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Research paper

Selection Drought Index Calculation Methods Using Electre, Topsis, and Analytic Hierarchy Process

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Abstract

The drought index is an essential indicator for calculating forest fires' potential. Many methods are developed to maintain the drought index. However, they provide less suitable at many places. Every area has their own character, and each of methods has their own specification. The spot problem is how to find the right method for those places. The forest of Bukit Suharto, has particular character as one of the rain tropical forests, and it needs suitable method. Furthermore, this study is conducted to examine the right methods that compatible for the forest. They are: Palmer Drought Severity Index (PDSI), Keetch Byram Drought Index (KBDI), Reconnaissance Drought Index (RDI), Standard Precipitation Index (SPI), Effective Drought Index (EDI), McArthur Forest Fire Danger Index (MFFDI), and Standard Precipitation Evapotranspiration Index (SPEI). Every method has specific variables for the calculation, namely, the period, the data's type, the formula's complexity, the usability, and scale results' type. On processing the seven methods, the researcher uses other techniques to asses them, namely, ELECTRE, TOPSIS, and Analytic Hierarchy Process. In final process, the conclusion is compared through the result. In summary, the results show that KBDI's method is the most recommended, and TOPSIS is the best technique for recommendations.

Keywords: *Drought; Drought Index; Forest Fire; Electre; KBDI.*

1. Introduction

Calculating the drought index requires an appropriate method, according to the needs and circumstances of the environment. Not all techniques can be used in all places because it relies on the character of the region. Nowadays, the formula for calculating the drought index has been developed by many scientists. To make a proper measurement, a user needs to choose the best method in calculating the drought index based on the specific purposes. However, errors in selecting the right approach can result less data accuracy.

Some people have not realized that measuring the drought index is important to anticipate forest fires. In fact, the drought index can increase people awareness even though after the fires occurs. Drought indexes must be monitored from time to time so that an increase or decrease trend can be identified, especially in the summer. By knowing the pattern of the drought index, preventive actions can be done in advance [1]. The problem is how to increase the awareness of the community around the forest about the drought index and understand the potential for forest fires that might occur.

Like other objects, each method has a character which attached to it. Like an object that has names, properties, types, and other attributes, a technique also has characteristics such as properties, abilities, characters, and others. For instance, the Keetch-Byram Drought Index (KBDI) method, the measurement required the maximum air temperature and the total rainfall during the last 24 hours [2].

Standardized Precipitation Index (SPI) [3] is one method commonly used to calculate the drought index with the character of the ability to calculate in large amounts of data, has a simple formulation, and the number of output classifications is quite complete. These methods are recommended and commonly used in many different countries.

Selecting a method must be based on the results of the comparison with other methods. Some previous studies had conducted comparative study between one method with another by calculating the drought index in particular area, the findings then are being compared based on the calculation. Research has been done to analyze the comparative performance of several drought index methods undertaken in the Chi River Basin, Thailand [4]. The results of approximations that are close to the factual condition are considered to be the most suitable method. Selecting the best approach from various available techniques in such a way is not always wrong, but another model as an alternative is needed to help determining a method by comparing the properties of each process.

The selection of the best alternative using the method was carried out by S. Nazir et al., who used some criteria to determine the best option, such as effectiveness, efficiency, satisfaction, safety, and usability. The purpose is to choose the best opportunity to implement so that productivity remains good or even increased, also it can minimize the cost, and improve quality [5] and evaluation [6]. The same idea is used to evaluate components used in software [7], making inspiration for choosing the right method to calculate the drought index using a technique.

In this study, researcher compared seven methods of drought index calculation method: the Palmer Drought Severity Index (PDSI), Keetch-Byram Drought Index (KBDI), Reconnaissance Drought Index (RDI), Standardized Precipitation Index (SPI), Effective Drought Index (EDI), McArthur Forest Fire Danger

Index (MFFDI) and Standardized Precipitation Evapotranspiration Index (SPEI). The selection techniques based on topic popularity in the past ten years. Based on search results using Google Scholar, since 2010 PDSI discussed in about 17,900 articles, SPI discussed as approximately 698,000 articles, EDI as 203,000 articles, RDI as around 12,000 articles, and the SPEI as 23,400 articles. The seven methods can be categorized as suitable methods to compare.

