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AN APPLICATION OF FUZZY MULTI CRITERIA DECISION MAKING APPROACH IN AGRICULTURAL CROPS

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ABSTRACT

Suitability analysis employs multicriteria decision-making procedures such as ranking, rating, and so on. This procedure is highly subjective in nature because it combines expert knowledge and judgement by decision makers at multiple levels. Although systems such as the Analytic Hierarchy Process (AHP) utilise experts' knowledge, they fail to address the inherent ambiguity in experts' knowledge. This research focuses on addressing uncertainty in the process of land suitability analysis for agricultural crops, which includes many criteria such as soil pH, fertility, and so on. It makes use of the techniques AHP, fuzzy numbers, fuzzy extent analysis, alpha cut, and lambda function. As previously said, the decision-making process incorporates a variety of factors as well as a significant quantity of expert knowledge and judgments.

Keywords: Land Suitability; Fuzzy AHP; Alpha Cut; Lambda Value; MCDM; Fuzzy Extent Analysis.

I. INTRODUCTION

Agriculture has profited immensely from technology developments ranging from shifting cultivation to high precision farming, as it is man's most primordial vocation. With the arrival of civilization, man learned about new crops and began to cultivate a wider range of crops. People began to settle in one spot and cultivate the same land year after year as the human population rose and civilization evolved. Commercial agriculture is the name given to agriculture now that it has evolved into a profession, with precision agriculture and sustainable agriculture as essential components.

These days, the world's population is steadily expanding. The agricultural community must produce more and more to meet the increased demand for food. Because it is impossible to cultivate more land (extensive farming) in the current situation, when land is scarce, the agricultural community should take on the challenge of producing more and more food with the land that is available (intensive farming). Increased amounts of pesticides and fertilisers, as well as genetically engineered plants, are, on the other hand, being opposed by a growing global concern for mankind's health and the environment.

On the other hand, the latter are currently available technologies that have the potential to improve food production. To address this problem, the agricultural sector must produce an increasing amount of high-quality food using environmentally friendly ways. Precision farming, sustainable farming, organic farming, and other environmentally friendly concepts have emerged as a result of the desire for ecologically friendly operations. Increased productivity, profitability, and human health, as well as the environment, are among agriculture's contemporary issues. As a result, picking the greatest crop for a specific location receives a lot of attention.

Crop requirements and soil/land conditions influence adaptability. Suitability is determined by matching the land features to the crop requirements. 'Suitability is a measure of how well a land unit's features match the needs of a specific type of land use' (FAO). Aside from land/soil qualities, additional driving elements that can impact crop choices include socioeconomic, market, and infrastructure factors.

Fuzzinessin Land Suitability Decision Making

Many aspects that are constant in nature, such as soil qualities and climate conditions, are considered in land suitability studies. It also deals with a variety of socioeconomic criteria that lack a standard measurement scale and are depicted using linguistic terms such as "market is near," "nearer," "far away," "extremely far," and so on. It is impossible to model the ambiguity and imprecision of environmental and socioeconomic elements using Boolean logic. When the information about a phenomenon is wholly unknown, the probabilistic technique can be employed, but it cannot be used when the knowledge is imprecise and incomplete. Fuzzy (probabilistic) reasoning comes in handy in such an uncertain circumstance. Fuzzy logic helps to represent imprecise, incomplete, and vague data in the most accurate way possible.

Expert information is included into land suitability analyses at various levels of decision-making. Because experts cannot be certain all of the time, fuzzy logic can be used to handle the uncertainty and imprecision that comes with expert knowledge. Many scholars (Burrough 1989; Burrough et al. 1992; McBratney and Odeh 1997) have employed fuzzy logic in land evaluations, however they have only addressed the uncertainty connected with data, not the uncertainty associated with expert knowledge. The goal of this study is to look into the function of fuzzy logic in multi-criteria land suitability evaluations for various agricultural crops and compare the results to existing conventional approaches. As a result, a fuzzy set is a gathering of elements or objects with no apparent restrictions. In the actual world, fuzzy logic can be used to define ambiguous and uncertain objects. The fuzzy sets are well-defined by the membership grades. To represent the grade of any division x of X in A, fuzzy sets are utilized. The degree to which an element belongs to a set is gritty by a number between 0 and 1.

II. PRELIMINARY

Definition 1: Triangular Membership Function

A triangular member function is a type of bisected linear function that can be symmetric or asymmetric. It is defined by the lower limit "a", upper limit "b" and "m" value, where a<m<b.

$$\mu A(x) = \begin{cases} 0, \ x \le a \\ \dfrac{x-a}{x-b}, \ a < x \le m \\ \dfrac{b-x}{b-m}, \ m < x \le b \\ 0, \ x \le b \end{cases}$$

Definition 2:ATFN $\widetilde{A}$ issaidtobenormalizedif $\mu_{\widetilde{A}} = 1$ anditcanberepresentedas $\widetilde{A} = (a^l, \widetilde{a}, a^u : \mu_{\widetilde{A}})$.

