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The Application of Integrated Neutrosophic CRITIC and Preference Selection Index Methods for Multi Criteria Decision Making Over the Implementation of An Integrated Fish Farming System

S. Rubeela Mary[1]*, R. Sophia Porchelvi[2]

[1]*Assistant Professor, Department of Mathematics, Idhaya College for Women, (Affiliated to Bharathidasan University), Kumbakonam-612001, Tamil Nadu, India

[2]Associate Professor, Department of Mathematics, A.D.M College for Women (Autonomous), (Affiliated to Bharathidasan University), Nagapattinam-611001, Tamil Nadu, India

*rubeelamaryphd@gmail.com andsophiaporchelvi@gmail.com

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Abstract: This paper presents the application of integrated Neutrosophic CRITIC (The Criteria Importance Through Inter-criteria Correlation) and PSI (Preference Selection Index) methods using by the linguistic variables are converted to Neutrosophic set, which is an effective decision making model in a real life environment. This integrated methods is used to rank the 5 alternatives (Labeo rohita , Cirrhina mrigala , Catfishes, Catla catla, Murrels or Snakeheads) and 6 main criteria(Azolla with Duck Cum-Fish Culture, Paddy -Cum -Fish Culture, Duck- Cum -Fish farming, Fish - Cum -Poultry farming, Fish- cum Pig Culture, Cattle -Fish integrated farming system) for the growth of different varieties of fish by using Neutrosophic Environment.

Keywords: Multi-criteria Decision Making, CRITIC, PSI method, Neutrosophic set, Single valued Neutrosophic set, Fish Farm.

1. Introduction

In 1999, Smarandache [7] introduced the concept of Neutrosophic sets, as generalization of the fuzzy sets theory and their extensions. Wang and Smarandache [8] defined Single Valued Neutrosophic Set (SVNS). Multiple Criteria Decision Making(MCDM) plays a vital role and it is one of the fastest growing subfields of Management science and Operation Research [9]. Ye [10] also introduced the Concept of simplified Single valued Neutrosophic sets and it is applied in MCDM Problem.

CRITIC method is developed by Diakoulaki et al. in (1995) essentially to be used to determine the weights of attributes which are not in contradiction with each other. The CRITIC method [1] in many decisions - making methods are also very useful and also CRITIC method can determine the weight of each attribute according to the relationship

between the attributes. Peng [5] used the CRITIC method to calculate objective weights in financial risk assessment decisions on generalized orthogonal fuzzy sets

Preference selection index method was developed by Maniya and Bhatt (2010) for solving the multi-criteria decision making (MCDM) problems [2]. In the developed framework, the CRITIC method is used to calculate the criteria weights and the PSI method is utilized to evaluate the rank of alternatives under neutrosophic Sets.

The rest of this paper is organized as follows: In section 2, basic definitions regarding neutrosophic sets are overviewed. Section 3, consists of Proposed Method Algorithm. Section 4, presents numerical example of proposed method. Finally, the paper concludes the concept of this research work.

2. Preliminaries

This section reminds some basic definitions of NSs and SVNSs and its operators. It will be used in the upcoming sections.

Definition: 2.1

Let X be space of the objects and $x \in X$. A neutrosophic set A in X is defined by three functions: truth-membership function $\acute{T}_A(x)$, an indeterminancy- membership function $\acute{I}_A(x)$ and falsity-membership function $\acute{F}_A(x)$. These function $\acute{T}_A(x)$, $\acute{I}_A(x)$ and $\acute{F}_A(x)$ are defined on real standard or real non-standard subsets of $]\,0^-, 1^+[$. That is $T_A(x): X \rightarrow]\,0^-, 1^+[$, $\acute{I}_A(x): X \rightarrow]\,0^-, 1^+[$ and $\acute{F}_A(x): X \rightarrow]\,0^-, 1^+[$. There is no restriction on the sum of $\acute{T}_A(x), \acute{I}_A(x)$ and $\acute{F}_A(x)$, so $0^- \leq \sup \acute{T}_A(x) + \acute{I}_A(x) + \acute{F}_A(x) \leq 3^+$.

