IJARCCE ISSN (O) 2278-1021, ISSN (P) 2319-5940

International Journal of Advanced Research in Computer and Communication Engineering

Impact Factor 8.471 ⁙ Peer-reviewed & Refereed journal ⁙ Vol. 15, Issue 3, March 2026

DOI: 10.17148/IJARCCE.2026.153153

A Solid Transportation Problems under a Picture Fuzzy Environment

PARMPREET KAUR

Assistant Professor in PG Department of Mathematics, GSSDGS Khalsa College, Patiala-147001, Punjab, India
email: parmpreetsidhu@gmail.com

Abstract: In real-world shipping, companies often use different modes of transport like trucks, trains, or planes, to move goods from factories to markets which is called a Solid Transportation Problem. However, real shipping data like costs, supplies and demands are rarely exact because of changing market conditions. Mostly in many decision-making problems uncertainty, hesitation and refusal information cannot be effectively represented by classical fuzzy models. To solve this problem, the concept of Picture Fuzzy Sets (PFS) has been used. This approach includes positive, neutral, and negative membership degrees, creating a much better and more complete framework for managing real-world data uncertainty. In this paper a new model is introduced to solve Solid Transportation Problem under a Picture Fuzzy Environment. Here, all costs, supplies and demands are written as Picture Fuzzy Numbers to handle real-world uncertainty perfectly. In this model, a standard score function is used to change the fuzzy numbers into crisp numbers. A numerical example is provided to demonstrate the applicability, effectiveness and computational efficient of proposed method.

Keywords: Picture Fuzzy Sets, Solid Transportation Problems, Score Function

1. INTRODUCTION

The classical Transportation Problem (TP), originally introduced by Hitchcock [14], focuses primarily on minimizing the cost of moving commodities from sources to destinations. However, real-world logistics often demand a more comprehensive framework. To address this, Haley [13] introduced the Solid Transportation Problem (STP) by incorporating a critical third dimension: the mode of conveyance (such as trucks, trains, or flights). STP is much closer to real-world logistics because business rarely rely on just one type of vehicle. But in real life, shipping costs and market demands change constantly due to weather, fuel prices, or incomplete information. To deal with this vagueness, Zadeh [24] introduced Fuzzy Sets, which used a "membership degree" to handle uncertainty. This approach is powerful because it doesn't need years of past data; instead, it allows decision-makers to use their own professional judgment to create an effective delivery plan even when the future is uncertain.

Zimmermann [25] supported for the use of fuzzy numbers to provide a range of flexibility to the decision-maker. Oheigeartaigh [22] proposed an algorithm to find the crisp optimal solution for fuzzy transportation problems where availability and demand are represented by triangular fuzzy numbers. Chanas et al. [4] presented a fuzzy linear programming model to find the crisp optimal solution for problems with crisp cost coefficients but fuzzy availability and demand. Atanassov [2] extended basic fuzzy logic into Intuitionistic Fuzzy Sets (IFS), introducing a non-membership value alongside the standard membership value. Many researchers successfully applied IFS to solid transportation problems to capture both the optimistic and pessimistic estimates of logistics costs. Bit et al. [3] later formulated fuzzy multi-objective optimization methods specifically tailored for the solid transportation problem, demonstrating how to balance total cost against delivery times under vague conditions. Chanas and Kuchta [5] to introduce fuzzy integer values into transportation costs, creating the foundational Fuzzy Transportation Problem (FTP).

Jimenez and Verdegay [16] developed a genetic algorithm-based solution for parametric solid transportation problems where parameters are represented by trapezoidal fuzzy numbers. Gani and Samuel [10] proposed an algorithm for finding the fuzzy initial basic feasible solution where costs, availabilities and demands are all represented by triangular fuzzy numbers. Li et al. [18] proposed a method based on goal programming to find a crisp optimal solution for fuzzy transportation problems. Kumar and Kaur [17] introduced a new method for solving fuzzy transportation problems using

