Enhancing Guinea Pig Farming: A Neutrosophic Approach with Interval-Valued and Bipolar Sets in Decision-Making Methods

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Abstract

The study emphasizes the need of implementing several ways to promote guinea pig farming in small family units. It highlights the relevance of enhanced nutrition, effective health management, genetic enhancement, and acceptable habitat conditions as essential factors for enhancing productivity and profitability. Suggestions encompass the adoption of advanced breeding methods, offering training and technical support, and expanding the range of goods and markets to ensure the long-term economic viability of guinea pig farming. The utilization of neutrosophic sets provided a strong framework for assessing these techniques, enabling a thorough study that considers the inherent uncertainties in decision-making processes. To enhance future study, it is recommended to improve and broaden neutrosophic approaches to comprehend the intricacies of guinea pig farming systems more effectively. It will be beneficial to create more advanced models that include a broader set of factors and extensive data, as well as to undertake longitudinal studies to evaluate the long-term effects. It is essential to work together with local communities to customize tactics that are suitable for specific geographical conditions and socioeconomic contexts. This is necessary to ensure that these interventions are practical and successful.

Keywords: Neutrosophic; Guinea Pig Farming; Decision-Making; Neutrosophic TreeSoft Set; VIKOR

1. Introduction

The rearing of guinea pigs in small familial units is a noteworthy agricultural practice in several parts of the world, particularly in Latin America and sub-Saharan Africa [1]. These rodents, renowned for their capacity to acclimate to diverse climatic circumstances and their prolific breeding rate, serve as a significant source of sustenance and revenue generation for rural communities. Nevertheless, to optimize the advantages of this endeavor, it is imperative to employ efficient tactics that enhance output and enhance the profitability of guinea pig farming in domestic settings [2].

Scientific research has been crucial in identifying and assessing different techniques to improve guinea pig farming in small-scale household systems. Prior research has focused on crucial factors such as nutrition, health administration, genetics, and animal well-being to enhance the efficiency and long-term viability of this endeavor. Research has demonstrated that it is crucial to provide guinea pigs with a well-balanced diet that is sufficient in protein to promote optimal growth and maintain good health [3].

DOI: https://doi.org/10.54216/IJNS.240407
Received: February 27, 2024 Revised: April 21, 2024 Accepted: May 28, 2024

Aside from nutritional considerations, the adoption of efficient health management protocols is crucial in order to prevent diseases and minimize losses in guinea pig production. Studies have emphasized the significance of practices such as facility cleanliness and disinfection, parasite management, and continuous monitoring of animal health to achieve successful reproduction without any diseases. Implementing these measures is crucial for enhancing the health and welfare of guinea pigs, as well as guaranteeing the excellence and safety of meat products meant for human consumption [4].

The objective of this study is to analyze and categorize different methods for enhancing guinea pig reproduction in tiny family units, with a specific focus on utilizing neutrosophic sets as a means of evaluation. By adopting a holistic approach, our goal is to identify the most efficient strategies suitable for the unique requirements of family systems, with the aim of enhancing the productivity and profitability of this crucial agricultural activity. Neutrosophic sets are used in this context to handle the inherent uncertainty and imprecision in decision-making in guinea pig breeding. This allows for a strong and comprehensive scientific framework to evaluate and select improvement options.

2. Related Work.

This section presents some definitions of interval-valued neutrosophic set (IVNS) [5, 6].

Bipolar neutrosophic sets are an extension of neutrosophic sets that allow for the representation of uncertainties in decision-making where opinions can be true, false, or neutral. In these sets, elements can be classified into three categories: true (T), false (F), and neutral (N), reflecting the inherent ambiguity in many real-world problems.

The primary feature of bipolar neutrosophic sets is their ability to represent and handle uncertainty more comprehensively by allowing the coexistence of opposing opinions within the same set. This is particularly useful in situations with contradictory or incomplete information, as it provides a framework for managing ambiguity and making decisions under uncertain conditions.

In the context of decision-making, bipolar neutrosophic sets offer a flexible and adaptable approach that can be applied in various fields such as medicine, engineering, economics, and artificial intelligence. Their precision in modeling and handling uncertainty makes them a valuable tool for solving complex problems and making informed decisions.

Furthermore, these sets can be integrated with other modeling and analysis techniques such as fuzzy logic and fuzzy sets to provide more robust and accurate solutions. This integration allows for addressing multidimensional and multifaceted problems, considering a broader range of perspectives and relevant factors.

In summary, bipolar neutrosophic sets are a powerful and versatile tool for representing and handling uncertainty in decision-making. Their ability to capture opposing and neutral opinions makes them particularly suited for solving complex problems in environments where information is limited or contradictory, thereby providing a more comprehensive and robust approach to addressing real-world challenges.

