Novel Approach to Solve a Neutrosophic Transportation Problem

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Abstract

The transportation problem is a linear programming challenge focused on allocating resources efficiently across multiple locations while minimizing costs. Widely used in operations research, the transportation problem has numerous practical applications. Traditional approaches often struggle with imprecise data, which membership grades and fuzzy set theory can be used to address. Fuzzy sets concept provides a valuable framework for analysing transportation models under uncertainty. Neutrosophic sets have gained significant attention as a powerful tool for handling incomplete, ambiguous, and inconsistent data. Their ability to manage indeterminacy has made them increasingly popular in decision-making research, leading to extensive studies on their applications. This paper explores the use of imprecise parameters to improve transportation problem solution methods, emphasizing the versatility and advancements of neutrosophic sets. While various techniques exist for interpreting neutrosophic sets, certain limitations and field-specific requirements persist. In this study, trapezoidal fuzzy neutrosophic numbers make up fundamental components with respect to transportation problem. The proposed mathematical operations, algorithmic process, and framework achieve a 95% confidence level in clarifying uncertainties compared to the results with other methods. The effectiveness has been demonstrated with a numerical example for this approach, with comparisons to existing methods highlighting its advantages.

Keywords: Neutrosophic Fuzzy number; Neutrosophic fuzzy transportation problem (NFTP); Operations on NFTP; Score function

1. Introduction

Hitchcock originally devised basic elements of the simple transportation problem (TP) with the notion of reducing the cost of transferring specific amounts of sources to destinations. The first person to put forward the fuzzy sets as a viable method for capturing impreciseness or vagueness was Zadeh [24].

In an attempt to contend with the vagueness, Atanassov [1] presented the idea of intuitionistic fuzzy sets in the year 1986. Smarandache [18] offered neutrosophic theory over the first time during 1995. It dealt with specific types of uncertain data that occurred in practical scenarios, which cannot be handled by intuitionistic fuzzy sets. A fuzzy transportation problem (FTP) has undetermined values for demand, supply, and cost. There were different methods that were put forth; however, the parameters are not always accurate in practical situations depending upon a range of factors, which includes fuel price, road conditions and many more. These parameters can never be real numbers.

The traditional fuzzy set theory is being extended by neutrosophic sets that depicts more of uncertainty. It is important to understand that each component with regard to neutrosophic fuzzy set includes three membership functions that represent it. They are as follows:

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1. The extent or the degree to that the member is part of a set is the Truth membership function**,** is indicated using T.

2. The extent or the degree to that the membership of the member in a set is ambiguous or uncertain is the Indeterminacy membership function is indicated using I.

3. The extent or the degree to which the element does not exist in the set is the Falsity membership function, denoted by F.

Additionally, it should be mentioned about three membership functions above must meet the requirement, that is, $0 \leq T + I + F \leq 3$. however, each of these membership value functions can include values in the range [0, 1]. This makes it possible for the decision maker to illustrate the real world circumstances involving data, which is ambiguous or inadequate with greater flexibility.

Consider a real-world circumstance where an employee is assessed based on his achievements so far. In order to characterize his/her achievements in a particular field, let us define a neutrosophic set.

Extraordinary: E = (1,0,0)

- T = 1; The employee achieved greater heights in his field.
- I = 0; There is no inconsistency noted.
- F = 0; There is nothing relating to low achievements.

Satisfying: S = (0.8,0.1,0.1)

- T = 0.8
- I = 0.1
- F = 0.1

Below Average: B = (0.2,0.8,0.5)

- T = 0.2
- I = 0.8
- F = 0.5

In above example, it can be seen that it permits the decision maker to assess the achievements of an employee. The neutrosophic fuzzy sets takes into account not just the extraordinary performance of the employee in a particular field but also considers the ambiguity and not fitting into a specific field. In interviews and other assessments, where the achievements could be impacted by several circumstances and may not be simply defined, the neutrosophic fuzzy sets play a vital role. It is easy to comprehend the benefits and shortcomings of the neutrosophic fuzzy sets from proceeding tabular column -Table.1.

Table 1: Comparison tabular column highlighting the benefits and drawbacks of the adopted methodology

Perspective	**Fuzzy set**	**Intuitionistic Fuzzy set**	**Neutrosophic Fuzzy set**
Constituents	Truth membership	Truth, False & hesitancy	Truth, ambiguity & falsity
Condition	Range of T should be [0,1]	$\mu + \gamma \leq 1$	$0 \leq T + I + F \leq 3$.
Flexibility	Limited to the range of T	Includes a hesitation degree.	Flexible even when there are many uncertainties.
Complication	Easy representation	Little complicated	Complicated with various uncertainties.

In a variety of fields, neutrosophic sets contribute significantly, especially with the identification of patterns, health care diagnosis and making decisions. The neutrosophic concepts are represented in different ways in machine learning, decision making with different attributes, graphical representations, health assessments, flaw recognition and optimization planning where several kinds of ambiguities exist.

