Applying Topsis Method for Evaluating the Water Requirement of Agricultural Crops

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Abstract: In the present day scenario choosing the Best Crop plays a vital role for the farmers due to insufficient rainfall and water unavailability. Choosing the best crop which requires minimal water with shorter duration will make the farmers work with ease. This paper aims at giving an application of Topsis with entropy weights to find out the best alternative for choosing best crop by taking the subjective parameters into consideration. In this paper we have chosen five criteria and five alternatives. The alternative holding first rank will be considered as the most preferred alternative. The weights for a number of criteria are calculated based on the Entropy method. These weights are then evaluated by TOPSIS method where the rank of each crop is determined according to its results. Technique for Order Performance by Similarity to Ideal Solution (TOPSIS)is a multi-criteria decision making technique based on the minimization of geometric distances that allows the ordering of compared alternatives in accordance with their distances from the ideal and anti-ideal solutions. This paper was performed a ranking of the crops through the application of the TOPSIS method With Entropy Weight.

Keywords: *TOPSIS, Multi Criteria Decision Making, Entropy*

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1. INTRODUCTION

The technique for order performance by similarity to ideal solution (TOPSIS) was first developed by Hwang and Yoon [3].

The primary concept of TOPSIS approach is that the most preferred alternative should not only have the shortest distance from the positive ideal solution (PIS), but also have the farthest distance from the negative ideal solution (NIS) [7]. Generally speaking, the advantages for TOPSIS include (a) simple, rationally comprehensible concept, (b) good computational efficiency, (c) ability to measure the relative performance for each alternative in a simple mathematical form [6]. Mohammad Saeed Zaeri [5], illustrated a methodology to evaluate suppliers in supply chain cycle based on Technique for Order Preference by Similarity to Ideal Solution method (TOPSIS). After, the weights for a number of criteria are calculated based on the opinions of experts; these weights are processed by the TOPSIS method to rank suppliers. Entropy method is used to evaluate the weight of the feature attributes. Chiang Ku Fan, and Shu Wen Cheng [1], proposed a curriculum performance evaluation method combining the Analytical Hierarchy Process (AHP) and the Technique for Order Preference by Similarity to Ideal Solution (TOPSIS). The AHP is used in obtaining the relative weights of criteria, and then the TOPSIS approach is employed to rank how universities perform in using this curriculum. Products [4] and Banks [2] are evaluated and ranked through the application of TOPSIS method with Entropy Weight. In this paper crops are ranked through the application of the TOPSIS method with Entropy Weight.

2. METHODOLOGY

To find out the best quantitative solution from the alternatives, multi criteria decision making process provides ranking solutions of the alternatives. In this research paper we applied entropy method because it is highly reliable for information measurement and provide high accuracy in determination of weight of the feature attribute of the product. A MCDM problem can be expressed in matrix format as

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$$D = \begin{array}{c} \\ A_1 \\ A_2 \\ A_3 \\ \vdots \\ A_m \end{array} \begin{array}{c} \begin{array}{ccccc} C_1 & C_2 & C_3 & \dots & C_n \end{array} \\ \begin{bmatrix} x_{11} & x_{12} & x_{13} & \dots & x_{1n} \\ x_{21} & x_{22} & x_{23} & \dots & x_{2n} \\ x_{31} & x_{32} & x_{33} & \dots & x_{3n} \\ \vdots & \vdots & \vdots & \vdots & \vdots \\ x_{m1} & x_{m2} & x_{m3} & \dots & x_{mn} \end{bmatrix} \end{array}$$

$$w = [w_1, w_2, w_3, ..., w_n]$$

where $A_1, A_2, A_3, ..., A_m$ are possible alternatives among which decision makers have to choose $C_1, C_2, C_3, ..., C_n$ are criteria with which alternatives performance are measured, x_{ij} is the performance value of alternatives A_i with respect to criterion C_j, w_j is the weight of criterion C_j.

