



A New Approach to Solve Transportation Problems Under Neutrosophic Environment

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Abstract

The transportation problem has received a lot of attention in the field of operations research. In many circumstances, transportation planners may lack clear information on supply, demand, and transportation costs. Fuzzy sets can accept incomplete information by allowing for degrees of membership, which describe the level of certainty or uncertainty associated with each parameter. Three components—truth-membership, indeterminacy-membership, and falsity-membership degrees—are added to fuzzy numbers to create neutrosophic fuzzy numbers, which enables a more complex depiction of uncertainty. In this paper, we discuss the fuzzy transportation problem in a neutrosophic environment. Here the transportation costs, demands, and supplies are represented by neutrosophic trapezoidal fuzzy numbers. The neutrosophic trapezoidal fuzzy numbers are transformed into crisp numbers by using a ranking function and providing numerical examples to show the proposed method's efficiency to get the minimum optimal cost. Finally, we have demonstrated that our proposed method produced a better optimal solution to existing approaches by comparing its results to those of the existing ones.

Keywords: Transportation problem; Neutrosophic transportation problems; Neutrosophic trapezoidal numbers; Arithmetic operation; Comparison tables.

1. Introduction:

During World War II, the discipline of operation research emerged. A scientific method of decision-making that involves the operations of organizational systems is known as operation research. One of the most popular operations research methodologies is linear programming, created by George B. Dantzig (1940). Finding the optimal value for the given linear function is the focus of the linear programming problem. A specific kind of linear programming problem is the transportation problem. Because of its unique mathematical structure, the standard simplex approach cannot be used for solving transportation problems. F.L. Hitchcock (1941) developed the fundamental transportation problem. In real-world applications, due to unpredictable circumstances, all the characteristics of transportation problems may not be represented accurately. Random variables used from a probability distribution do not always accurately represent this kind of uncertain data. Fuzzy numbers can be used to describe this kind of data. Bellman and Zadeh introduced the concept of decision-making in a fuzzy environment. L.A. Zadeh introduced decision-making in a fuzzy environment [23]. Fuzzy optimization techniques have evolved from Zimmerman's [17] various fuzzy linear programming techniques for handling transportation issues. A method has been developed by Basir Zadeh [15](2011) for resolving the fuzzy transportation problem. Atanassov [20] presented the intriguing and beneficial intuitionistic

fuzzy set theory in 1986. Verdgay [19] gave an application of fuzzy optimization in operational research. Campos Ibanes [30] et.al proposed an approach for ranking fuzzy numbers. Ashok Kumar [4] et.al proposed a method to tackle the transshipment problem in an unpredictable environment. Gani [7] et.al had solved the two-stage fuzzy transportation problem. Kaur and Kumar [8] introduced a new method to solve fuzzy transportation problem using trapezoidal fuzzy numbers. Cheng [10] proposed a new approach for ranking fuzzy numbers using the distance method. Dinagar [14] et.al developed a solution for the transportation problem in a fuzzy environment.

Intuitionistic fuzzy is a fuzzy set extension. In fuzzy theory, we speak only about the truth membership whereas in intuitionistic fuzzy we discuss both truth and false membership degrees which leads us to a better optimal solution. Krassimir Atanassov [20] developed the transportation problem under an intuitionistic fuzzy environment. Singh [37] et. al made a new approach to solving the intuitionistic fuzzy transportation problem of type-2. Malihe Niksirat made a new approach for intuitionistic fuzzy hub location problems [26]. Muhammad Gulzar [27] et al. developed a unique use of complex intuitionistic fuzzy sets in group theory. Malik [28] et.al have introduced a goal programming technique for solving fully interval-valued intuitionistic fuzzy multi-objective transportation problems. Hussain [31] et. al had approached solving the intuitionistic fuzzy transportation problem. Ebrahimnejad [5] has made a new approach to solving the intuitionistic fuzzy transportation problem. An intuitionistic fuzzy transportation problem using a zero-suffix algorithm used by Nagoor Gani [6] et.al.