Shell put forth a transportation problem [21] about conveyance, stock and requirement for the purpose to describe the many forms of transportation that includes automobiles, ships, freight trains and freight airplanes. To obtain the best solution with minimum number of iterations, an innovative technique called zero adjacent to zero method was proposed by Mohammad and Aminur [12]. Hayley presented an enhanced version of the modified distribution

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technique [9] in an effort to optimize the solid transportation problem. Arokiyasironmani and Santhi, which was called the mac-min method, gave a novel approach [3] to the same. The fuzzy values were converted to the crisp values using a technique [14] defined by Purushoth Kumar and Ananthanarayanan. Rajesh Kumar Saini et al initially put the neutrosophic transportation problem [16] involving interval valued trapezoidal numbers forward.

In [19] and [13], researchers introduced an effective ranking methodology to determine fuzzy optimal solution considering unbalanced FTP. Meanwhile, study [11] explores various ranking approaches that convert neutrosophic fuzzy numbers (NFN) into crisp values. Additionally, [7] presents a solution for the Traveling Salesman Problem using single-valued triangular neutrosophic parameters through the Dhouib-Matrix-TSP1 heuristic. Furthermore, [6] discusses a multi-objective TP where price, stock, and requirements parameters being represented in interval form. A novel graphical depiction of the distance measure that pertains to the trapezoidal fuzzy neutrosophic number according to centroids being also presented in [4]. The transportation problem was resolved in [23] by using the VAM approach to generalized single-valued neutrosophic trapezoidal numbers. The fuzzy transportation problem was resolved in [16] when the authors introduced De-neutrosophication, is the technique that turns neutrosophic numbers to crisp numbers to use in practical applications. Fuzzy transportation problems involving triangular fuzzy numbers were solved by [15] using the α solution and a ranking mechanism. The fuzzy transportation problem could now be transformed as a result. The VAM technique and a new ranking function were used in [2] to address the fuzzy transportation problem.

Presuming an individual who makes decisions is not able to ascertain exact numbers of the commodity's availability, requirement, and shipment expenses; this paper proposes a new method to address fuzzy transportation challenges as well. Neutrosophic trapezoidal fuzzy numbers (NTFNs) are employed in the suggested approach in describing the product's supply and need. The suggested strategy can be seen by addressing a numerical example, and its outcomes are contrasted with those of prior techniques.

As an essential improvement when using the conventional method, people who make decisions will discover it very easy in understanding further to implement the proposed method for real-world problems associated with transportation.

2. Materials and Methods

2.1. Trapezoidal fuzzy number

Consider fuzzy number $\tilde{A}$ being convex and normalized fuzzy set defined over real numbers ($\mathbb{R}$). It is described by the membership function that is piecewise continuous, with distinct segments, and is typically represented by (a_1, a_2, a_3, a_4), $(a_1 \le a_2 \le a_3 \le a_4) \in R$ where the membership function $\mu_{\tilde{A}}(x)$ considered as

$$\mu_A(x) = \begin{cases} 0, & x \le a_1 \\ \dfrac{x - a_1}{a_2 - a_1} & a_1 < x \le a_2 \\ 1, & a_2 \le x \le a_3 \\ \dfrac{a_1 - x}{a_4 - a_3} & a_3 < x \le a_4 \\ 0, & x \ge a_4 \end{cases}$$

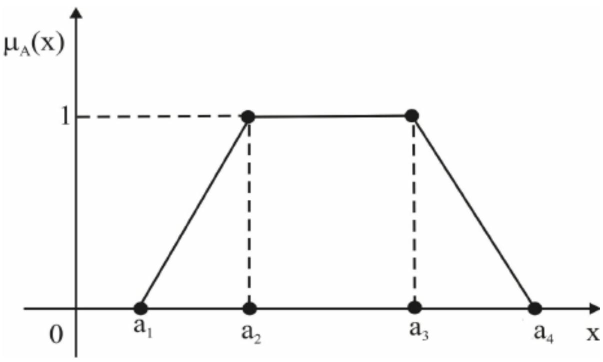

Figure 1. An illustration of the trapezoidal fuzzy number

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2.2. Neutrosophic Fuzzy Set:

The Neutrosophic fuzzy set A of X being characterized as "$A = \{x, \phi_{1A}N(x), \phi_{2A}N(x), \phi_{3A}N(x) / x \in\}$ where $\phi_{1A}N(x)$ Truth membership, $\phi_{2A}N(x)$ Indeterminacy membership and $\phi_{3A}N(x)$ Falsity membership functions by $\phi_{1A}N(x), \phi_{2A}N(x), \phi_{3A}N(x) : X \to [0,1]$ $\forall\, x \in X$ also $0 \le \phi_{1A}N(x) + \phi_{2A}N(x) + \phi_{3A}N(x) \le 3$."