International Journal of Advanced Research in Computer and Communication Engineering
Impact Factor 8.471 ⩽ Peer-reviewed & Refereed journal ⩽ Vol. 15, Issue 3, March 2026
DOI: 10.17148/IJARCCE.2026.153153

the ranking function approach, specifically focusing on the use of generalized trapezoidal fuzzy numbers to find the optimal cost. Ebrahimnejad [7] developed a simplified approach to solve fuzzy transportation problems where all parameters are fuzzy numbers, emphasizing the use of the complementary slackness theorem to ensure optimality. Gani and Abbas [8, 9] suggested a new technique to obtain optimal solution of transportation problems in intuitionistic fuzzy environment. While IFS was a big improvement, it still could not handle situations where experts were neutral or simply refused to provide an answer. To solve this problem, Cuong [6] introduced Picture Fuzzy Sets (PFS). Picture Fuzzy sets is employed which incorporates positive membership, neutral and negative membership degrees, providing more comprehensive frame work for handling uncertainty. Singh and Yadav [23] proposed a new method for solving fully fuzzy linear programming problems, which provided a foundation for handling transportation models where the decision variables are treated as fuzzy. Aggarwal and Gupta [1] developed advanced ranking structures using signed distance methods to solve solid transportation networks where costs were bounded by both membership and non-membership fields. Mahmoodirad et al. [20] studied the existing shortcomings and proposed a method to handle transportation problems involving intuitionistic fuzzy numbers. Geetha and Selvakumari [12] solved picture fuzzy transportation problems and obtained minimum transportation cost. Mahmood et al. [19] advanced the field by introducing Picture Fuzzy Sets (PFS), which expanded the standard model to include degrees of "neutrality" and "refusal," making it highly applicable to modern, complex logistics. Mehmood and Bashir [21] proposed a technique to solve fully picture fuzzy transportation problems by using a ranking function.

The rest of the paper is organized as follows: Section 2 reviews Preliminaries. Section 3 describes the formulation of Picture Fuzzy Solid Transportation Problem. In Section 4, a new method is proposed to solve Picture Fuzzy Solid Transportation Problem by using score function. Section 5 demonstrates the superiority of this proposed method through a numerical example. Finally, a concrete conclusion has been given in Section 6.

2. PRELIMINARIES

In this section, some basic definitions of Picture Fuzzy Sets, its Arithmetic Operations and Score Function is presented.

2.1 Picture Fuzzy Sets [15]: A Picture Fuzzy Set (PFS) $\widetilde{P_f}$ on a universe of discourse X is an object of the form $\widetilde{P_f} = \{(x, \mu_P(x),\ \eta_P(x),\ \nu_P(x))\ ; x \in X\}$ where $\mu_P(x) : X \longrightarrow [0,1]$, $\eta_P(x) : X \longrightarrow [0,1]$ and $\nu_P(x) : X \longrightarrow [0,1]$ is the degree of positive membership, degree of neutral membership and degree of negative membership respectively. Also $0 \leq \mu_P(x) + \eta_P(x) + +\nu_P(x) \leq 1\ \forall x \in X$. Furthermore, degree of refusal membership is denoted as $\pi_P(x) = 1 - \mu_P(x) - \eta_P(x) - \nu_P(x)$.

The pair $(\mu_P(x),\ \eta_P(x),\ \nu_P(x))$ is named as Picture Fuzzy Number (PFN).

2.11 Arithmetic Operation on Picture Fuzzy Numbers [15]

Let $\tilde{\alpha}_1 = (\mu_1,\ \eta_1, \nu_1)$ and $\tilde{\alpha}_2 = (\mu_2,\ \eta_2, \nu_2)$ be two PFNs. Then the basic addition and scalar multiplication are defined as :

(i) Addition: $\tilde{\alpha}_1 \oplus \tilde{\alpha}_2 = (\mu_1 + \mu_2 - \mu_1\mu_2\ ,\ \eta_1\eta_2\ ,\ \nu_1\nu_2)$

(ii) Scalar Multiplication: $\lambda\tilde{\alpha}_1 = \left(1 - (1-\mu_1)^\lambda\ ,\ \eta_1^\lambda\ , \nu_1^\lambda\ \right)$

2.12 Score Function [11]

Let $\tilde{\alpha} = (\mu,\ \eta,\ \nu)$ be a PFN. Then to compare and defuzzify PFNs, score function $S(\tilde{\alpha})$ [11] is used which maps the fuzzy number to a crisp one

$$S(\tilde{\alpha}) = \mu_\alpha - \nu_\alpha + \frac{1}{2}(\eta_\alpha) \quad \text{where} \quad S(\tilde{\alpha}) \in [-1, 1]$$

A higher score function indicates more efficient value of objective function.