Definition: 2.2

Let X be a universal space of the objects and $x \in X$. A single valued neutrosophic set (SVNS) $\widetilde{\mathrm{N}} \subset X$ can be expressed as $\widetilde{\mathrm{N}} = \{\langle x, \acute{T}_A(x), \acute{I}_A(x), \acute{F}_A(x)\rangle : x \in X\}$ Where $\acute{T}_A(x): X \rightarrow [\,0,1]$, $\acute{I}_A(x): X \rightarrow [\,0,1]$ and $\acute{F}_A(x): X \rightarrow [\,0,1]$ with $0 \leq \sup \acute{T}_A(x) + \acute{I}_A(x) + \acute{F}_A(x) \leq 3$ or all $x \in X$. The values $\acute{T}_A(x)$, $\acute{I}_A(x)$ and $\acute{F}_A(x)$ correspond to truth-membership degree, the indeterminacy- membership degree and the falsity-membership degree of x to $\widetilde{\mathrm{N}}$, respectively. When X consists of the single element, $\widetilde{\mathrm{N}}$ is called single valued neutrosophic number a single valued neutrosophic number is expressed by $\widetilde{\mathrm{N}}_\eta = \langle \acute{T}_A, \acute{I}_A, \acute{F}_A \rangle$ where $\langle \acute{T}_A, \acute{I}_A, \acute{F}_A \rangle \in [0,1]$ and $0 \leq \acute{T}_A + \acute{I}_A + \acute{F}_A \leq 3$.

3. Proposed Method

CRITIC (CRiteria Importance through Intercriteria Correlation) method is one of the weighting methods which determine objective weights for criteria. CRITIC method was proposed by Diakoulaki et al. in 1995 [1] and this method include the intensity of the contrast and the conflict in the structure of the decision making problem (Diakoulaki et al., 1995). It uses correlation analysis to find out the contrasts between criteria (Yılmaz and Harmancıoğlu, 2010)[11]. In this method the decision matrix is evaluated and the standard deviation of

normalized criterion values by columns and the correlation coefficients of all pairs of columns are used to determine the criteria contrast (Madić and Radovanović, 2015)[4].

Step 1: Formulation of decision matrix

Step 2: Normalization of the input matrix

Step 3: Estimation of standard deviation for the normalized matrix

Step 4: Establish Symmetric matrix- Linear correlation coefficient between the criteria measure of the conflict created by criterion

Step 5: Estimation of criterion information $C_j = \sigma_j * \sum_{j=1}^{m}(1 - r_{jk})$

Step 6: Measures of conflict created by criterion

$$w_j = \frac{C_j}{\sum_{k=1}^{m}(C_k)}$$

This method is specifically effective when there is conflict in deciding the relative importance between attributes and that is the advantage of PSI method. Using overall preference value, PSI for each alternative is calculated and alternative with higher value of PSI is selected as the best alternative. The steps involved in the PSI method are as follows (Maniya and Bhatt, 2010 [2] Maniya and Bhatt, 2011[3], Vahdani et al., 2011[5]):

Step 7: Creating neutrosophic decision matrix using linguistic variable.

$$X = \begin{pmatrix} [X_{11}^a, X_{11}^b, X_{11}^c] & [X_{12}^a, X_{12}^b, X_{12}^c] & \cdots & [X_{1m}^a, X_{1m}^b, X_{1m}^c] \\ [X_{21}^a, X_{21}^b, X_{21}^c] & [X_{22}^a, X_{22}^b, X_{22}^c] & \vdots\vdots & [X_{2m}^a, X_{2m}^b, X_{2m}^c] \\ \cdots & \cdots & & \cdots \\ [X_{n1}^a, X_{n1}^b, X_{n1}^c] & [X_{n2}^a, X_{n2}^b, X_{n2}^c] & \cdots & [X_{nm}^a, X_{nm}^b, X_{nm}^c] \end{pmatrix}$$

where, ${X_{ij}}^a, {X_{ij}}^b, {X_{ij}}^c$ respectively are truth, indeterminacy, and a false membership function of i^{th} alternative with respect to j^{th} criteria.

Step 8: Normalize the evaluation matrix.

Step 9: Compute preference variation value (PV_j)

$$PV_j = \sum_{i=1}^{N}\left(R_{ij} - \bar{R}_j\right)^2$$

Step 10: Determine the deviation in preference value: $\Phi_j \Omega_j$

Step 11: Determine overall preference $\Omega_j = \frac{\aleph_j}{\sum_{j=1}^{M}\aleph_j}$

Step 12: Obtain the preference selection index $\Phi_j = \sum_{j=1}^{N}(R_{ij} * \Omega_j)$

Step 13: Compute the preference selection index.

Step 14: Select the appropriate alternative for the given application: The alternative having the highest preference selection index will be ranked first and so on.