2.3. Neutrosophic trapezoidal fuzzy number (NTFN):

Consider $k_i, r_i, v_i \in R$ with $k_1 \le k_2 \le k_3 \le k_4 (r_i, v_i)$ and $\phi_{1A}, \phi_{2A}, \phi_{3A} \in [0,1] \subset R.$. Let the single-valued trapezoidal Neutrosophic number $A = \{[(k_1, k_2, k_3, k_4; \phi_{1A}), (r_1, r_2, r_3, r_4; \phi_{2A})(v_1, v_2, v_3, v_4; \phi_{3A})]\}$ be special Neutrosophic-set on R with truth membership value, indeterminacy value and falsity membership value be determined with the mappings, accordingly. $g_A : R \to [0, \phi_{1A}], i_A : R \to [\phi_{2A}, 1], f_A : R \to [\phi_{3A}, 1]$ is given by:

$$g_A(x) = \begin{cases} 0 & x < k_1 \\ \dfrac{\phi_{1A}(x - k_1)}{k_2 - k_1} & k_1 \le x \le k_2 \\ \phi_{1A} & k_2 \le x \le k_3 \\ \dfrac{\phi_{1A}(k_4 - x)}{k_4 - k_3} & k_3 \le x \le k_4 \\ 0 & x > k_4 \end{cases}$$

$$i_A(x) = \begin{cases} 1 & x < r_1 \\ \dfrac{(r_2 - x) + \phi_{2A}(x - r_1)}{r_2 - r_1} & r_1 \le x \le r_2 \\ \phi_{2A} & r_2 \le x \le r_3 \\ \dfrac{(x - r_3) + \phi_{2A}(r_4 - x)}{r_4 - r_3} & r_3 \le x \le r_4 \\ 1 & x > r_4 \end{cases}$$

$$f_A(x) = \begin{cases} 1 & x < v_1 \\ \dfrac{(v_2 - x) + \phi_{3A}(x - v_1)}{v_2 - v_1} & v_1 \le x \le v_2 \\ \phi_{3A} & v_2 \le x \le v_3 \\ \dfrac{(x - v_3) + \phi_{3A}(v_4 - x)}{v_4 - v_3} & v_3 \le x \le v_4 \\ 1 & x > v_4 \end{cases}$$

Consider functions from $[k_1, k_2] \to [0, \phi_{1A}], [r_3, r_4] \to [\phi_{2A}, 1], [v_3, v_4] \to [\phi_{3A}, 1]$ being non-decreasing continuous further they also fulfill the condition $t_A(u_1) = 0, t_A(u_2) = \phi_{1A}, i_A(t_3) = \phi_{2A}, i_A(t_4) = 1, f_A(v_3) = \phi_{3A}, f_A(v_4) = 1$.

2.4 Illustration

Graphic illustration of single-valued trapezoidal neutrosophic fuzzy number

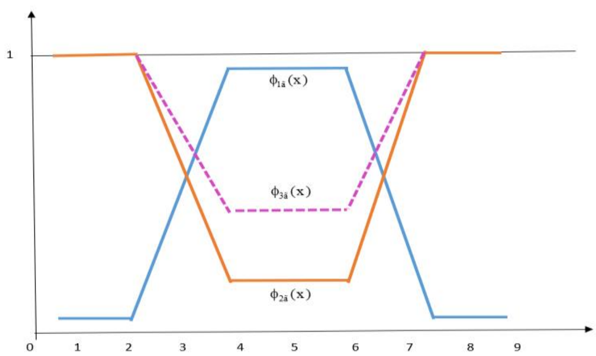

Figure 2. An illustration of trapezoidal neutrosophic fuzzy number

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2.5. Methodology for Ranking:

Consider $R(\tilde{a})$ to be the ranking of $\tilde{a}$ on the set of NTFN has the following definition.

$$\square(\tilde{a})=\left(\frac{\phi_{1\tilde{a}}+1-\phi_{2\tilde{a}}+1-\phi_{3\tilde{a}}}{3}\right)\left(\frac{a+b+c+d}{4}\right)$$

The simplex approach to solve a linear programming problem (LPP) requires that a standard form be used to represent the problem. It is well known that the direct simplex algorithm requires the issue to be processed in standard form in order to produce an optimal solution for any LPP. However, not every LPP takes the typical shape. Frequently, constraints are not written as equations but rather as inequalities.