Definition 1

Let Y be a universe of discourse with a generic element in Y denoted by y. We can define the neutrosophic variable y as $y = (T, I, F)$ where T, I and F refer to the degrees of truth, indeterminacy and falsity.

$$0 \leq \sup(T(y)) + \sup(I(y)) + \sup(F(y)) \leq 3 \quad (1)$$

We can define the IVNS as:

$$y = [T^L, T^U], [I^L, I^U], [F^L, F^U] \quad (2)$$

Definition 2

Let $y1 = ([T yL1, T yU1], [I yL1, I yU1], [F yL1, F yU1])$ and $y2 = ([T yL2, T yU2], [I yL2, I yU2], [F yL2, F yU2])$ two neutrosophic numbers with interval values, then some mathematical equations can be defined as:

$$y_1^c = [F_{y^L 1}, F_{y^U 1}], [1 - I_{y^U 1}, 1 - I_{y^L 1}], [T_{y^L 1}, T_{y^U 1}] \quad (4)$$

$$[1 + T yL2 - T yL1\, T yL2, T yU1 + T yU2 - T yU1\, T yU2],$$

$$y_1 y_2 = [I_{y^L 1} I_{y^L 2}, I_{y^U 1} I_{y^U 2}], \quad (5)$$

DOI: https://doi.org/10.54216/IJNS.240407
Received: February 27, 2024 Revised: April 21, 2024 Accepted: May 28, 2024

[1 F yL 2 , F yU 1 F yU 2]

[1 T yL 2, T yU 1 T yU 2],

$y_1 y_2 = [I_{y^L 1} + I_{y^L 2} - I_{y^L 1} I_{y^L 2}, I_{y^U 1} + I_{y^U 2} - I_{y^U 1} I_{y^U 2}]$, (6)

[1 + F yL 2 − F yL 1 F yL 2 , F yU 1 + F yU 2 − F yU 1 yU 2]

Definition 4

We can define bipolar neutrosophic sets (BNS) as [7,8]:

$A = \{< x, T^+(x), I^+(x), F^+(x), T^-(x), I^-(x), F^-(x) >\}$ (7)

Let $y_1 = (T_1^+(x), I_1^+(x), F_1^+(x), T_1^-(x), I1-(x), F_1^-(x))$ and $y_2 = (T_2^+(x), I_2^+(x), F_2^+(x), T_2^-(x), I_2^-(x), F_2^-(x))$

y 1 + y 2 = (− T − T 2− , −(− $^{T\,1+}$ I 1− $^{+}$ − ^{T} I $^{2+}$ 2− $^{-}$ − ^{T} I ^{1} 1− $^{+}$ I ^{T} 2- $^{2+}$) $^{\cdot}$, ^{I} − $^{1+}$ ($^{I\,2}$ − $^{+\,\cdot}$ F ^{F} 1− $^{1+}$ − $^{F\,2+}$ F $^{\cdot}$ 2− − F 1− F 2−) $_{)}$ (8)

y 1 · y 2 = ($^{T\,1}$ − $^{+\,T}$ (^{2} − $^{+\,\cdot}$ T ^{I} 1 ^{1} − $^{++}$ − $^{I\,2}$ T $^{+}$ 2− $^{-}$ − $^{I\,1+}$ T ^{I} 1− $^{2+}$ T $^{+}$ 2−) ^{F} , $^{1+}$ − I $^{+}$ 1− I ^{F} 2− $^{2+}$, − $^{-}$ F ^{F} 1− $^{1+}$ F ^{F} 2- $^{2+,}$ $_{)}$ (9)

Let U be a revelation of the universe and H be a non-empty subset of U, with $P()$ $be\ a\ powerset$.

Let TSR a set of attributes of the problem (criteria),

$TSR = \{ TSR_1, TSR_2, \dots, TSR_n \}, n \geq 1$ (10)

Where $TSR_1, TSR_2, \dots, TSR_n$ are criteria from the first level of the tree.

Each attribute TSR_1, $1 \leq i \leq n$, $is\ formed\ by\ sub - attrib\ utes$:

$TSR_1 = \{ TSR_{1,1}, TSR_{1,2}. \dots, \}$ $TSR_2 = \{ TSR_{2.1}, TSR_{2.2}. \dots, \}$

$TSR_n = \{ TSR_{n,1}, TSR_{n,2}. \dots, \}$

Where $TSR_{i,j}$ are sub-attributes.

Tree Set Soft can be made up of:

$F : P(Tree(TSR)) \rightarrow P(H)$ (11)

$Tree(TSR) = \{ TSR_i | i_1 = 1,2,3,\dots \} \cup \{ TSR_i | i_1, i_2 = 1,2,3,\dots \} \cup \{ TSR_i | i_1, i_2, i_3 = 1,2,3,\dots \} \cup \dots$

$\cup \{ TSR_i | i_1, i_2, \dots i_m = 1,2,3,\dots \}$ (12)

The next steps of the neutrosophic TreeSoft Set[9,10] with the VIKOR[11,12] method.

Step 1. Build a tree and define nodes.

The tree has more than one level, in the first level the main criteria are entered such as

$SWM_1, SWM_2 \dots, SWM_n$

At the second level, the sub-criteria are introduced as $SWM_{1.1}, SWM_{1.2}, \dots$. And $SWM_{2.1}, SWM_{2.2}, \dots$.

Step 2. Build the decision matrix[13, 14]

The decision matrix is constructed using information from decision makers and experts between criteria and alternatives.

Step 3. Calculate the weights of the criteria.

Criteria weights are calculated using the average method.