There are seven drought index calculation methods will be compared using ELECTRE, TOPSIS, and Analytic Hierarchy Process (AHP). The implementing multi-criteria based decision support systems, these three methods are prevalent because they are easy to implement, straightforward, comprehensive, and the results are reliable [9]. In the last ten years, AHP used 54,400 articles, TOPSIS as many as 43,900 articles, and ELECTRE as 16,000 articles.
Comparing the properties between methods does not have to do a drought index calculation then compares the results, but by identifying the nature of each process with the specified classification then calculated through an algorithm that can help decision making. The effect of the calculation is the basis of the most recommended way.
The results needed from this study are to produce a recommendation to decide one of the seven drought index calculation methods that are suitable for use in the forest of Bukit Suharto. It is also to test which of the three methods used to determine it (AHP, TOPSIS, ELECTRE) is the best result of the recommendations. The recommendations for suitable means will use in forests that have the same character or similar to the wood of Bukit Suharto.

2. Literature review

2.1. Multi-criteria decision making

The main problem for decision makers is that they often find different rules in determining the right decisions [10]. Part of the other problem is that many criteria used as a consideration for making decisions making decision makers hesitant about deciding which choice is the most appropriate. Before choosing a method is the availability of the required criteria and the relationship.
Multi-criteria decision support systems have been used by many researchers to solve problems, for example analyzing supplier information and communication technology offerings in the contracting process [11], to determine the criteria for a sustainable desalination plant location [12], determine the correct warehouse location [13], and so on. The key to the success of the decision support system is to identify the right method and variables that are appropriate to the needs of decision makers.
Quality of decision can improved by using multi-criteria because of the decision process more rational and efficient the results. MCDM can be a modern decision-making science by providing alternative options to make decision makers easier to make the right decisions [14]. The more appropriate criteria used in a method, the more possibilities that generated from the calculation. And that has a positive impact on decision makers to make more convincing decisions.
The development of decision support in the future will be better by conducting multi-criteria evaluations. Things that done by offering a flexible assessment framework using fuzzy, covering a broader field and involving some dimensions in solving problems [15]. An example of the use of fuzzy logic in the development of a decision support system is to investigate the supporting parts of the security system in improving security [16]. Overlapping fields require synergy between interrelated fields that will enrich input and use fuzzy to provide flexibility not only to determine 0 or 1 choices.

2.2. Electre

ELECTRE is a multi-criteria decision-making method that compares alternatives. ELECTRE is a multi-criteria decision-making method that compares options. In this method, a limited set of alternatives must be ranked best for the worst [14]. Each option that will be analyzed, that will be given a parameter value as a criterion and built in a pair between alternatives and appropriate measures.
ELECTRE (Elimination and Choice Translation Reality), is a method that is good enough to provide problem-solving services by considering the methodological tools and foundation of several criteria that help decisions. The ELECTRE method is currently relevant for consideration of decision-makers with the characteristics of decision makers wishing to include at least three criteria models, five criteria, or more than twelve or thirteen [17].
ELECTRE can also be generated as ranking assistance to regulate the number of limited decision alternatives, each of which explained regarding different characteristics. Characteristics are also often called attribute or decision criteria. Alternative pairs and decision criteria are represented using a two-dimensional matrix. For each measure, each decision maker must define the threshold of preference, indifference threshold, veto limit, a value of interest for each criterion [18].
According to Mary et al., the decision-making stage using ELECTRE is divided into a computation of concordance and discordance matrix, computation of credibility matrix, ascending preorder and descending preorder, and ranking of alternatives [18]. Regarding on the five stages, it was then developed into seven steps of calculation: normalization decision matrix, matrix weighting normalized, computation of concordance and discordance matrix, calculate, computation the dominant matrix of concordance dan discordance, determine of aggregate the dominant matrix, and elimination of less favorable alternative
To computation of concordance and discordance index, each pair of alternatives k and l (k, l = 1,2,3, .., m and k ≠ l) group of criteria split into two subsets, the concordance, and discordance. Alternative criteria in the concordance if:

$$C_{kl} = \{j, v_{kj} \geq v_{ij}\}, for\ j = 1,2,3, \dots, m. \quad (1)$$

a corresponding subset of the set of concordance is discordance:

$$D_{kl} = \{j, v_{kj} < v_{ij}\}, for\ j = 1,2,3, \dots, n. \quad (2)$$

To calculate the value of the elements in the matrix of concordance by summing the weights included in the set of concordance.

$$c_{kl} = \sum_{j \in C_{kl}} w_j \quad (3)$$

To determine the value of the elements in the matrix of discordance by dividing the maximum difference in the criteria included in the subset discordance with the maximum difference between the value of all existing criteria.

$$d_{kl} = \frac{max\{|v_{kj} - v_{ij}|\}_{j \in D_{kl}}}{max\{|v_{kj} - v_{ij}|\}_{\forall j}} \quad (4)$$

Finally, will get the results matrix E gives the preferred order of each alternative when the $e_{kl} = 1$ so A_k alternative is a better alternative than A_l. Thus, the best alternative is an alternative that dominates other alternatives

2.3. Topsis

TOPSIS (Technique for Order Preference by Similarity to Ideal Solution) is one of the popular methods in multi-criteria decision support systems [9]. TOPSIS became a common method because it was able to show solutions to problem-solving by providing the best alternative. The best alternative according to TOPSIS is the shortest distance from the positive ideal solution with the farthest distance from the negative ideal solution. The distance coefficient of each alternative is an important part to has been considered with the order of preference of the specified alternatives. All attributes considered so that the positive and negative ideal solutions are found [19]. From the calculation found the order of values for each alternative.
In general, the TOPSIS method is almost the same as the ELECTRE method at the beginning of the determination of alternatives, criteria, weighting, and decision makers provide value for each option that fits each standard. But the fundamental difference between the two is the completion, the TOPSIS method is more straightforward and produces conclusions in the form of an easy-to-understand.
Multi-criteria problem solving using TOPSIS through seven steps: Identifying evaluation attributes, Evaluation matrix and obtaining normalized decision matrix, obtain weighted normalized matrix, determine positive ideal solution (V+) and negative ideal solution (V-), calculate separation measures using n-dimensional Euclidean distance, calculate closeness coefficient, and determine percentage contribution of strategy [20]. Steps 1-4 are still the same as the electre method. The fundamental differences are in the next step and the purpose of decision making.
The basic thing in using the AHP method is to determine the preference parameter values that are appropriate because each preference value will be tested at the next stage [21]. The most important stage of the stages is the normalization of the decision matrix using the following formula:

$$R_{ij} = \frac{x_{ij}}{\sqrt{\sum_{j=1}^{M} x_{ij}^2}}, \text{ where } i=1,2,...m; \text{ and } j=1,2,..,n; \quad (5)$$

After getting the R matrix, then the next important step is to obtain the weight by multiplying the R matrix with the weight matrix:

$$V_{ij} = w_j \times R_{ij} \quad (6)$$

The next step is to determine the ideal positive and negative solution, where for a positive ideal solution is to determine the highest and negative ideal solution by determining the lowest value.
TOPSIS is a very effective method used to find the best alternative from many choices [9]. Active means that this method can provide appropriate recommendations easily as long as each indicator as a comparison with other signs is ranked. The best alternative is an alternative with the value of the calculation of the ratio of positive ideal solution and negative ideal solution.