2.6. Operations in Arithmetic:

If $\tilde{a}=\{(u_1,u_2,u_3,u_4);\phi_{1\tilde{a}},\phi_{2\tilde{a}},\phi_{3\tilde{a}}\}$ and $b=\{(t_1,t_2,t_3,t_4);\phi_{1\tilde{a}},\phi_{2\tilde{a}},\phi_{3\tilde{a}}\}$ be the two given trapezoidal neutrosophic numbers it follows that:

(i) $\tilde{a}+\tilde{b}=\langle(u_1+t_1,u_2+t_2,u_3+t_3,u_4+t_4);\phi_{1\tilde{a}}\wedge\phi_{1\tilde{b}},\phi_{2\tilde{a}}\wedge\phi_{2\tilde{b}},\phi_{3\tilde{a}}\wedge\phi_{3\tilde{b}}\rangle$

(ii) $\tilde{a}-\tilde{b}=\langle(u_1-t_1,u_2-t_2,u_3-t_3,u_4-t_4);\phi_{1\tilde{a}}\wedge\phi_{1\tilde{b}},\phi_{2\tilde{a}}\wedge\phi_{2\tilde{b}},\phi_{3\tilde{a}}\wedge\phi_{3\tilde{b}}\rangle$

(iii) $$\tilde{b}=\begin{cases}\langle(u_1t_1,u_2t_2,u_3t_3,u_4t_4);\phi_{1\tilde{a}}\wedge\phi_{1\tilde{b}},\phi_{2\tilde{a}}\wedge\phi_{2\tilde{b}},\phi_{3\tilde{a}}\wedge\phi_{3\tilde{b}}\rangle \text{if } u_4>0,t_4>0\\ \langle(u_1t_4,u_2t_3,u_3t_2,u_4t_1);\phi_{1\tilde{a}}\wedge\phi_{1\tilde{b}},\phi_{2\tilde{a}}\wedge\phi_{2\tilde{b}},\phi_{3\tilde{a}}\wedge\phi_{3\tilde{b}}\rangle \text{if } u_4<0,t_4>0\\ \langle(u_1t_1,u_2t_2,u_3t_3,u_4t_4);\phi_{1\tilde{a}}\wedge\phi_{1\tilde{b}},\phi_{2\tilde{a}}\wedge\phi_{2\tilde{b}},\phi_{3\tilde{a}}\wedge\phi_{3\tilde{b}}\rangle \text{if } u_4<0,t_4<0\end{cases}$$

(iv) $$\frac{\tilde{a}}{\tilde{b}}=\begin{cases}\left\langle\left(\frac{u_1}{t_4},\frac{u_2}{t_3},\frac{u_2}{t_2},\frac{u_4}{t_1},\right);\phi_{1\tilde{a}}\wedge\phi_{1\tilde{b}},\phi_{2\tilde{a}}\wedge\phi_{2\tilde{b}},\phi_{3\tilde{a}}\wedge\phi_{3\tilde{b}}\right\rangle \text{if } u_4>0,t_4>0\\ \left\langle\left(\frac{u_4}{t_4},\frac{u_3}{t_3},\frac{u_2}{t_2},\frac{u_1}{t_1},\right);\phi_{1\tilde{a}}\wedge\phi_{1\tilde{b}},\phi_{2\tilde{a}}\wedge\phi_{2\tilde{b}},\phi_{3\tilde{a}}\wedge\phi_{3\tilde{b}}\right\rangle \text{if } u_4<0,t_4>0\\ \left\langle\left(\frac{u_4}{t_1},\frac{u_3}{t_2},\frac{u_2}{t_3},\frac{u_1}{t_4},\right);\phi_{1\tilde{a}}\wedge\phi_{1\tilde{b}},\phi_{2\tilde{a}}\wedge\phi_{2\tilde{b}},\phi_{3\tilde{a}}\wedge\phi_{3\tilde{b}}\right\rangle \text{if } u_4<0,t_4<0\end{cases}$$

(v) $k\tilde{a}=\langle(ku_1,ku_2,ku_3,ku_4);\phi_{1\tilde{a}}\wedge\phi_{1\tilde{b}},\phi_{2\tilde{a}}\wedge\phi_{2\tilde{b}},\phi_{3\tilde{a}}\wedge\phi_{3\tilde{b}}\rangle$

(vi) $\tilde{a}^{-1}=\left\langle\left(\frac{1}{u_4},\frac{1}{u_3},\frac{1}{u_2},\frac{1}{u_1}\right);\phi_{1\tilde{a}},\phi_{2\tilde{a}},\phi_{3\tilde{a}}\right\rangle$, where $\tilde{a}\neq 0$

3. Mathematical Formulation of the Problem

The approach introduces the transportation problem using single valued neutrosophic setup. Suppose that there is the transportation problem having m sources also n destinations. The person who makes decisions does not know about exact cost of transportation beginning at the i^{th} source to the j^{th} destination, however, there is not ambiguity regarding product's supply also demand with the following presumptions and restrictions in place.

Consider $\tilde{a}_i\,(a_i\geq 0)$ being feasible in source i and $\tilde{b}_j\,(b_j\geq 0)$ being prerequisite in destination j.

Consider NC_{ij} being unit FT cost linking source i and destination j.

Consider $\tilde{x}_{ij}$ represent number of fuzzy units which is carried connecting source i and destination j.

This challenge aims to identify a feasible approach to transport in which feasible cost is being minimized.