DOI: https://doi.org/10.54216/IJNS.240407
Received: February 27, 2024 Revised: April 21, 2024 Accepted: May 28, 2024

$\sum w_j = 1$ (14)

$j = 1$

Step 4. Calculate the alternative closeness to the optimal solution.

$U_i = \{\sum j = 1 [_* - r_{j-})] \} = 1,2,\ldots, m ; j = 1,2, \ldots, n ; 1 \leq P \leq \infty$ (15)

where $r_j{}^*$ is the best and $r_j{}^-$ it's the worst

$r j * =$ maximum $x ij$

$\{ r - =$ minimum $^i x_{ij}$ ($positive\ criteria$) $i = 1,2, \ldots, m ; j = 1,2, \ldots, n$ (16)

Step 5. Calculate the values of S_i

$$S_i = \sum w_j \frac{(r_j^* - r_{ij}^-)}{* \quad -} \quad i = 1,2, \ldots, m ; j = 1,2, \ldots, n \ (18)$$

$j = 1 \ (r_j - r_j)$

Step 6. Calculate the values of R_i

$$R_i = \max \left[w_j \frac{(r_j^* - r_{ij}^-)}{* \quad -} \right] i = 1,2, \ldots, m ; j = 1,2, \ldots, n \ (19)$$

$j \quad (r j - r j)$

Step 7. Calculate the VIKOR index.

$$Q_i = t * \left[\frac{(S_i - S^*)}{} \right] + (1 - t) * \left[\frac{(R_i - R^*)}{} \right] i = 1,2 \ S_- - S \ R - - R * , \ldots, m ; j = 1,2, \ldots, n \ (20)$$

$S^* =$ minimum S_i, $S^- =$ maximum S_i, $R^* =$ minimum R_i, $R^- =$ maximum R_i (21)

Where $t = 0.5$

Step 8. Ranking

The components are ranked in descending order according to their Q values . $_i$.

3. Case Study

Implementing effective strategies is essential for increasing the well-being and productivity of guinea pigs. Here are some key approaches:

Firstly, ensuring optimal nutrition is paramount. A diet rich in fiber, vitamin C, and essential nutrients is crucial for guinea pig health. Providing fresh vegetables, high-quality pellets, and unlimited access to hay supports their digestive health and prevents nutritional deficiencies.

Secondly, creating a spacious and stimulating living environment is vital. Guinea pigs thrive in large, well-ventilated enclosures that allow for plenty of room to roam and explore. Providing tunnels, hiding spots, and toys encourages natural behaviors, reduces stress, and promotes physical and mental stimulation.

Thirdly, regular veterinary care is essential for maintaining guinea pig health. Scheduling routine check-ups with a qualified veterinarian helps monitor their overall well-being, address any health concerns promptly, and ensure they receive necessary vaccinations and parasite control.

Additionally, social interaction plays a significant role in guinea pig welfare. These social animals benefit from companionship, so housing them in pairs or groups of compatible cage mates allows for socialization, reduces loneliness, and promotes natural behaviors like grooming and play.

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Received: February 27, 2024 Revised: April 21, 2024 Accepted: May 28, 2024

Finally, environmental enrichment and regular exercise are crucial. Providing a variety of toys, rotating them frequently, and offering supervised playtime outside of the enclosure promotes mental stimulation and prevents boredom. Encouraging regular exercise helps maintain their physical health and prevents obesity.

In conclusion, implementing these strategies effectively ensures the health, happiness, and overall well-being of guinea pigs. By providing optimal nutrition, a stimulating environment, regular veterinary care, social interaction, and opportunities for exercise, guinea pig owners can enhance the quality of life for their furry companions.

Seven strategies are presented to increase guinea pig breeding in small family units:

1. Improving nutrition: Providing a balanced diet rich in proteins is essential for the growth and health of guinea pigs. This may include the use of commercial feeds specific to guinea pigs, as well as the incorporation of fresh vegetables and forages into the diet.

2. Optimizing health management: Implementing proper hygiene practices in breeding facilities, as well as performing regular health checks and vaccinations, will help prevent diseases and reduce production losses.

3. Genetic improvement: Selecting and crossing guinea pigs with desirable characteristics, such as larger body size, growth rate and disease resistance, can improve the quality and productivity of progeny.

4. Habitat suitability: Providing a suitable environment for the guinea pigs, with sufficient space, good ventilation and protection from the weather elements, will contribute to the well-being and reproductive performance of the animals.

5. Implementation of reproduction techniques: Use techniques such as selective mating and reproduction control to optimize birth rate and offspring survival.

6. Training and technical assistance: Providing training and technical support to farmers on proper management practices, nutrition, health and commercial aspects will improve their skills and knowledge to efficiently manage guinea pig farming.

7. Diversification of products and markets: Exploring the diversification of products derived from guinea pigs, such as the sale of fresh, processed or canned meat, as well as skins and value-added products, can open new market opportunities and increase family income.

Evaluation criteria:

Evaluation criteria for strategies to increase guinea pig farming in small family units:

1. Nutritional effectiveness: Evaluate whether the proposed strategy guarantees adequate and balanced nutrition for guinea pigs, promoting optimal growth and good health.

2. Impact on animal health and well-being: Consider how the strategy affects the health and well-being of guinea pigs, including disease prevention, parasite control and stress reduction.