2.4. Analytic hierarchy process

Data input for the AHP method is also a matrix such as the ELECTRE and TOPSIS methods. The initial stage of this method is to determine the criteria weight then assess the importance of each sub-criteria [22]. Input in a multi-criteria decision support system method is a matrix because it stores information from two dimensions between alternatives and criteria. This method is called hierarchy because “criteria” will be divided into “sub-criteria”, and each sub-criterion consists of parameters.
AHP provides a solution for decision makers in a structured manner, to be able to solve complex problems involving three elements: objectives, sub (criteria) and alternatives. Six steps to solve the problem using AHP method: identify each alternative with the criteria (sub-criteria) with the appropriate value so that it represents the goal, create a pairwise comparison matrix between elements of the hierarchy at each level, determine the importance or relative weight of the criteria and alternatives at each level, calculate the consistency of pairwise comparison ratios for criteria and alternatives, hierarchical analysis to get results, and make final decisions based on results [23]. All of these stages apply to criteria and each sub-criteria.
Like TOPSIS, an important step in the AHP method is to construct the normalization of the decision matrix and construct the weighted [19]. The normalization construction using the equation:

$$c_{ij} = \frac{a_{ij}}{\sum_{j=1}^{n} a_{ij}}, \text{ where } i=1,2,...m; \text{ and } j=1,2,..,n; \quad (7)$$

Based on the matrix *c*, the next step is the construction of the weight matrix (w) using the formula:

$$w_i = \frac{\sum_{j=1}^{n} c_{ij}}{n}, \text{ where } i=1,2,...m; \text{ and } j=1,2,..,n; \quad (8)$$

The final result of the calculation using AHP is the order of values for each alternative. Decision makers choose which alternative is the highest value is the solution that is closest to the truth. Recommendations are generated in ranks so they are not ambiguous.
The key to success in the AHP method is to determine the degree of importance between criteria. Errors in determining which criteria are more important than other criteria will significantly affect the calculation results. The pairwise comparison scale used to give an assessment shown in table 1.

Table 1: Saaty’s pairwise comparison scale [19]

Scale	Compare factor of i & j
1	Equally important
3	Weakly important
5	Strongly important
7	Very strongly important
9	Extremely important
2,4,6,8	An intermediate value between adjacent scales

3. Research method

3.1. Selection of alternatives

There is seven drought index calculation method as an alternative:
A1. Palmer Drought Severity Index (PDSI)
Calculates the drought index of the PDSI method, using monthly rainfall data records and temperature. The balance of groundwater can be categorized as soil moisture (which was divided into upper and lower layers) depending on soil character. Variables that are also important are Available Water Capacity (AWC) and Runoff (RO) [24]. PDSI calculated based on soil moisture supply and demand models. Calculating demand is more difficult than calculating supply because of not only the temperature and amount of moisture in the soil but also factors that are difficult to calibrate include evapotranspiration and refill rates. In this method, an algorithm developed that can calculate based on data, rainfall, and temperature.
Classes for wet and dry periods are divided into eleven categories starting from extremely wet if the drought index value is more than 4 and extremely drought for drought index values less than -4. As for the near-normal condition, the value equals between 0.49 and -0.49 [25].
A2. Keetch-Byram Drought Index (KBDI)
Drought index according to Keetch-Byram is a number that represents the effect of evapotranspiration and deposition of water in the soil which results in cumulative moisture deficiency or the quantity associated with organic matter in the ground is flammable [3].

KBDI fire risk levels split into six classes, namely very low, low, moderate-high, very high, and extreme. To calculate the daily drought factor (dQ) using the Keetch-Byram Drought Index using S.I. Unit equation [26]:

$$dQ = \frac{(203.2 - Q)\left(0.968exp^{(0.0875m+1.5552)} - 8.30\right)dr}{1 + 10.88e^{(-0.001736R)}} x10^{-3} \quad (7)$$

A3. Reconnaissance Drought Index (RDI)
RDI is a method that often used in assessing drought index because it has high sensitivity and resistance. The more specific calculation period can be adjusted according to circumstances. The advantage of this method is the incorporation of inputs and outputs from the circulation of water in the soil so that it indirectly indicates the amount of water in the real ground. RDI is suitable to be used to calculate the drought index in agriculture [27]. In this method, effective precipitation is very dominant because this is known how much water deposits in the soil, including if there is water that is still below the plant roots. RDI divides the output into seven classes.