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" $\text{Minimize } \tilde{Z} = \sum_{i=1}^{m} \sum_{j=1}^{n} NC_{ij} \tilde{x}_{ij}$

subject to

$$\sum_{j=1}^{n} \tilde{x}_{ij} = \tilde{a}_i, i = 1, 2, 3, ...m.$$

$$\sum_{i=1}^{m} \tilde{x}_{ij} = \tilde{b}_j, j = 1, 2, 3, ...n.$$ "

$$\sum_{i=1}^{m} \tilde{a}_i = \sum_{j=1}^{n} \tilde{b}_j, i = 1, 2, 3, ...m, j = 1, 2, 3, ...n.$$

$$\tilde{x}_{ij} \geq 0$$

Table 2: The NFTP is represented by the tabular column below

Sources\ Destinations	D_1	D_2	-	D_n	Supply
S_1	NC_{11}	NC_{12}	--	NC_{1n}	$\tilde{a}_1$
-	-	-	-	-	-
S_i	NC_{i1}	NC_{i2}	-	NC_{in}	$\tilde{a}_i$
-	-	-	-	-	-
S_m	NC_{m1}	NC_{m2}	-	NC_{mn}	$\tilde{a}_m$
Demand	$\tilde{b}_1$	$\tilde{b}_2$	-	$\tilde{b}_n$	Total

3.1 Method for Proposed Algorithms Using Neutrosophic Numbers

We suggested an alternative approach to transportation difficulties in this work by employing the algorithm below. The suggested approach should work in the following ways:

Step 1: The balancing condition being examined in relation to the transportation problem.

Step 2: The least cost combination from each row is determined, and all possible combinations are recognized.

Step 3: Locate the row with the least cost option out of all the combinations that were chosen. Next, assign as much of the supply and demand as is feasible to the variable, which is, designated row or column that has least unit cost. By choosing the row or column that is set to zero, additionally, we can change supply and demand. We select corresponding row where the element with lowest costing in comparison with chosen element if neither the row nor the column is set to zero in the combination.

Step 4**:** Return to Step 3 further proceed until all rows and columns have been utilized, after choosing the next combination with the lowest cost.

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3.2 Algorithm flow chart

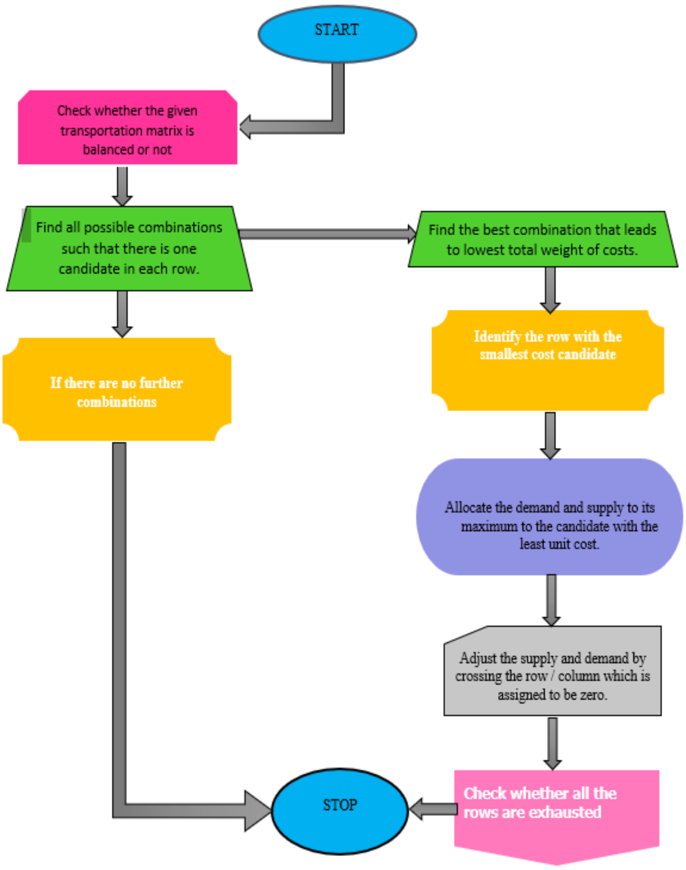

Figure 3. Algorithm flow chart

4 A Numerical Illustration

Let us observe the transportation problem where products are being carried to four separate sites to create the required item after being principally stored at three different places. This commodity has the trapezoidal neutrosophic unit transportation cost, and supply and demand are crisp. (Table 3).