If $0 \le a^l \le \widetilde{a} \le a^u$ then $\widetilde{A}$ iscalledstandardizedFN.ThroughoutthispaperweusednormalizedTFN.

TFNMoforder $m \times n$ isdefinedas $\widetilde{A} = (a_{ij})m \times n$ where $a_{ij} = (a_{ijL}, a_{ijM}, a_{ijU})$ istheij^th^elementof $\widetilde{A}$.

a_{ijL}, a_{ijU} aretheleftandrightspreadsof a_{ij} respectivelyand a_{ijM} isthemiddlingvalue.

Let $\widetilde{A} = (a_{ij})_{n \times n}$ and $\widetilde{B} = (b_{ij})_{n \times n}$ betwoCTFMofsameorder. Then

(i) AdditionOperation

$\widetilde{A}(+)\widetilde{B} = (a_{ij} + b_{ij})_{n \times n}$ where $a_{ij} + b_{ij} = (a_{ijL} + b_{ijL}, a_{ijM} + b_{ijM}, a_{ijU} + b_{ijU})$ istheij^th^elementof $\widetilde{A}(+)\widetilde{B}$.

(ii) SubtractionOperation

$\widetilde{A}(-)\widetilde{B} = (a_{ij} - b_{ij})_{n \times n}$ where $a_{ij} - b_{ij} = (a_{ijL} - b_{ijL}, a_{ijM} - b_{ijM}, a_{ijU} - b_{ijU})$ istheij^th^numberof $\widetilde{A}(-)\widetilde{B}$. TheconditionholdsforCTFmembershipnumber.

Let $\widetilde{A} = (a_{ij})_{m \times p}$ and $\widetilde{B} = (b_{ij})_{p \times n}$ betwoCTFNM.ThentheMultiplicationOperation:

$\widetilde{A}(\cdot)\widetilde{B} = (c_{ij})_{m \times n}$, where $(c_{ij}) = p \times k = 1 \ a_{jk} \cdot b_{kj}$ for $i = 1,2,\ldots,m$ and $j = 1,2,\ldots,n$.

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III. FUZZY AHP IMPLEMENTATION IN THE CONTEXT OF LAND SUITABILITY ANALYSIS

The fundamental PCM employed in the Conventional AHP approach is used as input to the fuzzy AHP methodology. The experts' PCM is fuzzified with triangular fuzzy numbers to produce fuzzy PCM.

Table 3.1: Crisp Pairwise Comparison Matrix

pH	S1	S2	S3	N1	N2
S1	1	2.6	5.5	7.5	8.6
S2	½.6	1	3	3.8	4.9
S3	1/5.5	½.6	1	2	3
N1	1/7.5	1/4	1/2	1	2
N2	1/8.6	1/5	½.6	1/2	1

Table 3.2: Fuzzified Pairwise Comparison Matrix

S1	(1,1,1)	(1,2.6,5)	(4,5.5,7.5)	(5.5,7.5,10)	(7,8.6,11)
S2	(1/5,1/2.6,1/1)	(1,1,1)	(1,2.6,5)	(2,4,5.)	(2.6,5,7)
S3	(1/7.5,1/5.5,1/4)	(1/5,½.6,1/1)	(1,1,1)	(1,2,4)	(1,2.6,5)
N1	(1/10,1/7.5,1/5.5)	(1/5.5,1/4,1/2)	(1/41/21/1)	(1,1,1)	(1,2,4)
N2	(1/11,1/8.6,1/7)	(1/7,1/5,1/2.6)	(1/5,1/2.6,1/1)	(1/4,1/2,1)	(1,1,1)

The matrix's fuzzy performance is calculated as described, resulting in a fuzzy performance matrix.

Table 3.3: Performances: AHP andfuzzy AHP

pH	Crisp perform-ances	Fuzzy Performances		
		Lower	Middle	Upper
S1	0.4909	0.2507	0.5110	1.0408
S2	0.3023	0.1042	0.2523	0.6030
S3	0.1330	0.0440	0.1330	0.3340
N1	0.1033	0.0330	0.1033	0.2077
N2	0.0410	0.0221	0.0410	0.1032

The alpha value of 0.6 was chosen since the ph can be determined with moderate accuracy.

This will produce a performance matrix including the range of values.