A4. Effective Drought Index (EDI)
Calculating the dryness index using EDI by estimating the Effective Precipitation (EP), then figuring the average EP of 30 years, calculating the Daily Effective Precipitation (DEP), and when the DEP results are negative, the condition is drier than average. If this condition is continuous, then recalculate the EP for the suspended period, then calculate the Mean EP (MEP) and DEP, divided by the standard deviation of the DEP for the previous 30 years. EDI calculation period is carried out for an annual or 365 days precipitation. The class distribution of drought index with extreme drought indication is more than -2, serve drought between -2.0 to -1.5, moderate drought between 1.5 to -1, and close-normal between -1 to 1 [1].

A5. Standardized Precipitation Index (SPI)
SPI is a method that is very well known and used in various countries in the world. This method is very flexible to monitor drought and used as an early warning system for the impact of drought in a region. The area covered in this method can be expansive with the number of data records that can be calculated very long with a monthly calculation period. The parameter used to input data is deposition (the quantity of water in the soil). Calculations using SPI do not have to be sequential but can use different time data with a duration that can be determined 1, 3, 6, 9 or 12 months. The weakness of this method is because it only uses water absorption data so it can just measure rainfall deficits [4].

A6. The McArthur Forest Fire Danger Index (MFFDI)
This method uses calculations based on the dry-bulb temperature in Celsius degree (T), relative humidity (U), wind speed (km/h) taken at an altitude of 10 m above ground level (H) and Drought Factor (DF). MFFDI calculation uses the formula:
MFFDI = 2 exp (-0.45 + 0.987 ln DF + 0.0338T – 0.0345H + 0.0234U)) [28]

A7. Standardized Precipitation Evapotranspiration Index (SPEI)
The calculation of the drought index using SPEI is to calculate the difference between Potential Evapotranspiration (PET) and rainfall which describes the level of deviation from dry and wet conditions. The calculation stage is to calculate the difference between monthly deposition and PET, then the accumulation of differences with different time scales (3, 6, or 12 months, or other) is then normalized. If the SPEI value is above 1 then it shows a humid climate and if the SPEI value is below -1 then it shows a dry climate [24].

3.2. Selection of criteria

There are five criteria referenced in the decision:

C1. Calculation period
This calculation period includes the range between one data and the next data that is input into the calculation. Examples of current calculation periods are daily, monthly, and yearly. The calculation period needed is the daily period because it will be used to predict the daily drought index, so the daily period has the highest value (value 5) and monthly has a value below (value 4), and the annual value is 3.

C2. The type of data needed for calculation
The kind of the data required to do the intended calculation are the types of variables that are input in the count. Examples are daily maximum temperature, daily rainfall data, humidity, wind direction, and so on. The more full the input variable, the higher the value.

C3. The complexity of the formula used
The complexity of the calculation referred to in this study is the level of difficulty in using mathematical calculations. Calculation of the drought index requires not too complicated but also not too simple. Giving value to this criterion is increasingly complex the higher the value.

C4. Usability (by many people/countries)
The more used by researchers or states, the better the calculation method. However, precisely this criterion will be assessed which methods are often used to calculate in the tropics.

C5. The type of calculation result scale
The use of a level to represent the results becomes one of the method assessment criteria to be chosen. A method usually classifies the calculation results into a certain range. The more range provided, the better the classification of the type of drought index.

3.3. Rating suitability

Rating suitability of each alternative on each criterion rated 1 to 5 with the provisions of very bad (1), bad (2), enough (3), good (4), and very good (5).

