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A Mixed Method using AHP-TOPSIS for Dryland Agriculture Crops Selection Problem

Wiwien Hadikurniawati, Edy Winarno, Dwi Budi Santoso, Purwatiningtyas
Faculty of Information Technology
Universitas Stikubank Semarang Indonesia
wiwien@edu.unisbank.ac.id, edywin@edu.unisbank.ac.id, dbs@edu.unisbank.ac.id, purwati@edu.unisbank.ac.id

Abstract— **Determination of the selection of food crops on a suitable land planted based on the characteristics of the land is very important for decision makers. A proposed model that aggregated weight of parameters and determined the best alternative using an AHP and TOPSIS mixed method. Priority weights for parameters are calculated using the AHP method and then making a sequence alternative uses the TOPSIS method. The appliance of the planned model can help users in deciding the most suitable food crops to be planted on certain land according to the characteristics of the land. Based on calculations using the AHP and TOPSIS mix methods the highest priority results obtained from the alternative. The highest priority alternative to the consideration of 11 parameters is green beans. Ranking in this application depends on the choice of preference type and determination of parameter thresholds. Proposed method can solve the problem of determining food crops that are suitable for planting in dry land.**

Keywords— multi attribute decision making, AHP, TOPSIS, food crop

I. Introduction

In this present time, for complex decisions regarding the thought of numerous variables, analysts have been centered around Multi Attribute Decision Making (MADM) techniques. An assortment techniques have been proposed to manage such issues [1]. In MADM, a few alternatives as per a few criteria are positioned and chose. Positioning and choosing will be settled on among choice options portrayed by certain parameters (factors) through chief learning and experience. Nevertheless, decision making with more criteria, conflicts and judgments is a very important thing to consider. This complex decision making is called MADM. MADM has the goal of choosing the most suitable alternative from several alternatives with the feasibility of using multiple choice criteria and the priority of criteria varies [2][3].

The problem that characterizes AHP [4][5][6] begins with defining the problem that occurs by identifying the objectives to be achieved, pairing the pairwise comparison of elements related to the criteria and finally arranging them as hierarchies. This hierarchy is seen as a logical form and is organized in representing problems. The advantage of this analysis is that many criteria provide a balanced view of the problem. AHP looks at problems in totality by including all relevant parameter [5].

AHP is a method that is widely proposed. Especially related to solving problems with various criteria. For example in the selection of electricity [5], choosing the right supplier [1]. The approach in AHP is systematically used for decision making based on experience, intuition and heuristics. It is a hypothesis of estimation for managing quantifiable and immaterial criteria that has been connected to various regions, for example, choice hypothesis and compromise. Most decision making uses the method by determining the weighting of alternatives for each criteria involved in making decisions [7][8][9]. TOPSIS is a useful and valuable procedure for positioning and determination of various remotely decided choices through separation measures. So far, the application of TOPSIS in supply chain management, engineering and manufacturing, human resource management and other fields has been considered successful[10][11].

Land and plants are two related things. which is part of agriculture. Agriculture develops and the use of natural resources is used as in human life. Dry land is one of the ecosystem land resources that have great potential for agricultural development, both food crops, horticulture and plantations. Agricultural dry land is used for agriculture using limited water and only gets from rainfall. Knowledge about dry land agriculture is obtained from agricultural experts, both land experts and agribusiness. Many problems that occur in farmers include 1) problems on agricultural land, 2) problems of farmers' need for information, knowledge that is cheap, fast, quality and flexible, 3) problem of decision making on several alternative choices in determining the type of plants in accordance with the characteristics of the land [12]. A decision support system application is needed to determine the plants that are most suitable for climatic conditions, rainfall, water availability and soil types so to optimize the function and productivity of the land. The purpose of this study is to create a model that is able to provide recommendations for food crops to be planted by farmers.