In 1999, Smarandache [14] introduced the neutrosophic set. He proved the degree of indeterminacy as an independent component. Single-valued trapezoidal neutrosophic numbers are the solution to the transportation problem have been suggested by Rajesh Kumar [29]. In 2010, the concept of a single-valued neutrosophic set was introduced by Wang [18]. Using the mean and complete contingency cost table, Sikkannanl and Shanmugavel [21] presented a novel approach to the optimization of the neutrosophic fuzzy transportation problem. Using artificial neural networks and a trapezoidal neutrosophic fuzzy analytic hierarchy method was discussed by Akash Singh[1]et. al.

Ashok Kumar [3] et al. presented a solution to the transportation problem in a neutrosophic setting. By altering mathematical assumptions. Singh [2] et.al proposed a new strategy for solving the neutrosophic transit problem. Rajesh Kumar Saini [30] addressed the use of single-valued trapezoidal neutrosophic numbers in transportation difficulties. Deli [13] et al introduced a novel ranking function for single-valued neutrosophic numbers and demonstrated its use in multi-attribute decision-making issues. Broumi [38, 39] et. al suggested a novel strategy to optimizing real-world transportation problems in a neutrosophic setting. Binoy Krishna [9] addressed the neutrosophic multi-objective green four-dimensional fixed-charge transportation problem and discussed the applications of single-valued trapezoidal neutrosophic numbers in transportation problems in 2020 and also, they made a novel approach by using inter-valued trapezoidal neutrosophic numbers in transportation problems in 2022.

Motivation of the work

Moreover, there are a lot of complicated and unclear things in the real world that neither standard crisp sets nor even fuzzy sets can fully describe. Neutrosophic fuzzy numbers make it easier to model and study these kinds of things because they are more flexible and creative. Motivated by this, the neutrosophic fuzzy numbers can be used as a parameter in the fuzzy transportation problem lies, which provides a more comprehensive and flexible framework for representing and reasoning with uncertainty, ambiguity, and indeterminacy.

Novelty of the work

By expressing each parameter as a neutrosophic fuzzy number and applying the suitable score function that provides a quantitative measure of the degree of truth, falsity, or indeterminacy associated with an element's membership in a set. When compared with the existing methods, most of the authors found only the initial solution and neglected the optimality, but in this paper, the optimality is verified and also the obtained optimal solution shows the advantages of the proposed method over existing methods.

The structure of this paper is as follows: Sections 2 provide the basic terminology of fuzzy set and neutrosophic set, a mathematical formulation of the neutrosophic transportation problems and its basics theorems are discussed in section 3. Section 4 illustrates the proposed approach to solve the problem of the form in section 3. In section 5, numerical examples and their comparative study of the considered numerical examples are discussed. Finally, a conclusion is drawn from the comparison of solutions.

2. Preliminaries:

In this section, several concepts related to fuzzy set, neutrosophic set, and their arithmetic operations are discussed.

Definition: 2.1.

If X is a universe of discourse and x be any particular element of X , then a fuzzy set \tilde{F} defined on x written as a collection of ordered pairs $\tilde{F} = \{(x, \mu_{\tilde{F}}(x)); x \in X\}$, where each pair $(x, \mu_{\tilde{F}}(x))$.

Definition: 2.2.

A fuzzy set \tilde{F} is said to be a fuzzy number if its membership function has the following characteristics:

- \tilde{F} must be a normal fuzzy set (i.e.) $\mu_{\tilde{F}}(K) = 1$ where $K \in \mathbb{R}$.
- \tilde{F} must be a convex fuzzy set. For every $K_1, K_2 \in \mathbb{R}$ such that $\mu_{\tilde{F}}(\lambda K_1 + (1-\lambda)K_2) \geq \min(\mu_{\tilde{F}}(K_1), \mu_{\tilde{F}}(K_2))$ where $\lambda \in [0, 1]$.
- $\mu_{\tilde{F}}(K)$ must be piece-wise continuous (i.e.) $\mu_{\tilde{F}}(K) > 0$.

Definition: 2.3.