A. ENTROPY

According to the degree of index dispersion, the weight of all indicators is calculated by information entropy. Suppose we have a decision matrix D with m alternatives and n indicators:

Step 1: In matrix D, feature weight P_{ij} is of the i^{th} alternatives to the j^{th} factor:

$$P_{ij} = \frac{x_{ij}}{\sum_{i=1}^{m} x_{ij}}, \qquad (1 \le i \le m, 1 \le j \le n)$$

Step 2: Calculate the entropy value e_j of the j^{th} factor becomes

$$e_j = -k \sum_{i=1}^{m} p_{ij} \ln p_{ij}, \ (k = 1/\ln m, \ 1 \le j \le n)$$

Step 3: Variation coefficient of the j^{th} factor d_j can be defined by the following equation:

$$d_j = 1 - e_j, \ (1 \le j \le n)$$

Step 4: Calculate the weight of the entropy w_j of index j:

$$w_j = \frac{1 - e_j}{n - \sum_{j=1}^{n} e_j}$$

B) TECHNIQUE FOR ORDER PREFERENCE BY SIMILARITY TO IDEAL SOLUTION (TOPSIS)

Technique for order preference by similarity to ideal solution TOPSIS was initially developed by Hwang and Yoon (1981). TOPSIS finds the best alternatives by minimizing the distance to the ideal solution and maximizing the distance to the nadir or negative-ideal solution . All alternative solutions can be ranked according to their closeness to the ideal solution.

Step 1: Construct the normalized weighted decision matrix $V = (v_{ij})_{m \times n}$:

$$v_{ij} = w_j \times p_{ij}$$

where w_j is the weight of the i^{th} criterion and $\sum_{j=1}^{n} w_j = 1$.

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Step 2: Determine the positive ideal and negative ideal solutions

$$V^{+} = \{v_1^{+}, v_2^{+}, \ldots, v_n^{+}\}, \text{ where } v^{+} = \{\max(v_{ij}) \text{ if } j \in J; \min(v_{ij}) \text{ if } j \in J\}$$
$$V^{-} = \{v_1^{-}, v_2^{-}, \ldots, v_n^{-}\}, \text{ where } v^{-} = \{\min(v_{ij}) \text{ if } j \in J; \max(v_{ij}) \text{ if } j \in J\}$$

Step 3: Calculate the separation measures, using the m-dimensional Euclidean distance

$$S^{+} = \sqrt{\sum_{j=1}^{n}(V_{ij} - V^{+})^2}, \text{ where } (1 \le i \le m, 1 \le j \le n)$$
$$S^{-} = \sqrt{\sum_{j=1}^{n}(V_{ij} - V^{-})^2}, \text{ where } (1 \le i \le m, 1 \le j \le n)$$

Step 4: Calculate the relative closeness to ideal solution

$$C_i^{+} = \frac{S_i^{+}}{S_i^{+} + S_i^{-}} \quad i = 1, 2, \ldots, m$$

where the larger is, C_i the closer the alternative is to ideal solution

Step 5: The larger TOPSIS value, the better the alternative.

3. NUMERICAL EXAMPLE

In this paper to demonstrate the decision making approaches, an example is taken into consideration. A farmer is given a data pertaining to five different types of crops along with duration and the quantity of water required. According to the farmers requirement 5 personal data assistant design alternatives A_1, A_2, A_3, A_4, A_5 selected are Sorghum, Cotton, Maize, Groundnut and Ragi. The Criteria are C_1, C_2, C_3, C_4 and C_5 are Initial Stage, Development Stage, Mid Season Stage, Late Season Stage and Water Required

3.1 Table of Criteria Details

Criteria	***Description***
Initial stage	This is the period from sowing or transplanting until the crop covers about 10% of the ground.
Crop development stage	This period starts at the end of the initial stage and lasts until the full ground cover has been reached (ground cover 70-80%); it does not necessarily mean that the crop is at its maximum height.
Mid - season stage	This period starts at the end of the crop development stage and lasts until maturity; it includes flowering and grain-setting.
Late season stage	This period starts at the end of the mid season stage and lasts until the last day of the harvest; it includes ripening
Water Required	Quantity of Water required for the crop