In this paper, performance evaluation of determine food crops that are suitable for climate conditions, rainfall, water availability, type and content of soil nutrients so as to optimize the function and productivity of agricultural land is presented. The planned approach relies on two-step AHP and TOPSIS methodology for choosing the best food crop. AHP is utilized as an initiate step for calculating attribute weights and weights of all candidates in every attribute. Next, these weights has a possibility for being used in TOPSIS mechanism. Performance evaluation of determine food crops that are suitable for climate conditions, rainfall, water availability, type and content of soil nutrients so as to optimize the function and productivity of agricultural land is given. In this study, the approach is based on the hybrid AHP-TOPSIS method to select and rank the best food crop.

II. AHP (Analytic Hierarchy Process)

Pairwise comparison and AHP usage has inspired other decision making methods. Initially AHP estimate related data. Namely, the estimated value of aij and Wj from the decision matrix. The use of pairwise comparisons in this study is to calculate the relative importance of each alternative. These interests are expressed as parameters. Pairwise comparisons are expressed on a scale. The scale proposed by Saaty is depicted in Table 1. In AHP the pairwise comparison in the assessment matrix is considered consistent if the corresponding consistency ratio (CR) is less than 10%. The consistency index (CI) is calculated by adding a column in the grading matrix and multiplying the resulting vector with the priority vector obtained previously. This results in a maximum eigen value (δ max). The CI equation = (δ max - n) / (n - 1) is used to get the CI value. The CI value divided by the Random Consistency index (RCI) results in a Consistency Ratio (CR).

TABLE I. Scale of Relative Importance

Rating Importance	Definition	Explanation
1	Equivalent significance	Two actions commit close to the goal
3	Weak importance of one over another	Experience and judgment prefer one activity more than another
3	Essential importance	Experience and judgment strongly favor one activity over another
7	Demonstrated importance	A highly preferred activities
9	Suprime significance	The highest level of affirmation is determined through support for one activity over another
2,4,6,8	Intermediate values between the two adjacent judgments	at the point when bargain is required

III. TOPSIS (Technique For Order of Preference By Similarity To Ideal Solution)

TOPSIS is known as a practical technique. In ranking and choosing alternatives that vary through determining external steps, TOPSIS is very useful. The techniques used on TOPSIS are normalization, distance measures and mean operators. The shortest distance from the positive ideal solution and the farthest distance from the negative ideal solution are the main conditions of the alternative chosen The steps in the TOPSIS method :

1. Build a decision matrix used for ranking.
2. Make a calculation from the normalized decision matrix.
3. Calculate the weighted normalized decision matrix
4. Determine the positive ideal solution and negative ideal solution.
5. Calculate the detachment measures.
6. Calculate the closseness coeffisient
7. Rank the alternatives

IV. Case Study

The decision making model in this research consisted of eleven parameters and five alternatives. The proposed model is shown in Figure 1. The parameters used in this decision making include physical and chemical parameters, natural factors such as temperature and rainfall. We use eleven parameters and five alternatives in this study. The formulation of food crop performance selection models as shown in Fig. 1 is based on literature considerations and expert opinions. A survey of dry agricultural land has been prepared in the Kendal area, Central Java. and agricultural data related to soil conditions, pH, humidity, etc.

These parameters are used in determining land suitability. The objects used in this study include 5 types of food plants namely: maize, soybean, green bean, sweet potato and upland rice will be matched with eleven soil parameters, namely: rainfall (mm / year), Temperature (◦C), slope class (%), Drainage, Erosion, Texture, Effective depth (cm), pH, Cation Exchange Capacity (me / 100gram), Base Saturation (%), C-Organic (%). The 11 parameters will be matched with the dry soil conditions in the Kendal area of Central Java. By matching land suitability based on these criteria, it will be easier for farmers to determine which food crops are suitable for the area. Agricultural output is expected to increase further. These problems can be illustrated by the hierarchical structure shown in Fig. 2.