A fuzzy number $\tilde{K} = (s, t, u, v)$, where $s \leq t \leq u \leq v$ is said to be a trapezoidal fuzzy number, if its membership function is given by,

$$\mu_{\tilde{K}}(x) = \begin{cases} 0, & x < s \\ \frac{x-s}{t-s}, & s < x < t \\ 1, & t < x < u \\ \frac{v-x}{v-u}, & u \leq x < v \\ 0, & x > v \end{cases}$$

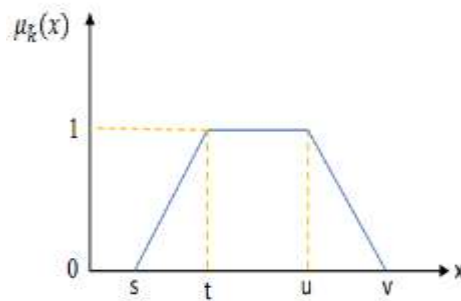


Figure 1: Graphical Representation of Trapezoidal Fuzzy Number

Definition: 2.4.

An intuitionistic fuzzy set is the set where the universe set x in X , \tilde{M}^I is defined as

$$\left\{ \left(x, \theta_{\tilde{M}^I}(x), \lambda_{\tilde{M}^I}(x) \right) \mid x \in X, 0 \leq \theta_{\tilde{M}^I}(x) \leq 1, 0 \leq \lambda_{\tilde{M}^I}(x) \leq 1 \right\}$$

here, $\theta_{\tilde{M}^I}(x)$ and $\lambda_{\tilde{M}^I}(x)$ indicate the degree of membership and non-membership of x in \tilde{M}^I . Such that $\theta_{\tilde{M}^I}(x) + \lambda_{\tilde{M}^I}(x) \leq 1$.

Definition: 2.5.

An intuitionistic fuzzy set \tilde{M}^I is said to be a intuitionistic fuzzy number if it has the following characteristics

- $\text{Supp } \tilde{M}^I$ must be bounded.
- \tilde{M}^I must be normal.
- \tilde{M}^I must be convex.

Definition: 2.6.

An intuitionistic trapezoidal fuzzy number $\tilde{M}^I = (m_1, m_2, m_3, m_4; m'_1, m'_2, m'_3, m'_4)$ where

$m'_1 \leq m_1 \leq m'_2 \leq m_2 \leq m_3 \leq m'_3 \leq m_4 \leq m'_4$, whose membership and non-membership is defined as

$$\theta_{\tilde{M}^I}(x) = \begin{cases} \frac{x - m_1}{m_2 - m_1}, & m_1 < x \leq m_2 \\ 1, & m_2 < x \leq m_3 \\ \frac{m_4 - x}{m_4 - m_3}, & m_3 < x \leq m_4 \\ 0, & \text{otherwise} \end{cases}, \quad \lambda_{\tilde{M}^I}(x) = \begin{cases} \frac{m'_1 - x}{m'_2 - m'_1}, & m'_1 < x \leq m'_2 \\ 0, & m'_2 < x \leq m'_3 \\ \frac{x - m'_3}{m'_4 - m'_3}, & m'_3 < x \leq m'_4 \\ 1, & \text{otherwise} \end{cases}$$

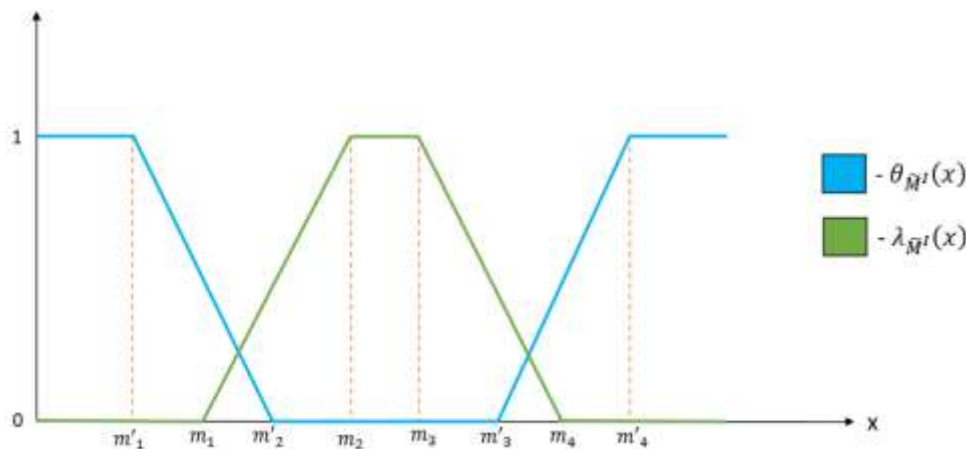


Figure 2: Graphical representation of intuitionistic trapezoidal fuzzy number

Definition:2.7.

