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Rational Positioning of Zoological Gardens with Triangular Fuzzy Numbers

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The respected Comrade Kim Jong Un said:

"We should conduct a regular survey of the species and habitat conditions of the animals and plants that are found in mountains and river basins, and take proactive steps to protect the endangered, rare and other biological species and to preserve biodiversity."

Rational positioning of zoological gardens is one of the most significant issues to provide people with entertainment and to further deepen the research on protecting and increasing animal species.

The formal decision-making method was commonly used for positioning of construction projects; not much research was done on the soft decision-making method.

With triangular fuzzy number we did research into the positioning of zoological gardens with the soft decision-making method.

1. Mathematical Modeling

First of all, estimation indices are set for rational positioning.

And using the triangular fuzzy number F (l, m, n), the estimation results of the indices are quantitated. Here, $\{l,\ m,\ n | l \le m \le n\ \ l,\ m,\ n \in lR\}$

The function of F (l, m, n) can be defined as follows.

$$\mu_F(x) = \begin{cases} 0; & x \le l, \quad x \ge n \\ \dfrac{x-l}{m-l}; & l < x < m \\ \dfrac{n-x}{n-m}; & m < x < n \end{cases}$$

The qualitative factors are then interpreted to triangular fuzzy numbers. The figures are shown in Table 1.

Based on Table 1, the sites proposed for zoological gardens are evaluated qualitatively and the matrix of triangular fuzzy numbers $\tilde{A}$ is formed using the triangular fuzzy number relevant to the result.

Table 1. Triangular fuzzy number of qualitative factors

No.	Qualitative factors	Triangular Fuzzy number	No.	Qualitative factors	Triangular Fuzzy number
1	Much worse	(0, 0.1, 0.2)	6	A little good	(0.5, 0.6, 0.7)
2	Very bad	(0.1, 0.2, 0.3)	7	Good	(0.6, 0.7, 0.8)
3	Bad	(0.2, 0.3, 0.4)	8	Very good	(0.7, 0.8, 0.9)
4	A little bad	(0.3, 0.4, 0.5)	9	Much better	(0.8, 0.9, 1.0)
5	Not so bad	(0.4, 0.5, 0.6)			

$$\tilde{A} = [(a_{ij}^l,\, a_{ij}^m,\, a_{ij}^n)],\quad i = \overline{1, s},\quad j = \overline{1, t}$$

where s is the number of the indices, t is the number of proposed sites, $a_{ij}^l, a_{ij}^m, a_{ij}^n$ are the values of the lowest limit, midrange value and the highest limit of the triangular fuzzy number of the jth proposed site for the ith index.

Next, the standard weight W_i for the given indices are determined.

$$\sum_{i=1}^{s} W_i = 1$$

Also $\tilde{A}$ is standardized and the standard matrix of the triangular fuzzy numbers $\tilde{B}$ is calculated.

$$\tilde{B} = [(b_{ij}^l,\, b_{ij}^m,\, b_{ij}^n)] \tag{1}$$

where $b_{ij}^l = \left(\dfrac{1}{a_{ij}^n}\right) \Bigg/ \left(\displaystyle\sum_{j=1}^{t}\left(\dfrac{1}{a_{ij}^l}\right)^2\right)^{1/2}$, $b_{ij}^m = \left(\dfrac{1}{a_{ij}^m}\right) \Bigg/ \left(\displaystyle\sum_{j=1}^{t}\left(\dfrac{1}{a_{ij}^m}\right)^2\right)^{1/2}$, $b_{ij}^n = \left(\dfrac{1}{a_{ij}^l}\right) \Bigg/ \left(\displaystyle\sum_{j=1}^{t}\left(\dfrac{1}{a_{ij}^n}\right)^2\right)^{1/2}$.

And using $\tilde{B}$, the ideal standard inferior triangular fuzzy number $\tilde{C}_{ij}^-$ is determined.

$$\tilde{C}_{ij}^- = [(c_{ij}^{l-},\, c_{ij}^{m-},\, c_{ij}^{n-})] \tag{2}$$

$$c_{ij}^{l-} = \min_j b_{ij}^l,\ c_{ij}^{m-} = \min_j b_{ij}^m,\ c_{ij}^{n-} = \min_j b_{ij}^n.$$

Next, using equation (1), (2), the ideal inferior triangular fuzzy number and the relative distance between the proposed sites are calculated.

$$\tilde{d}_{ij}^- = (\tilde{B} - \tilde{C}_i^-)$$

$$D_{ij}^- = \frac{d_{ij}^{l-} + 2d_{ij}^{m-} + d_{ij}^{n-}}{4}$$

The weight of the methods mentioned above is evaluated in general.

$$Z_j^- = \sum_{i=1}^{s} W_i D_{ij}^- \tag{3}$$

Finally, using (3), the most rational positioning method is selected.

$$Z_k = \max_j Z_j^-$$

2. Application

We applied this method in positioning of the Y Zoological Garden.