Table 3: NFTP table

	D1	D2	D3	D4	Supply
S1	(3, 5, 6, 8); 0.6, 0.5, 0.4	(5, 8, 10, 14); 0.3, 0.6, 0.6	(12, 15, 19, 22); 0.6, 0.4, 0.5	(14, 17, 21, 28); 0.8, 0.2, 0.6	26
S2	(0, 1, 3, 6); 0.7, 0.5, 0.3	(5, 7, 9, 11); 0.9, 0.7, 0.5	(15, 17, 19, 22); 0.4, 0.8, 0.4	(9, 11, 14, 16); 0.5, 0.4, 0.7	24
S3	(4, 8, 11, 15); 0.6, 0.3, 0.2	(1, 3, 4, 6); 0.6, 0.3, 0.5	(5, 7, 8, 10); 0.5, 0.4, 0.7	(5, 9, 14, 19); 0.3, 0.7, 0.6	30
Demand	17	23	28	12	80

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By transforming, the trapezoidal neutrosophic unit transportation cost is specified by above tabular column into the crisp transportation cost, the score function aids in generating of Table 4.

Table 4: Rank of the transportation costs

	D1	D2	D3	D4	Supply
S1	(□ = 3)	(□ = 3)	(□ = 9)	(□ = 13)	26
S2	(□ = 16)	(□ = 5)	(□ = 7)	(□ = 6)	24
S3	(□ = 7)	(□ = 2)	(□ = 3)	(□ = 4)	30
Demand	17	23	28	12	80

Construct below the trapezoidal neutrosophic transportation table (Table 5) after giving allocations.

Table 5: Allocation of NFTP

	D1	D2	D3	D4	Supply
S1	**17** (□ = 3)	**9** (□ = 3)	(□ = 9)	(□ = 13)	26
S2	(□ = 16)	(□ = 5)	(□ = 7)	**10** (□ = 6)	24
S3	(□ = 7)	(□ = 2)	**28** (□ = 3)	**2** (□ = 4)	30
Demand	17	23	28	12	80

Therefore, minimized possible total neutrosophic cost given by,

$$Minimize\tilde{Z} = \sum_{i=0}^{3}\sum_{j=0}^{4}\tilde{C}_{ij}\,\tilde{X}_{ij}$$

= (440,536,652,862);0.3, 0.7, 0.7

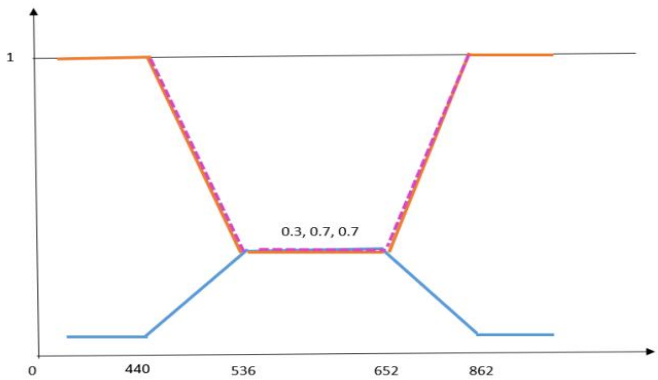

Figure 4. Neutrosophic fuzzy transportation cost represented graphically

The optimum value of trapezoidal neutrosophic fuzzy transportation expenses is provided in the trapezoidal neutrosophic transportation table (Table 6).

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Table 6: Allocation table for optimal values

	D1	D2	D3	D4	Supply
S1	**17** (□ = 3)	**9** (□ = 3)	(□ = 9)	(□ = 13)	26
S2	(□ = 16)	**12** (□ = 5)	(□ = 7)	**12** (□ = 6)	24
S3	(□ = 7)	**2** (□ = 2)	**28** (□ = 3)	(□ = 4)	30
Demand	17	23	28	12	80

Therefore, minimized total neutrosophic cost obtained given by,

$$Minimize\tilde{Z} = \sum_{i=0}^{3}\sum_{j=0}^{4} \tilde{C}_{ij}\,\tilde{X}_{ij}$$

= (406,605,700,878); 0.3, 0.7, 0.7

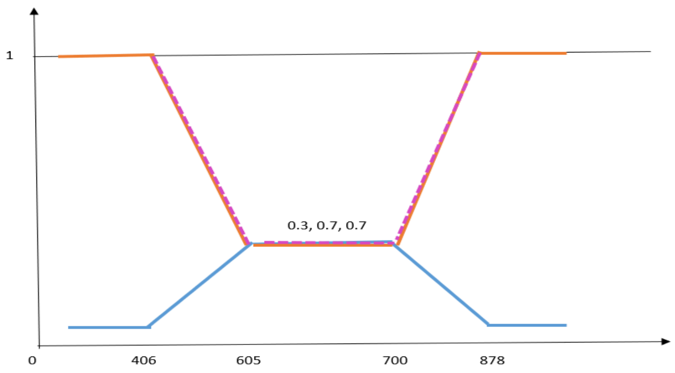

Figure 5. NFTP optimum value represented graphically

The trapezoidal neutrosophic fuzzy transportation costs derived utilizing Vogel's Approximation by the displayed trapezoidal neutrosophic transportation table (Table 7).