Let $u \in U$ where U is a space of points and u is the generic element of U . A neutrosophic set N is defined as

$$N = \left\{ \left\langle u : \alpha_N(u), \beta_N(u), \gamma_N(u) \right\rangle, u \in U \right\}$$

here α_N is the truth-membership function, β_N is an indeterminacy- membership function and γ_N is a falsity-membership function .Such that the function $\alpha, \beta, \gamma : U \rightarrow]^{-0, 1^+}$ has the condition

$$^{-0 \leq \alpha_N(u) + \beta_N(u) + \gamma_N(u) \leq 3^+.$$

Definition: 2.8.

A neutrosophic fuzzy set N is said to be a neutrosophic fuzzy number if $0 \leq T + I + F \leq 3$ which is defined as $N = (T, I, F)$.

Definition:2.9.

A trapezoidal neutrosophic fuzzy number is the set of real numbers defined as $\tilde{y} = \left\langle (y_1, y_2, y_3, y_4); \alpha_{\tilde{y}}, \beta_{\tilde{y}}, \gamma_{\tilde{y}} \right\rangle$ where

$\alpha_{\tilde{y}}, \beta_{\tilde{y}}, \gamma_{\tilde{y}} \in [0, 1]$ and $y_1, y_2, y_3, y_4 \in \mathbb{R}$ with the condition $y_1 \leq y_2 \leq y_3 \leq y_4$..

$$\mu_{\tilde{y}}(v) = \begin{cases} \frac{(v - y_1)\alpha_{\tilde{y}}}{y_2 - y_1}, & y_1 \leq v \leq y_2 \\ \alpha_{\tilde{y}}, & y_2 \leq v \leq y_3 \\ \frac{(y_4 - v)\alpha_{\tilde{y}}}{y_4 - y_3}, & y_3 \leq v \leq y_4 \\ 0, & \text{otherwise} \end{cases}, \theta_{\tilde{y}}(v) = \begin{cases} \frac{y_2 - v + (v - y_1)\beta_{\tilde{y}}}{y_2 - y_1}, & y_1 \leq v \leq y_2 \\ \beta_{\tilde{y}}, & y_2 \leq v \leq y_3 \\ \frac{v - y_3 + (y_4 - v)\beta_{\tilde{y}}}{y_4 - y_3}, & y_3 \leq v \leq y_4 \\ 1, & \text{otherwise} \end{cases},$$

$$\lambda_{\tilde{y}}(v) = \begin{cases} \frac{y_2 - v + (v - y_1)\gamma_{\tilde{y}}}{y_2 - y_1}, & y_1 \leq v \leq y_2 \\ \gamma_{\tilde{y}}, & y_2 \leq v \leq y_3 \\ \frac{v - y_3 + (y_4 - v)\gamma_{\tilde{y}}}{y_4 - y_3}, & y_3 \leq v \leq y_4 \\ 1, & \text{otherwise} \end{cases}$$

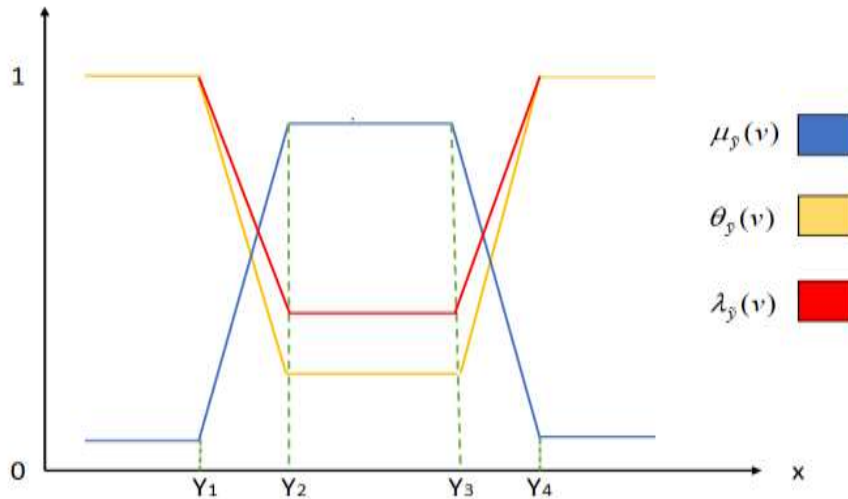


Figure 3: Graphical representation of trapezoidal neutrosophic fuzzy number

Definition:2.10.