3. Economic profitability: Analyze the economic viability of the strategy, considering its cost-benefit and its ability to generate additional income for family units.

4. Environmental sustainability: Evaluate the environmental impact of the strategy in terms of use of natural resources, generation of waste and conservation of the environment.

5. Adaptability to local conditions: Determine if the strategy is appropriate and viable for the specific conditions of the geographic, climatic and socioeconomic environment in which guinea pig farming takes place.

6. Ease of implementation and maintenance: Assess the ease with which the strategy can be implemented and maintained by family units, considering available resources, necessary training and time required.

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Received: February 27, 2024 Revised: April 21, 2024 Accepted: May 28, 2024

7. Social and community impact: Analyze how the strategy contributes to the well-being and prosperity of the local community, including employment generation, strengthening food security and socioeconomic development.

In this section, we present the results of TreeSoft using the BNS and VIKOR methods. This study used seven criteria and seven factors as described. Three experts evaluated the criteria and alternatives using bipolar neutron counting (BNN).

Step 1: Build the tree and define the nodes.

There are two or more levels in the tree, at the first level the main criteria are presented as follows:

$SWM_{1}, SWM_{2} ..., SWM_{n}$

At the second level, the subcriteria are indicated with the $SWM_{1.1}, SWM_{1,2}, \ldots$ and $SWM_{2.1}, SWM_{2.2}, \ldots$

Step 2: Create a decision matrix of equations. (13). Table 1 shows the decision matrix.

To perform calculations with the neutrosophic matrices provided, we need to understand the operations involved. Neutrosophic matrices contain three types of elements: positive, neutral, and negative. Each element is represented as a triplet (a, b, c), where 'a' represents the positive component, 'b' represents the neutral component, and 'c' represents the negative component.

Here's how we can perform some basic operations on neutrosophic matrices:

1. Addition: To add two neutrosophic matrices, we add the corresponding elements of the matrices.

2. Subtraction: To subtract one neutrosophic matrix from another, we subtract the corresponding elements of the matrices.

3. Scalar Multiplication: To multiply a neutrosophic matrix by a scalar, we multiply each element of the matrix by the scalar.

4. Multiplication: Neutrosophic matrix multiplication is more complex and involves certain rules.

Since you haven't specified which calculations you want to perform, I can demonstrate one example calculation. Let's add MATRIX 1 and MATRIX 2 element-wise:

MATRIX 1+MATRIX 2=[Element-wise addition of corresponding elements of MATRIX 1 and MATRIX 2]

For example, to calculate the sum for the element in the first row and first column:

MED1,C.T.1=[0.90,0.30,0.30,−0.30,−0.70,−0.90]+[0.30,0.30,0.50,−0.50,−0.30,−0.30]

= [0.90 + 0.30, 0.30 + 0.30, 0.30 + 0.50, −0.30 − 0.50, −0.70 − 0.30, − 0.90 − 0.30]

= [1.20, 0.60, 0.80, -0.80, -1.00, -1.20]

We perform similar operations for all corresponding elements in the matrices to obtain the result.

Table 1: The decision matrix.