Table 3.2 Specification of five different crops

	Criteria				
Alternative	**Initial Stage (Days)**	**Dev Stage (Days)**	**Mid Season (Days)**	**Late Season (Days)**	**Water Required (mm)**
Sorghum	20	30	40	30	350
Cotton	30	50	55	45	550
Maize	20	30	50	10	500

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Groundnut	25	35	45	25	550
Ragi	15	25	40	25	350

Step 1:

For the weight using entropy analysis, the procedure is as follows, the decision matrix shown in Table 3.2

$$P_{ij} = \frac{x_{ij}}{\sum_{i=1}^{m} x_{ij}}, \qquad (1 \le i \le m, 1 \le j \le n)$$

$P_{11} = \frac{20}{110} = 0.1818$

Table 3.3 Entropy Normalization Matrix

Alternative	Criteria				
	Initial Stage (Days)	Dev Stage (Days)	Mid Season (Days)	Late Season (Days)	Water Required (mm)
Sorghum	0.1818	0.1765	0.1739	0.2222	0.1522
Cotton	0.2727	0.2941	0.2391	0.3333	0.2391
Maize	0.1818	0.1765	0.2174	0.0741	0.2174
Groundnut	0.2273	0.2059	0.1957	0.1852	0.2391
Ragi	0.1364	0.1471	0.1739	0.1852	0.1522

Step 2:

To find the value of $P_{ij} \ln (P_{ij})$

$P_{11} \ln (P_{11}) = 0.1818 \ln(0.1818) = -.3100$

Table 3.4 Weighted Estimation

Alternative	Criteria				
	Initial Stage (Days)	Dev Stage (Days)	Mid Season (Days)	Late Season (Days)	Water Required (mm)
Sorghum	-0.3100	-0.3061	-0.3042	-0.3342	-0.2865
Cotton	-0.3543	-0.3599	-0.3421	-0.3662	-0.3421
Maize	-0.3100	-0.3061	-0.3318	-0.1928	-0.3318
Groundnut	-0.3367	-0.3254	-0.3192	-0.3123	-0.3421
Ragi	-0.2717	-0.2819	-0.3042	-0.3123	-0.2865

Step 3: Calculate e_j, d_j *and* w_j

$$e_j = -k \sum_{i=1}^{m} p_{ij} \ln p_{ij}, \; (k = 1/\ln m, \; 1 \le j \le n)$$

$$d_j = 1 - e_j, \; (1 \le j \le n)$$

$$w_j = \frac{1 - e_j}{n}$$

$$n - \sum_{j=1} e_j$$

e_1 = -06213(-1.5827) = 0.9834
d_1= 1 - 0.9834 = 0.0166
w_1 = 0.1514

Table 3.5 Entropy Weight

Criteria	e_j	d_j	w_j
Initial Stage (Days)	0.9834	0.0166	0.1514
Dev Stage (Days)	0.9814	0.0186	0.1698
Mid Season (Days)	0.9951	0.0049	0.0450
Late Season (Days)	0.9431	0.0569	0.5184
Water Required (mm)	0.9873	0.0127	0.1155

Now applying different Multi Criteria Decision Making methods for obtaining ranking solution of the product with using Entropy Normalization Matrix.

Step 4:

Elements of matrix of V gain their values from multiplying each column of the entropy normalised decision matrix by the associated entropy weight, using V = ($P_{ij} * w_j$)

Table 3.6 Weights of Criteria

Alternative	Criteria				
	Initial Stage (Days)	Dev Stage (Days)	Mid Season (Days)	Late Season (Days)	Water Required (mm)
Sorghum	0.0275	0.0300	0.0078	0.1152	0.0176
Cotton	0.0413	0.0499	0.0107	0.1728	0.0276
Maize	0.0275	0.0300	0.0098	0.0384	0.0251
Groundnut	0.0344	0.0350	0.0088	0.0960	0.0276
Ragi	0.0206	0.0250	0.0078	0.0960	0.0176