For neutrosophic trapezoidal fuzzy number $\tilde{Y} = \langle (y_a, y_b, y_c, y_d); \alpha_{\tilde{y}}, \beta_{\tilde{y}}, \gamma_{\tilde{y}} \rangle$, its ranking function is defined by

$$R(\tilde{y}) \text{ as follows: } R(\tilde{y}) = \left(\frac{y_a + y_b + y_c + y_d}{4} \right) \times \left(\frac{2 + \alpha_{\tilde{y}} - \beta_{\tilde{y}} - \gamma_{\tilde{y}}}{3} \right). \text{ -----(*)}$$

3. Mathematical formulation of neutrosophic transportation problem:

Let there be p number of sources and q number of destinations then the neutrosophic transportation problem represented mathematically as follows:-

$$\min z = \sum_{i=1}^p \sum_{j=1}^q \tilde{c}_{ij}^N d_{ij}$$

Subject to $\sum_{j=1}^q d_{ij} = \tilde{K}_i^N$ for all $i = 1, 2, 3, \dots, p$

$$\sum_{i=1}^p d_{ij} = \tilde{L}^N \text{ for all } j = 1, 2, 3, \dots, q, \text{ for all } d_{ij} \geq 0.$$

Theorem 3.1.1:

The condition $\sum_{i=1}^u s_i = \sum_{j=1}^v t_j$ (i.e. total supply = total demand) is both necessary and sufficient condition for the existence of the feasible solution of transportation problem:-

$$\min z = \sum_{i=1}^u \sum_{j=1}^v e_{ij} f_{ij}$$

Subject to

$$\sum_{j=1}^v f_{ij} = t_i, \quad i = 1, 2, 3, \dots, u$$

$$\sum_{i=1}^u f_{ij} = s_j, \quad j = 1, 2, 3, \dots, v, \quad \forall f_{ij} \geq 0.$$

This can be put in the following way: if all the sources are empty and all the destinations are full, If $\sum s_i = \sum t_j$ then a feasible solution to the transportation problem is exists.

Proof:

Necessary condition:

Suppose there exist a feasible solution $f_{ij} = f'_{ij}$ to the transportation problem

$$t_i = \sum_{j=1}^v f'_{ij}$$

$$\Rightarrow \sum_{i=1}^u t_i = \sum_{i=1}^u \sum_{j=1}^v f'_{ij} = \sum_{j=1}^v \sum_{i=1}^u f'_{ij} = \sum_{j=1}^v s_j$$

This proves the results.

The sufficient condition:

Let $\sum_{i=1}^u s_i = \sum_{j=1}^v t_j$ and $f_{ij} = k_i s_j$ where k_i is the proportionality factor for the i^{th} source. Since the supply must be completely distributed.

$$\sum_{i=1}^u f_{ij} = k_i \sum_{j=1}^v s_j$$

$$f_{ij} = k_i s_j = \frac{t_i}{\sum_{j=1}^v s_j} s_j$$

$$\sum_{i=1}^v f_{ij} = k_i \sum_{j=1}^v s_j = \frac{t_i}{\sum_{j=1}^v s_j} \sum_{j=1}^v s_j = t_i$$

$$\sum_{i=1}^u f_{ij} = \frac{s_j}{\sum_{i=1}^u t_i} \sum_{i=1}^u t_i = s_j$$

Similarly , Moreover $x_{ij} \geq 0$, since $t_i \geq 0, s_j \geq 0$ for all i, j .

This proves that all the constrains are satisfied. Hence a feasible solution of transportation problem exist.

Theorem 3.1.2:

The transportation problem remains unchanged with respect to the optimal solution if all the elements of the cost matrix are increased or decreased by the same amount.

Theorem 3.1.3:

The transportation problem remains unchanged with respect to the optimal solution if the elements in any particular row or column of the cost matrix are increased or decreased by the same amount.