MATRIX 1							
	C.T. 1	**C.T. 2**	**C.T. 3**	**C.T. 4**	**C.T. 5**	**C.T. 6**	**C.T. 7**

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MED 1	[0.90, 0.30, 0.30, −0.30, −0.70, −0.90]	[0.90, 0.30, 0.30, −0.30, −0.70, −0.90]	[0.70, 0.70, 0.70, −0.30, −0.70, −0.70]	[0.90, 0.30, 0.30, −0.30, −0.70, −0.90]	[0.90, 0.30, 0.30, −0.30, −0.70, −0.90]	[0.70, 0.70, 0.70, −0.30, −0.70, −0.70]	[0.90, 0.30, 0.30, −0.30, −0.70, −0.90]
MED 2	[0.70, 0.70, 0.70 , −0.30, −0.70, −0.70]	[0.90, 0.30, 0.30 , −0.30, −0.70, −0.90]	[0.90, 0.30, 0.30 , −0.30, −0.70, −0.90]	[0.90, 0.30, 0.30 , −0.30, −0.70, −0.90]	[0.90, 0.30, 0.30 , −0.30, −0.70, −0.90]	[0.90, 0.30, 0.30 , −0.30, −0.70, −0.90]	[0.90, 0.30, 0.30 , −0.30, −0.70, −0.90]
MED 3	[0.30, 0.30, 0.50 , −0.70, −0.30, −0.30]	[0.30, 0.70, 0.50 , −0.90, −0.30, −0.30]	[0.90, 0.30, 0.30 , −0.30, −0.70, −0.90]	[0.30, 0.70, 0.50 , −0.90, −0.30, −0.30]	[0.30, 0.70, 0.50 , −0.90, −0.30, −0.30]	[0.70, 0.70, 0.70, −0.30, −0.70, −0.70]	[0.30, 0.70, 0.50 , −0.90, −0.30, −0.30]
MED 4	[0.30, 0.30, 0.50 , −0.70, −0.30, −0.30]	[0.70, 0.70, 0.70 , −0.30, −0.70, −0.70]	[0.30, 0.70, 0.50 , −0.90, −0.30, −0.30]	[0.70, 0.70, 0.70 , −0.30, −0.70, −0.70]	[0.70, 0.70, 0.70 , −0.30, −0.70, −0.70]	[0.30, 0.30, 0.50, −0.70, −0.30, −0.30]	[0.70, 0.70, 0.70 , −0.30, −0.70, −0.70]
MED 5	[0.30, 0.70, 0.50 , −0.90, −0.30, −0.30]	[0.70, 0.70, 0.70 , −0.70, −0.70, −0.70]	[0.70, 0.70, 0.70 , −0.30, −0.70, −0.70]	[0.70, 0.70, 0.70 , −0.70, −0.70, −0.70]	[0.70, 0.70, 0.70 , −0.70, −0.70, −0.70]	[0.30, 0.30, 0.50 , 0.70, −0.30, −0.30]	[0.70, 0.70, 0.70 , −0.70, −0.70, −0.70]
MED 6	[0.90, 0.30, 0.30, −0.30, −0.70, −0.90]	[0.30, 0.30, 0.50 , −0.70, −0.30, −0.30]	[0.70, 0.70, 0.70 , −0.70, −0.70, −0.70]	[0.90, 0.30, 0.30 , −0.30, −0.70, −0.90]	[0.30, 0.30, 0.50 , −0.70, −0.30, −0.30]	[0.30, 0.70, 0.50, −0.90, −0.30, −0.30]	[0.30, 0.30, 0.50 , −0.70, −0.30, −0.30]
MED 7	[0.90, 0.30, 0.30 −0.30, −0.70, −0.90]	[0.30, 0.70, 0.50, −0.90, −0.30, −0.30]	[0.30, 0.30, 0.50, −0.70, −0.30, −0.30]	[0.70, 0.70, 0.70, −0.30, −0.70, −0.70]	[0.30, 0.30, 0.50 , −0.70, −0.30, −0.30]	[0.30, 0.30, 0.50 0.70, −0.30, −0.30]	[0.30, 0.30, 0.50 , −0.70, −0.30, −0.30]
MATRIX 2							
	C.T.	**C.T.**	**C.T.**	**C.T.**	**C.T.**	**C.T.**	**C.T.**

DOI: https://doi.org/10.54216/IJNS.240407
Received: February 27, 2024 Revised: April 21, 2024 Accepted: May 28, 2024

	1	2	3	4	5	6	7
MED 1	[0.30, 0.30, 0.50 , −0.50, −0.30, −0.30]	[0.30, 0.30, 0.50 , −0.50, −0.30, −0.30]	[0.70, 0.50, 0.50 , −0.30, −0.70, −0.70]	[0.30, 0.30, 0.50 , −0.50, −0.30, −0.30]	[0.90, 0.30, 0.30 , −0.30, −0.70, −0.90]	[0.30, 0.30, 0.50 , 0.50, −0.30, −0.30]	[0.90, 0.30, 0.30 , −0.30, −0.70, −0.90]
MED 2	[0.70, 0.50, 0.50 , −0.30, −0.70, −0.70]	[0.70, 0.50, 0.50 , −0.30, −0.70, −0.70]	[0.90, 0.30, 0.30 , −0.30, −0.70, −0.90]	[0.70, 0.50, 0.50 , −0.30, −0.70, −0.70]	[0.90, 0.30, 0.30 , −0.30, −0.70, −0.90]	[0.70, 0.50, 0.50 , 0.30, −0.70, −0.70]	[0.90, 0.30, 0.30, −0.30, −0.70, −0.90]
MED 3	[0.90, 0.30, 0.30 , −0.30, −0.70, −0.90]	[0.90, 0.30, 0.30 , −0.30, −0.70, −0.90]	[0.90, 0.30, 0.30 , −0.30, −0.70, −0.90]	[0.90, 0.30, 0.30 , −0.30, −0.70, −0.90]	[0.30, 0.70, 0.50 , −0.90, −0.30, −0.30]	[0.90, 0.30, 0.30 , 0.30, −0.70, −0.90]	[0.30, 0.70, 0.50 , −0.90, −0.30, −0.30]
MED 4	[0.30, 0.70, 0.50 , −0.90, −0.30, −0.30]	[0.30, 0.70, 0.50 , −0.90, −0.30, −0.30]	[0.30, 0.70, 0.50 , −0.90, −0.30, −0.30]	[0.30, 0.70, 0.50 , −0.90, −0.30, −0.30]	[0.70, 0.50, 0.50 , −0.30, −0.70, −0.70]	[0.30, 0.70, 0.50 , 0.90, −0.30, −0.30]	[0.70, 0.50, 0.50 , −0.30, −0.70, −0.70]
MED 5	[0.30, 0.70, 0.50 , −0.90, −0.30, −0.30]	[0.50, 0.50, 0.50 , −0.50, −0.50, −0.50]	[0.70, 0.50, 0.50 , −0.30, −0.70, −0.70]	[0.50, 0.50, 0.50 , −0.50, −0.50, −0.50]	[0.50, 0.50, 0.50 , −0.50, −0.50, −0.50]	[0.30, 0.30, 0.50 , 0.50, −0.30, −0.30]	[0.50, 0.50, 0.50 , −0.50, −0.50, −0.50]
MED 6	[0.90, 0.30, 0.30 , −0.30, −0.70, −0.90]	[0.30, 0.30, 0.50 , −0.50, −0.30, −0.30]	[0.50, 0.50, 0.50 , −0.50, −0.50, −0.50]	[0.30, 0.30, 0.50 , −0.50, −0.30, −0.30]	[0.30, 0.30, 0.50 , −0.50, −0.30, −0.30]	[0.30, 0.70, 0.50 , 0.90, −0.30, −0.30]	[0.30, 0.30, 0.50 , −0.50, −0.30, −0.30]
MED 7	[0.90, 0.30, 0.30 , −0.30, −0.70, −0.90]	[0.70, 0.50, 0.50 , −0.30, −0.70, −0.70]	[0.30, 0.30, 0.50 , −0.50, −0.30, −0.30]	[0.70, 0.50, 0.50 , −0.30, −0.70, −0.70]	[0.70, 0.50, 0.50 , −0.30, −0.70, −0.70]	[0.30, 0.30, 0.50 , 0.50, −0.30, −0.30]	[0.70, 0.50, 0.50 , −0.30, −0.70, −0.70]