Table 3.4: Application of Alpha Cut analyses

Suitability Class	Alpha Cut(60%)	
S1	0.020	0.335
S2	0.009	0.190
S3	0.004	0.106
N1	0.003	0.063
N2	0.002	0.033

The range value matrix is multiplied by 0.5 to create a crisp weight matrix. The rationale is that it assesses the expert's level of confidence in the factor under consideration. Values of 0.5 suggest that the expert is unsure of his conclusions or preferences, and that there is some uncertainty in his preferences.

Table 3.5: Crispper formance values obtained at three different lambda values

Suitability	Lambda(0)	Lambda(0.5)	Lambda(1)
S1	0.020	0.176	0.335
S2	0.009	0.099	0.189
S3	0.004	0.055	0.106
N1	0.003	0.033	0.063
N2	0.002	0.017	0.033

IV. RESULTS AND DISCUSSION

Rice crop is one of the six key LUTs chosen for the study region, and it will be used to test the ability of three multi-criteria evaluation methodologies. The criteria for evaluation are formulated and organised in a hierarchy. The key instruments used to decide on the LUTs, the evaluation criteria, and their hierarchical organisation were discussions with relevant specialists, literature surveys, and fieldwork. To begin, each criterion is classified into five appropriateness groups based on rice crop requirements: S1, S2, S3, N1 and N2. Second, as previously noted, three multi-criteria evaluation methodologies are used to assess land suitability. The outcomes of the three ways are combined and explained in this paper.

1. Standardization

The criteria are standardized in the AHP approach utilizing pairwise comparison techniques. The criteria were standardized, resulting in ratings ranging from 0 to 1.

Table 4.1: Standardization of the suitability classes using pair wise comparison

Slope	S1	S2	S3	N1	N2	Ratings
S1	1	2.6	5.5	7.5	8.6	**0.9**
S2	0.33	0.9	2.9	6.9	7.8	**0.511**
S3	0.166	0.333	1	4.8	6.7	**0.272**
N1	0.13	0.143	0.3	0.9	2.9	**0.095**
N2	0.111	0.13	0.143	0.333	0.9	**0.056**

The outcome of the criteria standardisation for slope is presented in a graph (Figure 5.1) for better comprehension, as is done in the usual linear scale transform, value function approach, and so on.

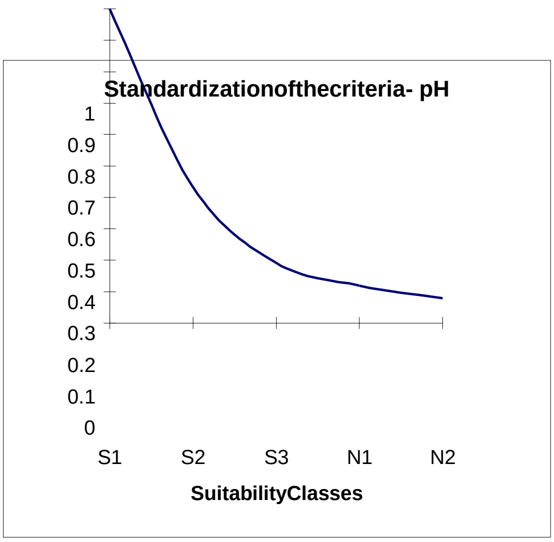

Figure 4.1: Visualization of standardizeds cores

V. CONCLUSION

Expert knowledge and ambiguity in the input data are not taken into account when evaluating land suitability. The parameters for determining land suitability are measured on a scale ranging from nominal to ratio. The maps of the criteria, which represent the complicated, continuous, and uncertain information in a simple, categorized map with clear borders among them, are one of the many inputs into the GIS-based land suitability evaluation. For the land suitability evaluation, Boolean approaches and other simple techniques are applied, which worsen the evaluation's outcomes. To address these issues, the current study investigates the potential of three approaches: AHP, Ideal Vector Approach, and Fuzzy AHP. The study's goal is to expand the Fuzzy AHP's capabilities into land suitability decision-making.

VI. REFERENCES

[1] A.,G.,G.G., and M.P(2001).For sustainable and precision farming, land and water quality is essential. MHIWCA.

[2] B. K. J., P. A. B. and D. E. MCC, (1987). “Proceedings of the international workshop on quantified land assessment processes, held in Washington, DC, 1986." IWQEPW.

[3] B.M,R.E. and L.A.Z(1970)."Making Decisions in a Fuzzy Environment." Management Sciences is a field of study that focusesvol 17(4):PP 141-164.

[4] B.,V. and T.G(1983)."On a short-coming of Saaty's method of Analytical Hierarchies."Vol 11:PP 228-230.

[5] B,C.G.E., J.G. deG and F.A.L."Multi-Criteria Decision Analysis with Fuzzy Pair wise Comparisons." FSSvol 29:PP 133-143,1989.