Theorem 3.1.4:

In the balanced transportation problem

$$\min z = \sum_{i=1}^u \sum_{j=1}^v g_{ij} f_{ij}$$

subject to the constraints

$$\sum_{j=1}^v f_{ij} = s_i, \quad i = 1, 2, 3, \dots, u$$

$$\sum_{i=1}^u f_{ij} = t_j, \quad j = 1, 2, 3, \dots, v$$

$$f_{ij} \geq 0 \quad \text{and} \quad \sum_{i=1}^u s_i = \sum_{j=1}^v t_j$$

the number of non-degenerate basic feasible solutions almost $m+n-1$.

4. Proposed Algorithm:

Step 1: Convert the given neutrosophic trapezoidal number into crisp number by using the ranking function (*).

Step 2: Now check whether the obtained crisp transportation table is balanced or unbalanced.

Step 3: If it is unbalanced then add a dummy row or column to the obtained transportation table to make it balanced.

Step 4: Take the least minimum value in each row and subtract it with the next minimum value. similarly do for each column.

Step 5: Select the maximum value from the values obtained by the previous step. Then choose the minimum value of the respective row or column.

Step 6: Select the minimum value among the demand and supply and allocate it to the chosen value.

Step 7: Follow the step 4 - 6 till all the demands and supplies are equalized.

Step 8: Check whether the solved problem is degenerate or non-degenerate. If it is degenerate, then proceed the problem. If it is non-degenerate, then make a dummy allocation to the table and make it degenerate.

Step 9: Find u_i and v_j for the rows and columns. Assign the values for $u_i = 0$ or $v_j = 0$ which represents the maximum number of allocations in a row or column respectively.

Step 10: Using the formula $c_{ij} = u_i + v_j$ get the other u_i 's and v_j 's for each occupied cells.

Step 11: Calculate d_{ij} as $c_{ij} - (u_i + v_j)$ for all empty cells and verify the sign of d_{ij} .

Step 12: The present basic feasible solution is optimum and this operation should be stopped if all $d_{ij} > 0$.

Step 13: If any one of $d_{ij} = 0$ an alternative solution exists, with a different set of allocations but the same transportation cost. Now, end this procedure.

Step 14: If any of $d_{ij} < 0$, then the given solution is not optimum and may be improved.

Step 15: Choose the unoccupied cell with the largest negative value and include it in the next solution.

Step 16: Draw a closed loop starting from the unoccupied cell that was selected in the previous step.

Step 17: The path should only have right-angle turns at occupied cells or at the original unoccupied cell. Mark each corner with a (+) or (-) sign alternatively, starting from the original unoccupied cell.

Step 18: From all the cells marked with a (-) sign in the path, choose the one with the minimum value.

Step 19: Assign this minimum value to the selected unoccupied cell to make it occupied.

Step 20: Add this minimum value to all the occupied cells marked with a (+) sign.

Step 21: Subtract this minimum value from all the occupied cells marked with a (-) sign.

Step 22: Repeat Steps 9 to 21 until an optimal solution is obtained.

Step 23: The procedure stops when all unoccupied cells have a value of $d_{ij} \geq 0$.

5. Numerical Example:

Example 5.1:

A numerical example discussed in [21] is solved using the proposed algorithm.

Table 5.1.1. Initial raw data of neutrosophic trapezoidal number

	A	B	C	D	Supply
X	(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	(22,26,28,32); 0.7,0.3,0.4
Y	(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	(17,22,27,31); 0.6,0.4,0.5
Z	(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	(21,28,32,37); 0.8,0.2,0.4
Demand	(13,16,18,21); 0.5,0.5,0.6	(17,21,24,28); 0.8,0.2,0.4	(24,29,32,35); 0.9,0.5,0.3	(6,10,13,15); 0.7,0.3,0.4	

Step1: Using the proposed ranking function (*) the neutrosophic trapezoidal numbers are converted into crisp numbers it shows in the following table:

Table 5.1.2. Converted crisp number

	A	B	C	D	Supply
X	3	3	10	13	18
Y	2	5	7	6	14

Z	7	2	2	4	22
Demand	8	16	21	7	

By using the step 3 to step 7 we obtained the following tables: Final allocated table for proposed method:

Table 5.1.3. Allocated value

	A	B	C	D	Dummy	Supply
X	3	3 (16)	10	13	0 (2)	18
Y	2 (8)	5	7	6 (6)	0	14
Z	7	2	2 (21)	4 (1)	0	22
Demand	8	16	21	7	2	

Total initial transportation cost = $(3 \times 16) + (2 \times 8) + (0 \times 2) + (6 \times 6) + (2 \times 21) + (4 \times 1) = 146$

The obtained solution is degenerate solution.