MATRIX 3

DOI: https://doi.org/10.54216/IJNS.240407
Received: February 27, 2024 Revised: April 21, 2024 Accepted: May 28, 2024

	C.T. 1	C.T. 2	C.T. 3	C.T. 4	C.T. 5	C.T. 6	C.T. 7
MED 1	[0.30, 0.30, 0.50 , −0.70, −0.30, −0.30]	[0.30, 0.30, 0.50 , −0.70, −0.30, −0.30]	[0.70, 0.70, 0.70 , −0.30, −0.70, −0.70]	[0.30, 0.30, 0.50 , −0.70, −0.30, −0.30]	[0.90, 0.30, 0.30 , −0.30, −0.70, −0.90]	[0.30, 0.30, 0.50 , 0.70, −0.30, −0.30]	[0.90, 0.30, 0.30 , −0.30, −0.70, −0.90]
MED 2	[0.70, 0.70, 0.70 , −0.30, −0.70, −0.70]	[0.70, 0.70, 0.70 , −0.30, −0.70, −0.70]	[0.90, 0.30, 0.30 , −0.30, −0.70, −0.90]	[0.70, 0.70, 0.70 , −0.30, −0.70, −0.70]	[0.90, 0.30, 0.30 , −0.30, −0.70, −0.90]	[0.70, 0.70, 0.70 , 0.30, −0.70, −0.70]	[0.90, 0.30, 0.30, −0.30, −0.70, −0.90]
MED 3	[0.90, 0.30, 0.30 , −0.30, −0.70, −0.90]	[0.90, 0.30, 0.30 , −0.30, −0.70, −0.90]	[0.90, 0.30, 0.30 , −0.30, −0.70, −0.90]	[0.90, 0.30, 0.30 , −0.30, −0.70, −0.90]	[0.30, 0.70, 0.50 , −0.90, −0.30, −0.30]	[0.90, 0.30, 0.30 , 0.30, −0.70, −0.90]	[0.30, 0.70, 0.50 , −0.90, −0.30, −0.30]
MED 4	[0.30, 0.70, 0.50 , −0.90, −0.30, −0.30]	[0.30, 0.70, 0.50 , −0.90, −0.30, −0.30]	[0.30, 0.70, 0.50 , −0.90, −0.30, −0.30]	[0.30, 0.70, 0.50 , −0.90, −0.30, −0.30]	[0.70, 0.70, 0.70 , −0.30, −0.70, −0.70]	[0.30, 0.70, 0.50 , 0.90, −0.30, −0.30]	[0.70, 0.70, 0.70 , −0.30, −0.70, −0.70]
MED 5	[0.30, 0.70, 0.50 , −0.90, −0.30 , −0.30]	[0.70, 0.70, 0.70 , −0.70, −0.70, −0.70]	[0.70, 0.70, 0.70 , −0, 30, −0.70, −0.70]	[0.70, 0.70, 0.70 , −0.70, −0.70, −0.70]	[0.70, 0.70, 0.70 , −0.70, −0.70, −0.70]	[0, 30, 0.30, 0.50 , 0.70, −0, 30, −0.30]	[0.70, 0.70, 0.70 , −0.70, −0.70, −0.70]
MED 6	[0.90, 0.30, 0.30 , −0.30, −0.70, −0.90]	[0.30, 0.30, 0.50 , −0.70, −0.30, −0.30]	[0.70, 0.70, 0.70 , −0.70, −0.70, −0.70]	[0.30, 0.30, 0.50 , −0.70, −0.30, −0.30]	[0.30, 0.30, 0.50 , −0.70, −0.30, −0.30]	[0.30, 0.70, 0.50 , 0.90, −0.30, −0.30]	[0.30, 0.30, 0.50 , −0.70, −0.30, −0.30]
MED 7	[0.90, 0.30, 0.30 , −0.30, −0.70, −0.90]	[0.70, 0.70, 0.70 , −0.30, −0.70, −0.70]	[0.30, 0.30, 0.50 , −0.70, −0.30, −0.30]	[0.70, 0.70, 0.70 , −0.30, −0.70, −0.70]	[0.70, 0.70, 0.70 , −0.30, −0.70, −0.70]	[0.30, 0.30, 0.50 , 0.70, −0.30, −0.30]	[0.70, 0.70, 0.70 , −0.30, −0.70, −0.70]

