Comparison study of SMART and AHP method for paddy fertilizer recommendation in decision support system

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Abstract. Decision support systems are used as evidence-based decision-making tools in agriculture to provide relevant information. The implementation is to recommend the provision of fertilizer for rice plants, to support plant growth based on location specifics. This study aims to analyze the final results of two SMART and AHP methods by comparing the final results in evaluating the best alternatives. The criteria analyzed are: location, the yield of rice productivity, Leaf Color, Planting Season, Nutrient Status of P, nutrient status of K soil, Fertilizer Cage, Organic Straw Material, Use of Compost Fertilizer. For alternative solutions in the form of rice fertilizer dosage N, P, K. The results of the analysis of the two methods show that both have similarities in determining location-specific rice fertilizer recommendations, which are measured by comparing alternative final results of the two methods with recommendations from experts. Tests were carried out in ten cases with different locations. The accuracy of the two methods was 70%.

1. Introduction

Decision support systems are a tool to recommend the provision of appropriate doses of fertilizer to support rice plant growth based on local location, as well as to reduce adverse effects on the environment [1]. Fertilization recommendations are an effort to increase rice production and to increase farmers’ income, as well as the sustainability of environmental functions. Balanced fertilization is based on the concept of site-specific nutrient management, for the determination of fertilizer recommendations. Provision of fertilizer is done to maintain balanced nutrient availability in the soil, so as to increase crop productivity, and avoid pollution to the environment [2].

Computer technology has been widely used in agriculture, one of which is a fertilization decision support system, system development is based on several fertilization experiments, with fertilization parameters tested including the function of effects, nutrient balance, and a combination of soil fertility [3]. Development of fuzzy decision support the system applications, regarding site-specific nitrogen fertilization, with parameters used in fertilizer application, namely: soil characteristics, weather, and agricultural practices [4]. The factors that influence the management of soil fertility by fertilizing are the right type, the right dosage, the right time, the right place [1]. Decision support systems are used as cloud-based decision support tools, which allow farmers to upload their data, and use several methods of data analysis to obtain information related to agricultural management [5]. The computer systems used to identify rice varieties by analyzing three types of features, namely; color, morphological features and texture features [6].
Application of a decision support system is used for electrification experts based on competency tests implemented by comparing various Multi-attribute Decision Making (MADM) methods, namely Analytic Hierarchy Process (AHP), Technique for Order Preference by Similarity to Ideal Solution (TOPSIS), Weighted Product (WP) and Simple Additive Weighting (SAW). AHP-TOPSIS hybrid method. The results of the decision making show that the WP and SAW methods rank the same alternative, and for the hybrid method, it is more valid in the alternative ranking [7]. The results of decision making using the AHP method compared to the TOPSIS Method, show that there are inconsistencies in the sample data, namely: some matrices in the data have a consistency ratio of more than 0.1, resulting in a different alternative rating [8]. The application of the Fuzzy TOPSIS method succeeded in determining the best supplier with stability in rank because it was related to different criteria weights and several sub-criteria [9]. The system for selecting priorities for improving government asset management by applying a combination of AHP and TOPSIS methods, testing with an accuracy rate of 83% for the determination of the best alternative order [10]. This study aims to compare the results of the analysis to obtain the best alternative using the method of Simple Multi-Attribute Rating Technique (SMART) and AHP in recommending location-specific rice fertilizers. The implementation of decision support systems in agriculture has been carried out, namely, decision support tools used to help determine the priority of agricultural land to be conserved [11]. Decision support system simulation for agent-based regional agricultural economics that can model agent-based agricultural development and be able to regenerate, and produce information on the possible reality that will occur [12]. Decision support tools as a basis for evidence-based decision making in agriculture, which serves to provide information regarding agricultural issues, caused farmers can act more precisely to increase agricultural productivity [13].

2. Methods
Decision Support System for location-specific rice fertilizer recommendations, using SMART and AHP methods to analyze criteria and alternatives to determine the best option. The results of the two analysts’ methods were compared to find out whether there were differences in the best alternative selection results. The initial stage is to determine the criteria that will be used to recommend rice fertilizer dosages N, P, K based on location specifics. The criteria used consisted of nine criteria namely; Location, the yield of rice productivity, Leaf Color, Planting Season, Nutrient Status of P, nutrient status of K soil, Fertilizer Cages, Organic Straw Material, Use of Compost Fertilizer[1,2]. The following section will explain two methods, namely SMART and AHP, along with the steps in their work for implementation in the application.