Table 7: Vogel's Approximation Method NFTP calculation

	D1	D2	D3	D4	Supply
S1	**11** (□ = 3)	(□ = 3)	(□ = 9)	(□ = 13)	26
S2	(□ = 16)	**12** (□ = 5)	(□ = 7)	**12** (□ = 6)	24
S3	**2** (□ = 7)	(□ = 2)	**28** (□ = 3)	(□ = 4)	30
Demand	17	23	28	12	80

Therefore, minimized total neutrosophic cost obtained given by,

$$Minimize\tilde{Z} = \sum_{i=0}^{3}\sum_{j=0}^{4} \tilde{C}_{ij}\,\tilde{X}_{ij}$$

= (422,601,734,928); 0.3, 0.7, 0.7

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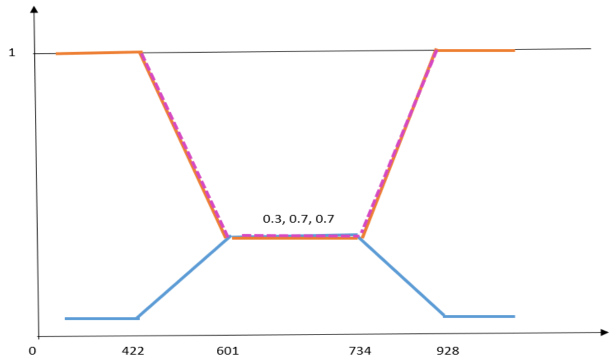

Figure 6. NFTP cost obtained by VAM method represented graphically

The Best Candidate approach for determining the Initial Basic Feasible Solution using trapezoidal NFTP has been applied in this paper. Furthermore, a comparative analysis (Table 8) using the current approaches has been performed.

Table 8: An Analysis of Comparisons

Methodology	**Outcomes**
Optimal Solution	(406, 605, 700, 878); 0.3, 0.7, 0.7
VAM solution	(422, 601, 734, 928); 0.3, 0.7, 0.7
Outcome observed from [22]	(350, 537, 662, 908);0.3, 0.7, 0.7
Proposed Approach	**(440, 536, 652, 862); 0.3, 0.7, 0.7**

The proposed approach has given 95% confidence level vagueness reduced cost **(440, 536, 652, 862); 0.3, 0.7, 0.7** while we compare the method discussed in [22] and other methods.

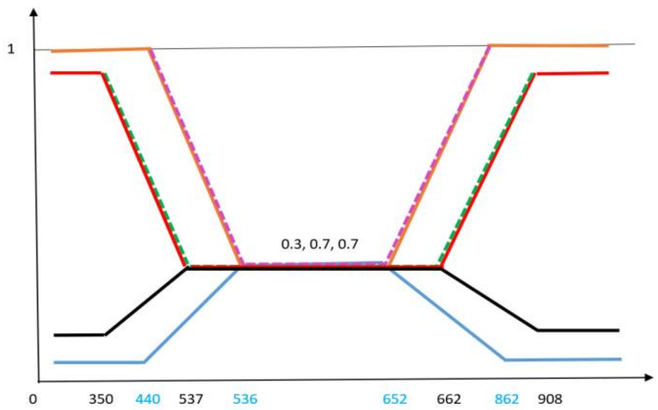

Figure 7. Comparison of Thamaraiselvi et al. [22] with the proposed techniques graphical representation

As shown by Figure [6], ——— gives truth-value, ——— gives indeterminacy further gives - - - falsity values of the transportation cost got in [22].

Likewise, ——— gives truth-value, ——— gives indeterminacy also - - - - gives falsity values of the transportation cost achieved using the approach we proposed.

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5 Conclusion

This study utilizes an innovative strategy to identify the initial basic feasible solution with the use of integrating ranking approach within the framework of a neutrosophic fuzzy transportation problem. Unlike conventional transportation models, this approach incorporates trapezoidal neutrosophic fuzzy numbers to represent transportation costs, capturing uncertainties more effectively by accounting for truth, indeterminacy, and falsity degrees. The proposed methodology extends beyond traditional transportation problems, demonstrating versatility in solving a wide range of optimization challenges, including project scheduling, assignment problems, and network flow problems.

References

[1] K. T. Atanassov, "Intuitionistic fuzzy sets," *Fuzzy Sets Syst.*, vol. 20, no. 1, pp. 1–6, 1986.

[2] Kaur and A. Kumar, "A new method for solving fuzzy transportation problems using ranking function," *Appl. Math. Model*, vol. 35, no. 2, pp. 5652–5666, 2011.

[3] Arockiasironmani and S. Santhi, "A New Technique for Solving Fuzzy Transportation Problem Using Trapezoidal Fuzzy Numbers," *J. Algebraic Stat.*, vol. 13, pp. 2216–2222, 2022.

[4] S. Broumi *et al.*, "A New Distance Measure for Trapezoidal Fuzzy Neutrosophic Number Based on the Centroids," *Neutrosophic Sets Syst.*, vol. 35, no. 2, pp. 478–502, 2020.