Now, for finding the optimal value by using step-9 to step-21.

Table 5.1.4. Optimal Value

	A	B	C	D	Dummy	Supply
X	3 (d)	3 (16)	10	13	0 (2)	18
Y	2 (8)	5	7	6 (6)	0	14
Z	7	2 (d)	2 (21)	4 (1)	0	22
Demand	8	16	21	7	2	

The optimal solution = $(3 \times 16) + (2 \times 8) + (0 \times 2) + (6 \times 6) + (2 \times 21) + (4 \times 1) = 146$.

By using our proposed method, the optimal cost for the given transportation is same as the initial cost.

EXAMPLE 5.2:

A numerical example discussed in [29] is solved using the proposed algorithm.

Table 5.2.1. Initial raw data of neutrosophic trapezoidal number

	A	B	C	Supply
X	(28,25,22,21.5); 0.7,0.4,0.3	(19,15,11,15); 0.6,0.4,0.2	(19.5,15,10,14); 0.5,0.4,0.3	(34,24,16,28); 0.7,0.4,0.2

Y	(21,16,12,16.5); 0.6,0.3,0.2	(10,9,7,7.5); 0.6,0.3,0.2	(16,14,12,11); 0.7,0.4,0.3	(35,28,22,25); 0.7,0.3,0.3
Z	(28,25,22,21); 0.8,0.4,0.3	(17,15,11,14); 0.6,0.4,0.2	(20,15,12,14); 0.7,0.3,0.2	(39,34,31,30); 0.6,0.3,0.2
Demand	(35,29,19,28); 0.7,0.4,0.3	(33,28,24,23); 0.7,0.4,0.2	(33,30,27,25); 0.7,0.4,0.3	

Step1: Using the proposed ranking function (*) the neutrosophic trapezoidal numbers are converted into crisp numbers it shows in the following table:

Table 5.2.1. Converted crisp number

	A	B	C	Supply
X	16	10	7	18
Y	11	6	9	19
Z	17	10	11	23
Demand	19	19	19	

By using the step 3 to step 7 we obtained the following tables, Final allocated table for proposed method:

Table 5.2.3. Optimal Value

	A	B	C	Dummy	Supply
X	16	10	7 (18)	0	18
Y	11 (19)	6	9	0	19
Z	17	10 (19)	11 (1)	0 (3)	23
Demand	19	19	19	3	

The total cost = $(7 \times 18) + (11 \times 19) + (10 \times 19) + (11 \times 1) + (0 \times 3) = 536$.

The obtained solution is degenerate solution. Now, for finding the optimal value by using step-9 to step-21.

	A	B	C	Dummy	Supply
X	16	10	7 (18)	0	18
Y	11 (19)	6 (d)	9	0	19
Z	17	10 (19)	11 (1)	0 (3)	23
Demand	19	19	19	3	

The optimal solution = $(7 \times 18) + (11 \times 19) + (10 \times 19) + (11 \times 1) + (0 \times 3) = 536$. By using our proposed method, the optimal cost for the given transportation is same as the initial cost.

Comparative Study: 5.3.1.

In many case, despite of several ranking methods, no-one can reliably rank the neutrosophic numbers with human intuition. Here, in order to solve the problems, we pointed out the shortcomings and we presented a simple method for ranking a trapezoidal neutrosophic numbers. And our proposed method shows the efficiency to solve a neutrosophic transportation problems by converting the given neutrosophic transportation problems into crisp equivalent problem and also using our proposed method its reduce the transportation cost comparing some other’s existing methods. In table (5.3.1) shows the efficiency of the proposed method comparing some other’s method.