Four sites were proposed for the Y Zoological Garden; C, D, A and E. The factors considered in positioning were the distance from the residential areas(X_1), traffic conditions(X_2), relations with surrounding cultural facilities(X_3), conditions for infrastructure(X_4), environmental conditions(X_5) and the site conditions(X_6).

Qualitative and quantitative evaluation results of the given indices for the proposed sites are shown in Tables 2 and 3.

Table 2. Qualitative evaluation of the proposed sites according to the indices

	Evaluation Indices					
	X1	X2	X3	X4	X5	X6
C	Very good	Very good	Very good	Very good	Good	Very good
D	Good	Very bad	Good	Okay	Good	Bad
A	Very good	Okay	Good	Bad	Very good	Very good
E	Good	Very bad	Bad	Okay	Good	Okay

Table 3 Quantitative evaluation of the proposed sites according to the indices

	Evaluation Indices					
	X1	X2	X3	X4	X5	X6
C	(0.7, 0.8, 0.9)	(0.7, 0.8, 0.9)	(0.7, 0.8, 0.9)	(0.7, 0.8, 0.9)	(0.6, 0.7, 0.8)	(0.7, 0.8, 0.9)
D	(0.6, 0.7, 0.8)	(0.1, 0.2, 0.3)	(0.6, 0.7, 0.8)	(0.4, 0.5, 0.6)	(0.6, 0.7, 0.8)	(0.2, 0.3, 0.4)
A	(0.7, 0.8, 0.9)	(0.4, 0.5, 0.6)	(0.6, 0.7, 0.8)	(0.2, 0.3, 0.4)	(0.7, 0.8, 0.9)	(0.7, 0.8, 0.9)
E	(0.6, 0.7, 0.8)	(0.1, 0.2, 0.3)	(0.2, 0.3, 0.4)	(0.4, 0.5, 0.6)	(0.6, 0.7, 0.8)	(0.4, 0.5, 0.6)

The result of standard triangular fuzzy number determinant $\tilde{B}$ is given here.

$$\tilde{B} = \begin{pmatrix} (0.251, 0.326, 0.423) & (0.246, 0.325, 0.430) & (0.251, 0.326, 0.423) & (0.246, 0.325, 0.430) \\ (0.147, 0.320, 0.253) & (0.081, 0.235, 0.684) & (0.132, 0.308, 0.560) & (0.081, 0.235, 0.684) \\ (0.207, 0.325, 0.467) & (0.203, 0.323, 0.474) & (0.203, 0.323, 0.474) & (0.157, 0.292, 0.551) \\ (0.209, 0.340, 0.467) & (0.190, 0.315, 0.495) & (0.158, 0.291, 0.550) & (0.190, 0.315, 0.495) \\ (0.244, 0.324, 0.431) & (0.244, 0.324, 0.431) & (0.269, 0.326, 0.424) & (0.244, 0.324, 0.431) \\ (0.230, 0.325, 0.438) & (0.216, 0.317, 0.467) & (0.237, 0.325, 0.438) & (0.216, 0.317, 0.467) \end{pmatrix}$$

And using $\tilde{B}$, the ideal standard inferior triangular fuzzy number $\tilde{C}_{ij}^{-}$ is determined as follows:

$$\tilde{C}_{ij}^{-} = [(0.246, 0.325, 0.43) \quad (0.081, 0.235, 0.684) \quad (0.157, 0.292, 0.551)$$
$$(0.158, 0.291, 0.55) \quad (0.244, 0.324, 0.431) \quad (0.216, 0.317, 0.467)]$$

Next D_{ij}^{-} can be calculated as follows:

$$D_{ij}^{-} = \begin{pmatrix} 0.003 & 0.059 & 0.029 & 0.029 & 0.002 & 0.011 \\ 0.002 & 0.038 & 0.028 & 0.027 & 0.002 & 0.007 \\ 0.003 & 0.056 & 0.028 & 0.021 & 0.003 & 0.011 \\ 0.002 & 0.038 & 0.023 & 0.027 & 0.002 & 0.007 \end{pmatrix}.$$

Z_j^{-} can be calculated using (3) and the results are 0.025 8, 0.019 54, 0.024 25, 0.018 45 respectively. As can be seen from the values, the most ideal position for the zoological garden is C and E is most unappealing.

Conclusion

With triangular fuzzy numbers, the soft decision-making method for zoological gardens can be solved on the scientific basis.

Reference

[1] 김일성종합대학학보(자연과학), 55, 5, 164, 주체98(2009).