[5] S. Chandrasekaran, G. Kokila, and J. Saju, "A New Approach to Solve Fuzzy Travelling Salesman Problems by using Ranking Functions," *Int. J. Sci. Res. (IJSR)*, vol. 4, no. 5, pp. 2258–2260, 2015.

[6] S. K. Das, A. Goswami, and S. S. Alam, "Multiobjective transportation problem with interval cost, source and destination parameters," *Eur. J. Oper. Res.*, vol. 117, no. 1, pp. 100–112, 1999.

[7] S. Dhouib, "Optimization of travelling salesman problem on single valued triangular neutrosophic number using dhouib-matrix-TSP1 heuristic," *Int. J. Eng.*, vol. 34, no. 12, pp. 1–6, 2021.

[8] G. Sharma, S. H. Abbas, and V. K. Gupta, "A New Approach to Solve Fuzzy Transportation Problem for Trapezoidal Number," *J. Prog. Res. Math.*, vol. 4, no. 3, pp. 386–392, 2015.

[9] K. B. Haley, "New methods in mathematical programming - the solid transportation problem," *Oper. Res.*, vol. 10, no. 4, pp. 448–463, 1962.

[10] J. Ye, "Trapezoidal Neutrosophic set and its Application to Multiple Attribute Decision-Making," *Neural Comput. Appl.*, vol. 26, no. 1, pp. 1157–1166, 2015.

[11] K. Kalaivani and P. Kaliyaperumal, "A neutrosophic approach to the transportation problem using single-valued trapezoidal neutrosophic numbers," *Proyecciones J. Math.*, vol. 42, no. 2, pp. 533–547, 2023.

[12] M. M. Uddin *et al.*, "Zero Next to Zero (ZnZ) Method: A New Approach for Solving Transportation Problem," *J. Phys. Sci.*, vol. 26, pp. 13–23, 2021.

[13] S. Muruganandam and R. Srinivasan, "A New Algorithm for Solving Fuzzy Transportation Problems with Trapezoidal Fuzzy Numbers," *Int. J. Recent Trends Eng. Res. (IJRTER)*, vol. 2, no. 3, pp. 428–437, 2016.

[14] M. K. Purushothkumar and Ananthanarayanan, "Fuzzy Transportation problem of Trapezoidal Fuzzy numbers with New Ranking Technique," *IOSR J. Math. (IOSR-JM)*, vol. 13, no. 1, pp. 6–12, 2017.

[15] M. R. Kumar and S. Subranmanian, "Solution of Fuzzy Transportation Problems with Trapezoidal Fuzzy Numbers using Robust Ranking Methodology," *Int. J. Pure Appl. Math.*, vol. 119, no. 16, pp. 3763–3775, 2018.

[16] R. K. Saini, A. Sangal, and M. Manisha, "Application of Single Valued Trapezoidal Neutrosophic Numbers in Transportation Problem," *Neutrosophic Sets Syst.*, vol. 35, no. 2, pp. 563–583, 2020.

[17] R. K. Saini, A. Sangal, and A. Ahirwar, "A Novel Approach by using Interval-Valued Trapezoidal Neutrosophic Numbers in Transportation Problem," *Neutrosophic Sets Syst.*, vol. 51, no. 1, pp. 234–253, 2022.

[18] F. Smarandache, "A concept of neutrosophic intuitionistic fuzzy set," 1995, p. 386.

[19] K. Sangeetha, T. Priyadharshini, and S. Mayuriya, "Solving Fuzzy Transportation Problem using Trapezoidal Fuzzy Numbers," *Eng. Technol.*, vol. 4, no. 4, pp. 244–249, 2018.

DOI: https://doi.org/10.54216/IJNS.270223

[20] S. Dhouib, "Solving the Single –Valued Trapezoidal Neutrosophic Transportation Problem Through the Novel Dhouib-Matrix-TP1 Heuristic," *Math. Problems Eng.*, vol. 2021, p. 11, 2021.

[21] E. Shell, "Distribution of a product by several properties, directorate of management analysis," in *Proc. Second Symp. Linear Program*, vol. 2, 1955, pp. 615–642.

[22] Thamaraiselvi and R. Santhi, "A New Approach for Optimization of Real Life Transportation Problems in Neutrosophic Environment," *Math. Problems Eng.*, vol. 2016, p. 9, 2016.

[23] R. M. Umanmageswari and G. Uthra, "Generalized Single Valued Neutrosophic Trapezoidal Numbers and their Application to Solve Transportation Problem," *J. Study Res.*, vol. 12, no. 1, pp. 164–170, 2020.

[24] L. A. Zadeh, "Fuzzy sets," *Inf. Control*, vol. 8, no. 3, pp. 338–353, 1965.

DOI: https://doi.org/10.54216/IJNS.270223