highest Value		2.019880547	100%

$$\begin{aligned}
 \text{Percentage} &= \frac{\text{Value of number of parts}}{\text{Value of sum of whole}} \times 100\% \\
 &= \frac{1.321668}{2.019880547} \times 100 \\
 &= 65\%
 \end{aligned}$$

Based on table 12. Balangeran vegetation is obtained as a recommendation with the highest utility value, namely 1.321668 with a live percentage of 1000 stems / hectare of trees planted is 65%.

3.2 Evaluation

To provide information on how big the forecast error is compared to the actual value of the series. The smaller the percentage error in MAPE, the more accurate the forecasting results will be. The actual value is obtained from the Forest and Land Rehabilitation (RLH) report from the Banjarbaru Environmental and Forestry Research and Development Center (BP2LHK). The percentage of life obtained from planting Balangeran trees is 61% of 1000 stems/ha with intensive reforestation. Analysis of the Mean Absolute Percentage Error (MAPE) value as shown in the table 13

Table 13. MAPE value range

Range MAPE	Meaning of VALUE
< 10%	The ability of the forecasting model is very good
10% - 20%	Good forecasting model ability
20% - 50%	The ability of the forecasting model is feasible
> 50%	Poor forecasting model ability

Mean Absolute Percentage Error (MAPE) with the formula as in the following equation:

$$MAPE = \sum_{i=1}^n \left| \frac{y_i - \hat{y}_i}{y_i} \right|$$

Calculation results as contained in the table 13

Table 14. Perhitungan MAPE

Target Value (\hat{y}_i)	65%
Actual Value (y_i)	61%
MAPE	0.065574 6.557377%

4. Discussion

The data used in this study is the data that will be used in this study is soil data and tree recommendations obtained from the Banjarbaru Environmental and Forestry Research and Development Center (BP2LHK) obtained from interviews with experts. Initial data in the form of data on the state of the soil starting from the physical properties of the soil, the chemical properties of the soil and the microbes in the soil. In addition to data collection, criteria, sub-criteria and attributes as well as recommendations for vegetation were also determined.

In addition to data collection, the creation of a hierarchical structure with the principle of decomposition divide a complete cases of elements into a hierarchical form of decision making process, where in elements are interconnected. To get accurate results, solving is done on the elements until it is impossible to do further solutions, so that several levels of the problem to be solved are obtained. The decision hierarchy structure can be categorized as complete and incomplete. A decision hierarchy is called complete if all elements at a level have a relationship with all elements at the another level (Figure AHP Hierarchy Structure), while in an incomplete decision hierarchy not all elements at each level have a relationship. In general, real problems have incomplete structural characteristics.

The data will be implemented using 2 methods, namely Analytic Hierarchy Process (AHP) method and SMARTER (Simple Multi-Attribute Rating Technique Exploiting-Rank). The AHP method is used as a comparative assessment, namely a pairwise comparison matrix containing the preference levels of several alternatives for each criterion, applied to the initial land data to obtain a value of importance. The preference scale used is a scale of 1 which indicates the equal importance to a scale of 9 which indicates the very importance. Determination of the value of interest is done by interviewing sources or experts. Followed by making a pairwise comparison matrix that describes the relative contribution or influence of each element on each goal or criterion level above. Comparisons are made based on the choice or judgment of the decision maker by assessing the level of importance of an element compared to other elements. The calculation is continued by normalizing the data by dividing the value of each element in the paired matrix by the total value of each column. This normalization aims to eliminate and reduce data redundancy and the second goal is to ensure data dependencies. Data is in the right table.

The data that has been normalized is then calculated for the eigenvector score and tested for consistency, if it is inconsistent, the data taker (preference) needs to be repeated. The eigenvector value in question is the maximum eigenvector value obtained using Microsoft Excel. The eigenvector of each pairwise comparison matrix. The eigenvector value is the weight of each element. This step synthesizes the choice and prioritization of elements at the lowest level of the hierarchy until the goal is achieved. Test the consistency of the hierarchy. If it does not meet the $CR < 0.100$ and then the

assessment have to be repeated. From the calculations, the consistency ratio is 0.033374725, so there is no need to re-calculate.

The weighting of the SMARTER method is calculated using the Rank Order Centroid (ROC) weighting formula. The ROC technique gives weight to each criterion according to the ranking that is assessed based on the priority level. The weight of the criteria and sub-criteria obtained from the previous AHP calculations are sorted by importance value. Attribute weighting is done by calculating the attribute values calculated by the ROC method with each of its respective sub-criteria. Then the final weight value will be obtained which will be used as a reference in alternative assessments.

Alternative assessment is to provide an assessment of all criteria for each alternative. The assessment is obtained by interviewing relevant sources or experts. The assessment is given referring to the resistance of alternative vegetation to soil conditions with soil attributes, namely normal soil, lightly burned soil and heavily burned soil. Normal soil conditions will be given a rating of 1, meaning that the tree or vegetation can only survive in normal conditions. A lightly burned soil will be given a rating of 2, meaning that the tree or vegetation can survive in a lightly burned soil. Severely burned land will be given a rating of 3, meaning that the tree or vegetation can survive even if planted on land that has experienced severe fires or large land fires.

Based on the MAPE results obtained in this study, the results of the overall calculations using the Analytic Hierarchy Process (AHP) method and SMARTER (Simple Multi-Attribute.Rating Technique Exploiting-Rank) methods show that MAPE results tend to be smaller than the actual values obtained from the Research and Development Institute Banjarbaru Environment and Forestry (BP2LHK). The percentage of life obtained from planting Balangeran trees is 61% from 1000 stems/ha with intensive reforestation. So the accuracy results from the Analytic Hierarchy Process (AHP) method and SMARTER (Simple Multi-Attribute Rating Technique Exploiting-Rank) methods are 65%, namely from 1000 stems/hectare. 65% of the hectare planted grew normally and the actual data was 61%, i.e. from 1000 stems/hectare planted, only 61% managed to grow normally. Then the MAPE results obtained are 0.065574 or in percentage is 6.5574%

5. Closing

5.1 Conclusion

From the research that has been done, the conclusions that can be drawn are :

1. The results of the algorithm Analytic Hierarchy Process (AHP) method algorithm and Simple Multi-Attribute Rating Technique Exploiting-Rank (SMARTER) algorithm for tree selection recommendations on burnt land are obtained from Balangeran vegetation as the main recommendation with the greatest utility value 1.321668.
2. The level of accuracy of the Analytic Hierarchy Process (AHP) method and Simple Multi-Attribute Rating Technique Exploiting-Rank (SMARTER) methods obtained that the best accuracy results on the value on the Balangeran vegetation with MAPE 6.5574% and the accuracy value obtained was 93,4426%.

5.2 Suggestion

The suggestions that can be given based on this research are::

1. In further research, it is recommended to use other soil samples such as ex-mining land.
2. In further research, it is recommended to try to use more criteria and sub-criteria.

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