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Received: February 27, 2024 Revised: April 21, 2024 Accepted: May 28, 2024

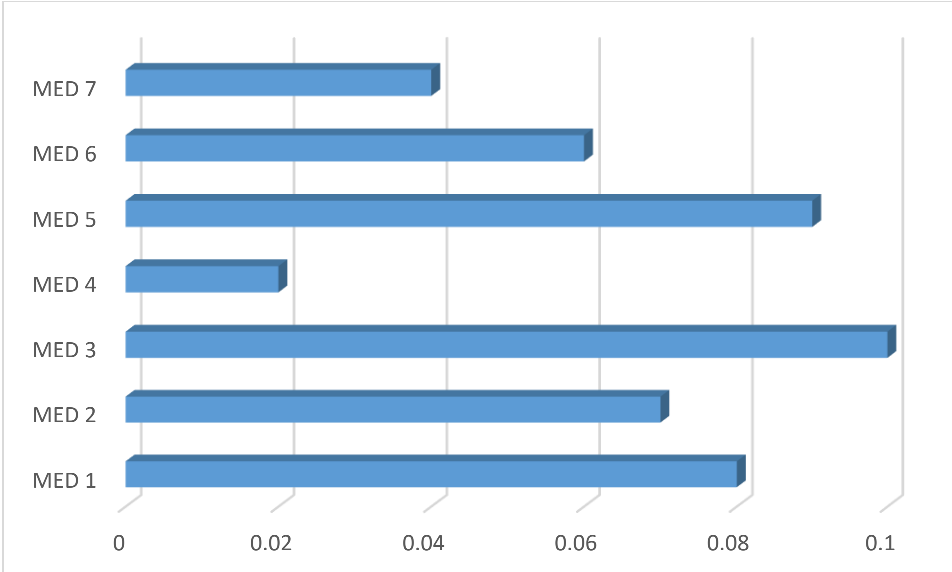

Figure 1: Weights.

Step 3. Calculate the initial weight as shown in Figure 1.

Step 4. Calculate the proximity of the alternatives to the best solution of the equation. (15).

Calculate the value of S_i Using Eq. (18).

Calculate the value of R_i Using Eq. (19).

Step 7. Calculate VIKOR index using the formula: (20, 21)

Step 8. Arrange the options as shown in Figure 4.

For poultry companies the following three have the greatest impact:

Genetic improvement: Selecting and crossing guinea pigs with desirable characteristics, such as increased body size, growth rate and disease resistance, can improve the quality and productivity of progeny.

Implementation of reproductive techniques: Use techniques such as selective mating and reproduction control to optimize birth rate and offspring survival.

Improving feeding: Providing a balanced diet rich in proteins is essential for the growth and health of guinea pigs. This may include the use of commercial feeds specific to guinea pigs, as well as the incorporation of fresh vegetables and forages into the diet.

Genetic improvement and the implementation of reproduction techniques are two fundamental aspects in guinea pig breeding that can have a significant impact on the quality and productivity of livestock. Selecting and crossing guinea pigs with desirable characteristics, such as larger body size and disease resistance, can result in more robust progeny adaptable to various environmental conditions. Similarly, the use of selective and controlled breeding techniques can help optimize birth rate and offspring survival, resulting in an increase in the total production of the family unit. On the other hand, improving nutrition is a key component to guarantee the healthy growth of guinea pigs and maximize their performance. Providing a balanced, protein-rich diet is essential to meet the nutritional needs of animals and promote optimal development. The inclusion of specific commercial feeds for guinea pigs, as well as the incorporation of fresh vegetables and forages in the diet, can further contribute to improving the health and well-being of guinea pigs, which in turn can translate into greater productivity for the guinea pigs. family units. In summary, both genetic improvement

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and the implementation of reproduction techniques as well as improved feeding are complementary strategies that can promote the success and sustainability of guinea pig breeding in small family units.

4. Conclusion

The conclusions of this study highlight the significant impact of various strategies on optimizing guinea pig farming in small family units. The integration of improved nutrition, effective health management practices, genetic improvement, and appropriate habitat conditions were found to be crucial in enhancing productivity and profitability. Additionally, implementing reproduction techniques, providing training and technical assistance, and diversifying products and markets can further support the sustainability and economic viability of guinea pig farming. The application of neutrosophic sets provided a robust framework for evaluating these strategies, allowing for a comprehensive analysis that addresses the inherent uncertainties in decision-making processes.

Future work in this area should explore the refinement and expansion of neutrosophic methodologies to better capture the complexities of guinea pig farming systems. Research should focus on developing more sophisticated models that incorporate a broader range of variables and more detailed data. Additionally, longitudinal studies that assess the long-term effects of various strategies on guinea pig farming will be valuable. Collaborations with local communities to tailor strategies to specific regional conditions and socio-economic contexts will also be crucial in ensuring the practical applicability and success of these interventions.