3.4. Determine the level of interest

The level of interest that will use as the weight of each preference criteria also evaluated with 1 to 5: Very Low (1), Low (2), Enough (3), High (4), and Very High (5).

3.5. Preference weights

Decision makers give preference weights as W = [5, 3, 4, 4, 5] with the consideration that the calculation and classification period of the calculation results become the essential variable so that the preference weight value is 5. Then the complexity of the formula is used and usability considered as the next important variable with the preference weight value of 4. The type variable of data needed for calculation is the next important variable with the preference weights value of 3. The result of giving preference weight then made into an identity matrix:

$$W = \begin{bmatrix} 5 & 0 & 0 & 0 & 0 \\ 0 & 3 & 0 & 0 & 0 \\ 0 & 0 & 4 & 0 & 0 \\ 0 & 0 & 0 & 4 & 0 \\ 0 & 0 & 0 & 0 & 5 \end{bmatrix}$$

3.6. Determined the suitability rating

Determining the suitability rating of each alternative in each of these criteria is based on the analysis of each alternative by assessing all criteria. The parameters used for each criterion vary depending on the data input requirements. This table is input into the three methods that will test, and specifically for ELECTRE and TOPSIS methods, table 2 will be converted into a matrix.

Table 2: the suitability rating of each alternative on each criterion

Alternative	C1	C2	C3	C4	C5
A1	3	5	5	3	3
A2	5	2	4	5	5
A3	3	2	3	3	3
A4	3	5	3	3	3
A5	3	3	3	5	5
A6	5	3	3	3	2
A7	3	3	5	3	5

4. Result and discussion

4.1. Calculation using electre

After the parameter value was determined and the weighting at the initial stage has been carried out. Based on alternative and criteria (table 2) then made a normalized decision matrix (R):

$$R = \begin{Bmatrix} 0.307794 & 0.542326 & 0.495074 & 0.307794 & 0.291386 \\ 0.512989 & 0.216930 & 0.396059 & 0.512989 & 0.485643 \\ 0.307794 & 0.216930 & 0.297044 & 0.307794 & 0.291386 \\ 0.307794 & 0.542326 & 0.297044 & 0.307794 & 0.291386 \\ 0.307794 & 0.325396 & 0.297044 & 0.512989 & 0.485643 \\ 0.512989 & 0.325396 & 0.297044 & 0.307794 & 0.194257 \\ 0.307794 & 0.325396 & 0.495074 & 0.307794 & 0.485643 \end{Bmatrix}$$

Then normalize the weights matrix V by multiplying the matrix R with matrix W.

$$V = \begin{Bmatrix} 1.538968 & 1.626978 & 1.980295 & 1.231174 & 1.456929 \\ 2.564946 & 0.650791 & 1.584236 & 2.051957 & 2.428215 \\ 1.538968 & 0.650791 & 1.118177 & 1.231174 & 1.456929 \\ 1.538968 & 1.626978 & 1.118177 & 1.231174 & 1.456929 \\ 1.538968 & 0.976187 & 1.118177 & 2.051957 & 2.428215 \\ 2.564946 & 0.976187 & 1.118177 & 1.231174 & 0.971286 \\ 1.538968 & 0.976187 & 1.980295 & 1.231174 & 2.428215 \end{Bmatrix}$$

The next stage, matrix f is multiplied by matrix f so as to produce a matrix e (e_{kl} = f x g).