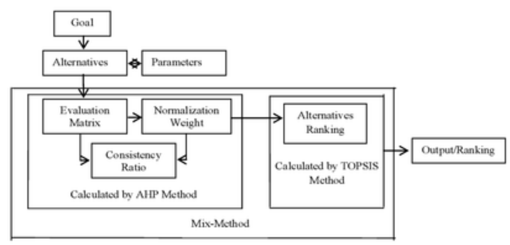

Fig. 1. Proposed model

Fig. 2. Hierarchy structure

Pairwise comparison matrices can be made using the AHP method approach. Table 2 displays the resulting priority weights. A reliable matrix is the main thing, to determine it consistency was measured using the consistency ratio equation and the results obtained were CR = 0.0967. According to Saaty, the matrix is consistent if the consistency ratio is less than 10%. In this case value of C.R. < 0.1; Seeing the resulting value, it can be concluded that the weight of the evaluation matrix has consistent parameters.

TABLE II. MATRIX FOR PRIORITY WEIGHTS OF PARAMETER

	P1	P2	P3	P4	P5	P6	P7	P8	P9	P10	P11
P1	1	5	0.20	0.33	0.14	0.33	3	3	0.20	0.33	3
P2	0.20	1	0.11	0.11	0.11	0.14	1	0.33	0.14	0.20	0.33
P3	5	9	1	3	1	3	9	7	7	7	7
P4	3	9	0.33	1	0.33	3	7	3	1	1	7
P5	7	9	1	3	1	3	9	9	7	5	9
P6	3	7	0.33	0.33	0.33	1	5	3	1	0.20	7
P7	0.33	1	0.11	0.14	0.11	0.20	1	1	0.20	0.20	0.33
P8	0.33	3	0.14	0.33	0.11	0.33	1	1	0.33	0.33	3
P9	5	7	0.14	1	0.14	1	5	3	1	5	5
P10	3	5	0.14	1	0.20	5	5	3	0.20	1	3
P11	0.33	3	0.14	0.14	0.11	0.33	3	0.33	0.20	0.33	1

After the criteria weights are obtained, the TOPSIS method approach is used for alternative order assessment. Initially, a decision matrix is developed for alternatives by considering parameters and then a normalized decision matrix is shown in Table 3 and Table 4. The weighted normalized decision matrix is calculated as shown in Table 5.

As per the current hypothesis of TOPSIS approach it is required to compute the separation of options from positive ideal solution and negative ideal solution. These separations are determined by utilizing Eqs(1) and appeared in Table 6 accordingly.

$$d_i^* = \sqrt{\sum_{j=1}^{n} d\,(v_{ij}^{\sim}\ , v_{ij}^{\sim *})^2}\ , i = 1,2,\ldots,m$$

$$d_i^- = \sqrt{\sum_{j=1}^{n} d\,(v_{ij}^{\sim}\ , v_{ij}^{\sim -})^2}, i = 1,2,\ldots,m. \qquad (1)$$

At last, by utilizing Eq. (2), relative closeness coefficients of options are determined as given in Table 7.

$$CC_i = \frac{d_i^-}{d_i^* + d_i^-} \qquad (2)$$

Based on the proximity coefficient, an alternative ranking can be determined. Comparison of all alternatives is shown in Fig. 3.

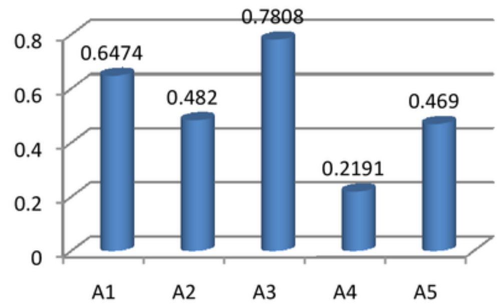

Fig. 3. Comparison of the closeness coefficient

TABLE III. PARAMETER WEIGHT

	P1	P2	P3	P4	P5	P6	P7	P8	P9	P10	P11	Sum
Weight	0,04045	0,0132	0,257	0,10196	0,25613	0,06804	0,01625	0,02833	0,10849	0,0811	0,02902	1,00001