4. Numerical Example

This section contains calculation of MCDM problem by integrated neutrosophic Critic - Preference Selection Index method. The Fish varieties are studied using hybrid approach as a methodology, integrated neutrosophic CRITIC and PSI. The criterion and alternatives to define varieties of Fish are created by using a simple questionnaires and interviews answered by the 36 integrated fish farmers in Thanjavour and Thiruvarur district and surrounding area helped in defining the alternatives are Labeo rohita , Cirrhina mrigala , Catfishes, Catla catla, Murrels and the Main Criteria are Azolla with Duck Cum-Fish Culture, Paddy -Cum -Fish Culture, Duck- Cum -Fish farming, Fish - Cum -Poultry farming, Fish- cum Pig Culture, Cattle -Fish integrated farming system. Our multi-criteria evaluation framework is used for evaluating the performance of a fish farm, located Thanjavour and Mayiladuthurai District and near the Villages. A Neutrosophic set of linguistic variable used by decision makers are defined as shown in Table 1.

Table 1: Linguistic variables and Importance weight based on neutrosophic values

S.No	Linguistic Variable	Code	SVNNs		
1	Very Low	VL	0	0	0.1
2	Low	L	0	0.1	0.3
3	Medium Low	ML	0.1	0.3	0.5
4	Medium	M	0.3	0.5	0.7
5	Medium High	MH	0.5	0.7	0.9
6	High	H	0.7	0.9	1
7	Very High	VH	0.9	1	1

Change the linguistic variables in to a Neutrosophic number based on the assessment of alternatives with respect to criteria. Each element has to be normalizd with the help of Step 2 and calculate the Measures of conflict created by criterion in table 2.

Table 2: Measures of conflict created by criterion

	MC_1	MC_2	MC_3	MC_4	MC_5	MC_6
MC_1	0	0.4044	0.5533	0.9202	0.3131	0.8852
MC_2	0.4044	0	0.6916	0.4023	0.9559	0.7497
MC_3	0.5533	0.6916	0	0.6218	0.0472	0.9723
MC_4	0.9202	0.4023	0.6218	0	0.719	0.6272
MC_5	0.3131	0.9559	0.0472	0.719	0	0.9525
MC_6	0.8852	0.7497	0.9723	0.6272	0.9525	0

Now, calculate the average of sub-criteria weight and the values are taken as a weightage of main criteria in table 3.

Table 3: Importance weight of criteria

MC_1	3.076	0.399	0.614	1
MC_2	3.204	0.068	0.109	4
MC_3	2.886	0.064	0.093	6
MC_4	3.29	0.065	0.107	5
MC_5	2.988	0.075	0.111	3
MC_6	4.187	0.073	0.152	2

From the importance measures of criteria, it is found that criteria weightage ranges in the order

$$\mathrm{MC}_1 > \mathrm{MC}_6 > \mathrm{MC}_5 > \mathrm{MC}_2 > \mathrm{MC}_4 > \mathrm{MC}_3$$

With the help of the farmer's neutrosophic decision matrix was created. After that, the evaluation matrix is normalized by using step 7. Then, the Normalized decision matrix is determined as per step 9 (Sec [3]). By using step 9, the preference variation $(PV_j)$is calculated. Now, the deviation of preference selection index is calculated by using step 10 then, by using step 11 is calculated overall preference $\Omega_j$with step 12 (Φ_j) calculated preference index selection in table 4. Finally, the ranking is found for all the alternatives and is given in table 5.

Table 4: The preference selection index

	MC_1	MC_2	MC_3	MC_4	MC_5	MC_6
A_1	0.0006	0.0064	0.0062	0.0087	0.0103	0.0011
A_2	0.008	0.0022	0.0008	0.0064	0.0027	0.0054
A_3	0.0019	0.0004	0.0003	0.0054	0.0003	0.0036
A_4	0.0041	0.0036	0.026	0.0087	0.0141	0.0002
A_5	0.0018	0.0022	0.0085	0.00005	0.0077	0.00057
sum(PV)	0.0164	0.0148	0.0418	0.0292	0.0351	0.0103
	0.9836	0.9852	0.9582	0.9708	0.9649	0.9897

Table 5: The ranking order of Alternatives

Alternatives	Preference Value	Rank
A_1	0.0039	3
A_2	0.007	2
A_3	0.0024	5
A_4	0.0078	1
A_5	0.003	4

5. Conclusion

This approach takes into consideration subjective judgments of the decision makers. The criteria weights are calculated by using the Critic method. Subsequently, rankings of the alternatives are determined by the PIS method. The proposed framework enables the decision makers to better understand the whole evaluation process. It provides a more accurate, effective, and systematic evaluation tool.

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