$$e_{kl} = \begin{Bmatrix} & 0 & 1 & 1 & 0 & 1 & 1 \\ 0 & & 1 & 1 & 1 & 1 & 0 \\ 0 & 0 & & 1 & 0 & 0 & 0 \\ 1 & 0 & 1 & & 0 & 1 & 0 \\ 0 & 0 & 1 & 1 & & 1 & 1 \\ 0 & 0 & 1 & 0 & 0 & & 0 \\ 1 & 0 & 1 & 1 & 1 & 1 & \end{Bmatrix} x \begin{Bmatrix} & 1 & 0 & 0 & 1 & 1 & 1 \\ 1 & & 0 & 1 & 0 & 0 & 0 \\ 1 & 1 & & 1 & 1 & 1 & 1 \\ 1 & 1 & 0 & & 1 & 1 & 1 \\ 1 & 1 & 0 & 0 & & 0 & 1 \\ 1 & 1 & 0 & 0 & 1 & & 1 \\ 0 & 1 & 0 & 0 & 1 & 0 & \end{Bmatrix} = \begin{Bmatrix} & 0 & 0 & 0 & 0 & 1 & 1 \\ 0 & & 0 & 1 & 0 & 0 & 0 \\ 0 & 0 & & 1 & 0 & 0 & 0 \\ 1 & 0 & 0 & & 0 & 1 & 0 \\ 0 & 0 & 0 & 0 & & 0 & 1 \\ 0 & 0 & 0 & 0 & 0 & & 0 \\ 0 & 0 & 0 & 0 & 1 & 0 & \end{Bmatrix}$$

The last step is elimination less desirable alternative. Regarding the matrix e, the value is 1:

e_{16} = 1, Alternative 1st better than alternative 6th
e_{17} = 1, Alternative 1st better than alternative 7th
e_{24} = 1, Alternative 2nd better than alternative 4th
e_{34} = 1, Alternative 3rd better than alternative 4th
e_{41} = 1, Alternative 4th better than alternative 1st
e_{46} = 1, Alternative 4th better than alternative 6th
e_{57} = 1, Alternative 5th better than alternative 7th
e_{75} = 1, Alternative 7th better than alternative 5th

Based on eight results of elements that have a value of 1, then the conclusion:

a. Alternative 2nd better than alternative 4th, 1st, 6th, 7th
b. Alternative 3rd better than alternative 4th, 1st, 6th, 7th
c. Counterproductive between e_{57} and e_{75} causes both to be ignored.

4.2. Calculation using topsis

By using the same data input (suitability rating and weights), it is now calculated using the TOPSIS method. Step 1-4 is almost the same as the electre method, then TOPSIS has a different way.

Based on the input from Table 2, a normalized matrix is formed using a formula:

$$r_{ij} = \frac{x_{ij}}{\sqrt{\sum_{j=1}^{J} x_{ij}^2}, j = 1,2,3,\ldots J; i = 1,2,3..n;}$$

After getting the normalized matrix, then each element is multiplied by its weight. The results of the multiplication are called the normalized and weighted matrix. From this matrix then determined the positive ideal solution (A*) and negative ideal solution (A^-). Table 3 shows the greatest value of each criterion element as a positive ideal solution and the smallest value of each criterion element as a negative ideal solution.

Table 3: the positive and negative ideal solution

Alternative	C1	C2	C3	C4	C5
A*	2.5649	1.6270	1.9803	2.0520	2.4282
A^-	1.5390	0.6508	1.1882	1.2312	.9713

The next step is to calculate the difference between each element of the normalized matrix and weighted with the positive or negative ideal solution. The final result of the calculation using TOPSIS shown in Table 4.

Table 4: Result of calculation using topsis

Alternative	S*	S-	RC	Rank
A1	1.6339	1.3477	0.4520	4
A2	1.0535	2.0015	0.6552	1
A3	2.0616	0.4856	0.1907	7
A4	1.8158	1.0903	0.3752	5
A5	1.4504	1.7036	0.5401	2
A6	1.9615	1.0763	0.3543	6
A7	1.4662	1.6900	0.5354	3

4.3. Calculation using analytic hierarchy process

In this method also uses input as in table 2. The first step is to determine the degree of importance of each criterion and each sub-criterion in a pairwise comparison matrix. Table 5 shows the determination of the weight values in the pairwise comparison of each criterion with other criteria based on Table 1.