TABLE IV. NORMALIZED DECISION MATRIX FOR ALTERNATIVES WITH RESPECT TO PARAMETERS

	P1	P2	P3	P4	P5	P6	P7	P8	P9	P10	P11
A1	0.1032	0.3130	0.2772	0.2000	0.2000	0.3836	0.0900	0.1062	0.2000	0.2000	0.1111
A2	0.1812	0.2869	0.2772	0.2000	0.2000	0.0921	0.0900	0.0432	0.2000	0.2000	0.1111
A3	0.6313	0.1146	0.2772	0.2000	0.2000	0.3899	0.0900	0.1062	0.2000	0.2000	0.1111
A4	0.0634	0.2171	0.1221	0.2000	0.2000	0.0392	0.0900	0.0744	0.2000	0.2000	0.5659
A5	0.0406	0.0682	0.0459	0.2000	0.2000	0.0953	0.6360	0.6699	0.2000	0.2000	0.1111

TABLE V. WEIGHTED NORMALIZED DECISION MATRIX

	P1	P2	P3	P4	P5	P6	P7	P8	P9	P10	P11
A1	0,021864	0,00605	0,14541	0,062931	0,1471125	0,037702	0,009568	0,013972	0,070621	0,02631	0,1650746
A2	0,027937	0,01008	0,18176	0,015733	0,1655016	0,031418	0,011482	0,023287	0,042373	0,06576	0,1857089
A3	0,019434	0,00605	0,10905	0,078664	0,1287234	0,047127	0,006379	0,013972	0,070621	0,03946	0,1444403
A4	0,002565	0,00287	0,03138	0,020392	0,051226	0,002667	0,001463	0,002108	0,021698	0,01622	0,0164224
A5	0,001642	0,0009	0,0118	0,020392	0,051226	0,006484	0,010335	0,018978	0,021698	0,01622	0,0032241

TABLE VI. POSITIVE IDEAL SOLUTION AND NEGATIVE IDEAL SOLUTION

	P1	P2	P3	P4	P5	P6	P7	P8	P9	P10	P11
Vj*	0,02794	0,0101	0,1818	0,07866	0,165502	0,04713	0,01148	0,02329	0,07062	0,0658	0,15126
Vj-	0,01943	0,006	0,1091	0,01573	0,128723	0,03142	0,00638	0,01397	0,04237	0,0263	0,14444

TABLE VII. FINAL RANGKING OF ALTERNATIVES

Alternatives	CC	Rank
A1	0,6474	2
A2	0,482	3
A3	0,7808	1
A4	0,2191	5
A5	0,469	4

CONCLUSION

The proposed model can assist users in selecting food crops that are suitable for the characteristics of dry land. The AHP method can calculate the attribute weights and overall weights from existing parameters.TOPSIS method used to improve the gaps between the alternative performance and the actual results and also finding the best alternative. In this study the proposed model which consists of eleven parameters as : Rainfall (P1), Temperature (P2), Grade Slope (P3), Drainage (P4), Erosion (P5), Texture (P6), effective depth (P7), pH (P8), cation exchange capacity (P9), saturation bases, (P10), C-Organic (P11) and five alternatives as: Maize (A1), Soybean (A2), Green Bean (A3) Sweet Potato (A4) and Upland Rice (A5) and analyzed using the AHP-TOPSIS hybrid method. Based on calculations using the AHP and TOPSIS mixed methods the highest priority results obtained from the alternative. The highest priority alternative to the consideration of 11 parameters is green beans. This model is an incredible and adaptable apparatus that is utilized to solve multi-attribute problem, was connected as the choice methodology, and a reasonable decision was chosen.

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