Table 5.3.1 Comparative table

Methods	Cost
Least cost method	154
North-west corner method	194
South-west corner method	359
Existing method	269
Proposed method	146
Optimal value	146

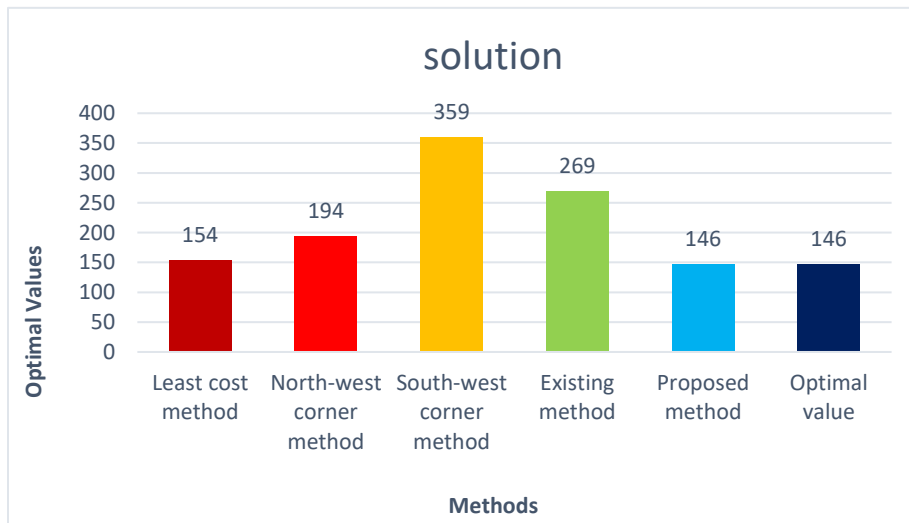


Figure 4: Comparison chart of the optimal value of the proposed method-1

Example 5.2:

Methods	Cost
Least cost method	574
North-west corner method	626
South-west corner method	594
Proposed method	536
Optimal value	536

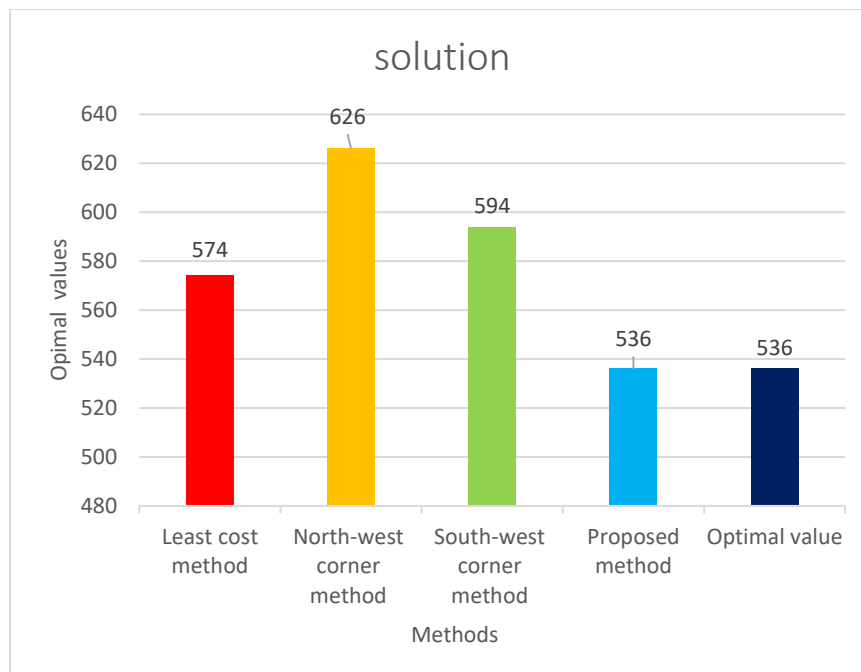


Figure 5: Comparison chart of the optimal value of the proposed method-2

6. Conclusion:

In this paper we solved the transportation problem under trapezoidal neutrosophic environment. We proposed a new ranking function for converting the neutrosophic trapezoidal fuzzy number into crisp numbers. Then we solved the converted crisp transportation problem and obtained the optimal solution by using the proposed method. Finally, we compared the proposed method solution with other existing methods solutions which shows the novelty of the paper.

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