Firstly, genetic improvement plays a crucial role. Selecting and crossing guinea pigs with desirable traits such as increased body size, growth rate, and disease resistance can result in progeny of higher quality and productivity. Investing in genetic improvement programs can lead to significant improvements in production efficiency and the quality of the animals raised.

The implementation of reproductive techniques is also fundamental. Using techniques such as selective mating and reproductive control can optimize birth rates and offspring survival. This allows poultry companies to manage guinea pig populations more effectively and plan breeding according to market demand and production capabilities.

Lastly, improving feeding is essential for the growth and health of guinea pigs. Providing a balanced diet rich in proteins is crucial, which can be achieved through the use of specific commercial feeds for guinea pigs and the incorporation of fresh vegetables and forages into the diet. Attention to proper nutrition can enhance feed efficiency and overall animal performance, thereby contributing to the profitability of the company.

In summary, by focusing on genetic improvement, implementing advanced reproductive techniques, and optimizing feeding, poultry companies can increase the quality and productivity of their guinea pig production. These strategies not only benefit companies by improving production efficiency and profitability but can also have a positive impact on the welfare and health of the animals raised.

Funding: "This research did not receive external funding"

Conflicts of interest: "The authors declare that they have no conflict of interest ."

References

[1] Kaiser, S., Krüger, C., & Sachser, N. (2024). The guinea pig. The UFAW handbook on the care and management of laboratory and other research animals, 465-483.

[2] Ossebi, W., Ayssiwede, S. B., Atchiwassa, S., Djettin, A. E., Malou, R., Diop, M., & Missohou, A. (2023). Zootechnical performances and profitability of local breed's pigs fattened through the application of feed and health technological packages in traditional livestock farms in Casamance, Senegal. Journal of Applied Animal Research, 51(1), 501-514.

[3] Lammers, P. J., Carlson, S. L., Zdorkowski, G. A., & Honeyman, M. S. (2009). Reducing food insecurity in developing countries through meat production: the potential of the guinea pig (Cavia porcellus). Renewable Agriculture and Food Systems, 24(2), 155-162.

[4] Shomer, N. H., Holcombe, H., & Harkness, J. E. (2015). Biology and diseases of guinea pigs. In Laboratory animal medicine (pp. 247-283). Academic Press.

DOI: https://doi.org/10.54216/IJNS.240407
Received: February 27, 2024 Revised: April 21, 2024 Accepted: May 28, 2024

[5] Şahin, N. M., & Uz, M. S. (2021). Multi-criteria Decision-making Applications Based on Set Valued Generalized Neutrosophic Quadruple Sets for Law. International Journal of Neutrosophic Science (IJNS), 17(1).
[6] Thong, N. T., Smarandache, F., Hoa, N. D., Son, L. H., Lan, L. T. H., Giap, C. N., ... & Long, H. V. (2020). A novel dynamic multi-criteria decision-making method based on generalized dynamic interval-valued neutrosophic set. Symmetry, 12(4), 618.
[7] Priyadarsini, S., Singh, A. V., & Broumi, S. (2023). Extraction of Knowledge from Uncertain Data Employing Weighted Bipolar and Neutrosophic Soft Sets. Neutrosophic Sets and Systems, 60(1), 5.
[8] Praveena, N., Begum, S. G., Rajkumar, A., Nagarajan, D., & Said, B. (2022). Nonagonal Neutrosophic Number and its Application in Optimization Technique. International Journal of Neutrosophic Science (IJNS), 19(2).
[9] Smarandache, F. (2023). Practical applications of IndetermSoft Set and IndetermHyperSoft Set and introduction to TreeSoft Set as an extension of MultiSoft Set. Neutrosophic Computing and Machine Learning, 25, 1-8.
[10] Dhanalakshmi, G., Sandhiya, S., & Smarandache, F. (2024). Selection of the best process for desalination under a Treesoft set environment using the multi-criteria decision-making method. International Journal of Neutrosophic Science, 23(3), 140-40.
[11] López, E., Vivar, S. M., & Chalacan, L. M. (2023). A Fusion Selection Approach of the Best Plan for Energy Remodeling Hospital Wards Using a Multi-Criteria Decision-Making. Fusion: Practice and Applications, 14(1), 138-38.
[12] Rogulj, K., Kilić Pamuković, J., & Ivić, M. (2021). Hybrid MCDM based on VIKOR and cross entropy under rough neutrosophic set theory. Mathematics, 9(12), 1334.
[13] Leyva-Vázquez, M., Quiroz-Martínez, M. A., Portilla-Castell, Y., Hechavarría-Hernández, J. R., & González-Caballero, E. (2020). A New Model for the Selection of Information Technology Project in a Neutrosophic Environment. Neutrosophic Sets & Systems, 32.
[14] Aziz, A. S., Emad, M., Ismail, M., Rashad, H., Ali, A. M., Abdelhafeez, A., & Mohamed, S. S. (2023). An Intelligent Multi-Criteria Decision-Making Model for selecting an optimal location for a data center: Case Study in Egypt. Journal of Intelligent Systems and Internet of Things, 9(2), 23-35.

DOI: https://doi.org/10.54216/IJNS.240407
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