2.1 SMART
SMART method is one method of multi-criteria decision making which means that each alternative has criteria and has certain values and weights. The analysis uses the SMART method based on linear additive models. This shows that the overall value of the alternative given is calculated as the total performance score (value) of each criterion (attribute), which will be multiplied by the criteria weight. The steps for implementing the SMART method are explained as follows [14].
1) Analysis of problems, determine criteria and alternatives to solve problems.
2) Determination of the range of values for each criterion then gives the weight of each criterion.
3) Normalization of values and weights for each criterion.
4) Calculate the average of the values given for each alternative.
5) Sensitivity analysis by calculating the value of each alternative utility.
6) Choose the highest utility alternative.
Determining separate criteria and alternative weighting criteria, different criteria scales need to be converted into a general internal scale, which can be done mathematically by decision-makers through a value function, or by using a linear scale (eg from 0 to 100). The results of testing the application of the SMART method indicate that the calculation process using the SMART method does not require a long time [15].
2.2 AHP

AHP method is used to solve problems by compiling a hierarchical structure of criteria, alternative results that become goals, by determining the weight or priority of the importance of each criterion for each alternative [16]. The initial stage of the AHP method begins with structuring the problem into a hierarchy and then evaluating the components with a pairwise comparison matrix. Goals are placed in the hierarchy at the top level, while the criteria and sub-criteria are at the middle level, alternatives are at the lowest level [14]. Comparison of paired matrices with one to nine scale values, used for all criteria and alternatives [17]. Then the weights are determined for each criterion, and all local weights for each criterion are calculated to obtain the global weights of all alternatives. The steps for applying the AHP method according to Gurung and Phipon (2016) [18] are;
1) Arrange a hierarchy that contains the objectives of the decision, alternatives, and criteria for evaluating alternatives.
2) Determination of priorities among hierarchical elements by making a series of assessments based on pairwise comparison matrices for all criteria and normalizing.
3) Calculate Consistency Index and Consistency Ratio, then check consistency <0.1.
4) Calculate all local weights for each criterion to obtain global values for all alternatives.
5) Determine the best alternative.

In figure 1, it shows the SMART and AHP method blocks diagram used to analyze the criteria, so as to produce alternative doses of rice fertilizer N, P, and K.

![Figure 1. Block diagram of implementation SMART and AHP methods](image)

3. Results and discussion

Experiments for testing the sensitivity of the SMART and AHP methods used fertilizer recommendation data for ten locations. The results of the analysis of the two methods are compared with the results of expert fertilizer recommendations. By doing this comparison, it aims to obtain the value/level of accuracy of each method. The results of the comparison of SMART and AHP methods and alternative recommendations from experts are shown in table 1.
The experiments were performed using data on cases of ten different locations, indicating that the results of both methods are the same in determining specific paddy fertilizer recommendations. The level of accuracy of the analysis using two methods, namely 70%. Comparison of two methods has been done with case studies of site selection for nuclear power plants, the results of the analysis of the application of the SMART and AHP methods indicate the level of similarity in the comparison of the final results [19]. However, it is not impossible for other case studies to show differences in the final results of the two methods.

| Number of Testing | SMART | AHP | EXPERT |
|-------------------|-------|-----|--------|
| Case 1            | A_{11} | A_{11} | A_{11} |
| Case 2            | A_{4}  | A_{4}  | A_{3}^* |
| Case 3            | A_{21} | A_{21} | A_{21} |
| Case 4            | A_{2}  | A_{2}  | A_{2}  |
| Case 5            | A_{5}  | A_{5}  | A_{5}  |
| Case 6            | A_{72} | A_{72} | A_{72} |
| Case 7            | A_{30} | A_{30} | A_{30} |
| Case 8            | A_{3}  | A_{3}  | A_{3}  |
| Case 9            | A_{17} | A_{17} | A_{9}^* |
| Case 10           | A_{18} | A_{18} | A_{10}^* |

Application of the SMART and AHP methods has advantages and disadvantages of each, besides that, both methods also have problems or domains for their implementation. The main advantages are SMART, easy to use and allow for all types of weighting techniques eg relative, absolute, and easy to obtain access to information to decision-makers. For general applications, SMART is in environmental issues, construction, transportation and logistics, military, manufacturing, and assembly problems. While the AHP method can be used to solve larger problems, making it ideal to deal with problems by comparing performance between alternatives. But if implemented for problems, with alternatives always increasing, it's best to avoid using this method. AHP advantages, easy to use, hierarchical structures can easily adjust according to the size of the number of problems. The disadvantages of this method are that there are interdependencies between criteria and alternatives, and can lead to inconsistencies between criteria and rank ratings, and ranking reversals. AHP general application for problems in determining the type of performance, selection, and management of resources, determination of public policy, political strategy, determination of company policies and strategies and planning [20]. One application of the AHP method for site selection is to provide information regarding health infrastructure location development plans [21].

4. Conclusion
The use of the Multi-Criteria Decision Making (MCDM) method for the implementation of decision support systems has their respective strengths and weaknesses. Especially in solving complex problems, allowing methods not suitable for use. This study compares the final results of two SMART and AHP methods, which provide information and benefits for practitioners to choose two methods, to solve certain problems. Measuring the accuracy of the two methods results in a level of similarity in the final results in evaluating alternative solutions.

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