Step 5 :

The maximum and minimum values in Table 3.6 represent the positive and negative ideal solutions for each decision making as shown below.

$$V^+ = \{v_1^+, v_2^+, \ldots\ldots, v_n^+\}, \text{where } v^+ = \{\max(v_{ij}) \text{ if } j \in J; \min(v_{ij}) \text{ if } j \in J'\}$$
$$V^- = \{v_1^-, v_2^-, \ldots\ldots, v_n^-\}, \text{where } v^- = \{\min(v_{ij}) \text{ if } j \in J; \max(v_{ij}) \text{ if } j \in J'\}$$

V^+ = {0.0413, 0.0499, .0107, 0.1728, 0.0276}
V^- = {0.0206, 0.0250, .0078, 0.0384, 0.0176}

Step 6:

The Separation measures of positive and negative ideal solutions for each alternative is defined as,

$$S^+ = \sqrt{\sum_{j=1}^{n} (V_{ij} - V^+)^2}, \text{ where } (1 \le i \le m, 1 \le j \le n)$$

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$$S^- = \sqrt{\sum_{j=1}^{n}\left(V_{ij} - V^-\right)^2}\text{ , where }\left(1 \le i \le m, 1 \le j \le n\right)$$

$$C_i^+ = \frac{S_i^+}{S_i^+ + S_i^-}\ i = 1, 2, \ldots, m$$

Table 3.7 Ranking Alternatives

Alternatives	S_i^+	S_i^-	C_i^+	Ranking
Sorghum	0.0634	0.0773	0.4506	4
Cotton	0.0000	0.1386	0.0000	5
Maize	0.1366	0.0115	0.9222	1
Groundnut	0.0786	0.0609	0.5634	3
Ragi	0.0840	0.0576	0.5932	2

4. CONCLUSION

In this study TOPSIS method for decision making to tackle multi criteria decision making problem affected by uncertainty and taking into account the preferences of the decision maker is applied. This method allows in finding the best alternative of crops by short duration and use of water is less to get good profit. Entropy weight is used in TOPSIS analysis which aid the farmer in making the right decision. Results from Entropy and TOPSIS analysis are objective and accurate. The ranking of the alternatives in order are $A_3 > A_5 > A_4 > A_1 > A_2$. Results indicate that A_3 is the best alternative with C_i^+ value of 0.9222 wherein A_3 which is Maize is the best alternative.

REFERENCES

[1] Chiang Ku Fan, and Shu Wen Cheng, “Using Analytic Hierarchy Process Method and Technique for Order Preference by Similarity to Ideal Solution to Evaluate Curriculum in Department of Risk Management and Insurance”, Graduate Institution of Finance and Insurance, Taipei, Taiwan, J Soc Sci, 19(1), pp1-8, (2009).

[2] Elsayed A Elsayed, Shaik Dawood A.K., Karthikeyan R. "Evaluating Alternatives through the Application of Topsis Method with Entropy Weight", International Journal of Engineering Trends and Technology (IJETT) Vol 46 (2), April, (2017).

[3] Hwang C.L., Yoon K., "Multiple Attribute Decision Making-Methods and Applications: A State-of-the-Art Survey", Springer-Verlag, New York, (1981).

[4] Kshitij Dashore, Shashank Singh Pawar, Nagendra Sohani, Devendra Singh Verma, "Product Evaluation Using Entropy and Multi Criteria Decision Making Methods", International Journal of Engineering Trends and Technology (IJETT) Vol. 4 (5),May, (2013).

[5] Mohammad Saeed Zaeri, “Application of Multi Criteria Decision Making Technique to Evaluation Suppliers in Supply Chain Management”, African Journal of Mathematics and Computer Science Research Vol 4 (3), pp. 100-106, March, (2011).

[6] 6 Yeh C.-H., "A problem-based selection of multi-attribute decision -making methods", International Transactions in Operational Research 9 ,pp.169-181, (2002).

[7] Zeleny M., Multiple Criteria Decision Making, McGraw-Hill, New York, (1982).