Table 5: the pairwise comparison matrix

Alternative	C1	C2	C3	C4	C5
C1	1	9	9	9	9
C2	0.111	1	7	5	7
C3	0.111	0.143	1	7	5
C4	0.111	0.200	0.143	1	9
C5	0.111	0.143	0.200	0.111	1

Determining the degree of importance of each criterion is the most crucial stage because it is very influential on the final results. Likewise, the determination of the degree of significance for each sub-criterion in the next phase. Finally, after the calculation of the consistency ratio of each criterion and sub-criteria, the results shown in Table 6.

Table 6: the result criteria and sub-criteria calculation

C1	C2	C3	C4	C5
0.553	0.206	0.125	0.088	0.028
Daily	Moderate	Moderate	Many	Many
1.000	1.000	1.000	1.000	1.000
Monthly	Complex	Complex	Moderate	Moderate
0.258	0.384	0.342	0.345	0.345
Yearly	Simple	Simple	Little	Little
0.095	0.097	0.652	0.079	0.079

Table 6 also explains each criterion having sub-criteria, such as the calculation period criteria has three sub-criteria: daily, monthly, and yearly. The final results of calculating the calculation period criteria getting a result value 0.553 and each sub-criterion also has a result value. Likewise for other criteria also get the results value with each sub-criterion.

Based on Table 6, the AHP method has completed the process of calculating criteria and sub-criteria values. From the results of the calculation, the input values then entered from Table 2. Each element of table 2 (which has been adjusting with each sub-criteria) value multiplied by the value of the final calculation result of criteria. The calculation results shown in Table 7.

Table 7: Result of calculation using the analytic hierarchy process

Alternative	C1	C2	C3	C4	C5	Total	Rank
A1	0.143	0.206	0.125	0.030	0.010	0.513	3
A2	0.553	0.020	0.043	0.088	0.028	0.732	1
A3	0.143	0.020	0.043	0.030	0.010	0.245	6
A4	0.143	0.206	0.043	0.030	0.010	0.431	5
A5	0.143	0.079	0.125	0.088	0.028	0.463	4
A6	0.553	0.079	0.043	0.030	0.02	0.708	2
A7	0.143	0.079	0.125	0.088	0.028	0.463	4

5. Conclusion

The recommended alternative for drought index calculation method using the ELECTRE method are alternative 2nd (Keetch-Byram Drought Index) and alternative 3rd (Reconnaissance Drought Index). Both results recommended with the final value which is equally better than the other alternatives, and both alternatives do not negate each other. The fifth and alternative of the seventh cannot conclude because they deny each other.

Using TOPSIS method, the alternative 2nd (Keetch-Byram Drought Index method) is more convincing to be the recommended method of other methods with the RC value is 0.6552, then the alternative 5th (Standard Precipitation Index Method) with the RC value is 0.5401.

Based on the results of calculations using the analytic hierarchy process method to produce the highest sequence of results is the alternative 2nd, then alternative 6th and alternative 1st

Based on the three ways (ELECTRE, TOPSIS, Analytic Hierarchy Process) it can be concluded that the Keetch-Byram Drought Index method is a method that is truly convincing according to the needs of drought index calculation in the forest of Bukit Suharto.

Based on the use of the three methods, it shows that the recommendations produced by TOPSIS are better because they presented in the form of ranking from the highest value so that they do not cause differences in interpretation. This result is different from the recommendations produced by ELECTRE which has two balanced proposals so that decision-makers must consider other things to decide. AHP also provides good suggestions, but giving a degree of importance to each criterion and sub-criteria test has a high risk of unstable final results.

The justification for evaluating the suitability rating of each alternative on each criterion and giving preference weighting is the most crucial step because the error in granting weight will result in different results. In this study, if one of the variables changed the value of justification and the importance of its preferences, potentially will produce different conclusions.

For the time being, the results of the selection of this method are promising. But it needs to be tested with other means of the many techniques that can be used to calculate the drought index and other test variables.

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