IJARCCE ISSN (O) 2278-1021, ISSN (P) 2319-5940

International Journal of Advanced Research in Computer and Communication Engineering

Impact Factor 8.471 ⪤ Peer-reviewed & Refereed journal ⪤ Vol. 15, Issue 3, March 2026

DOI: 10.17148/IJARCCE.2026.153153

3. MATHEMATICAL FORMULATION OF PICTURE FUZZY SOLID TRANSPORTATION PROBLEM (PFSTP)

In this section, a novel mathematical model for the Solid Transportation Problem is formulated under a Picture Fuzzy environment. The primary objective of this model is to minimize the total transportation cost. In this model consider a three-dimensional layout consisting of sources, destinations and distinct modes of conveyance (such as trucks or trains). It is assumed that the availability (supply), requirements (demand) and conveyance carrying capacities are known exactly (crisp) but transportation costs are represented as Picture Fuzzy Numbers (PFNs).

Let x_{ijk} represent the quantity of goods distributed from the i^{th} source to j^{th} destination via k^{th} conveyance mode. The primary goal of this model is to minimize the total transportation cost under picture fuzzy uncertainty. The mathematical formulation of PFSTP is as follow:

Minimize $\tilde{Z} = \sum_{i=1}^{m} \sum_{j=1}^{n} \sum_{k=1}^{t} \tilde{c}_{ijk}\, x_{ijk}$

Subject to

$$\sum_{j=1}^{n} \sum_{k=1}^{t} x_{ijk} = a_i, \quad i = 1, 2, \dots, m$$

$$\sum_{i=1}^{m} \sum_{k=1}^{t} x_{ijk} = b_j, \quad j = 1, 2, \dots, n$$

$$\sum_{i=1}^{m} \sum_{j=1}^{n} x_{ijk} \le e_k, \quad k = 1, 2, \dots, t$$

$$x_{ijk} \ge 0$$

Where

$\tilde{c}_{ijk}$: The PFN representing the variable transportation cost from source i to destination j via conveyance k

a_i : The supply available at the i^{th} source.

b_j : The demand required at the j^{th} destination.

e_k : The amount of material transported by the k^{th} conveyance.

x_{ijk} : the number of unit to be transported from i^{th} source to j^{th} destination by means of the k^{th} conveyance.

4. PROPOSED METHOD

In this section a systematic procedure is developed to solve the Picture Fuzzy Solid Transportation Problem (PFSTP) by using a score function. The steps of the proposed method are as follows:

Step 1: Collect and arrange the input parameters of the network. Identify the source supplies (a_i), destination demands (b_j) and conveyance limits (e_k) as crisp values. Represent the unit shipping costs from the three-dimensional layout as Picture Fuzzy Numbers (PFNs) in the form (μ, η, ν). Then formulate the Picture Fuzzy Solid Transportation Problem (PFSTP) as defined in Section 3

DOI: 10.17148/IJARCCE.2026.153153

Step 2: Check whether the PFSTP is balanced or not.

(i) (a) First check total crisp supply is equal to total crisp demand

i.e., $\sum_{i=1}^{m} a_i = \sum_{j=1}^{n} b_j$

(b) Second, calculate the total carrying capacity of all your transport modes combined (e_k) . This total capacity must be greater than or equal to the total volume of goods being shipped

i.e. $\sum_{k=1}^{t} e_k \geq \sum_{i=1}^{m} a_i \; or \; (\sum_{j=1}^{n} b_j)$

then it is a balanced PFSTP and go to Step 3.

(ii) (a) If total crisp supply is not equal to total crisp demand then it is not a balanced PFSTP i.e., $\sum_{i=1}^{m} a_i \neq \sum_{j=1}^{n} b_j$ Then add a dummy source or destination to balance the problem and go to Step 3.

(b) If $\sum_{i=1}^{m} a_i = \sum_{j=1}^{n} b_j$ but $\sum_{k=1}^{t} e_k < \sum_{i=1}^{m} a_i \; or \; (\sum_{j=1}^{n} b_j)$ then add dummy conveyance to balance the problem and go to Step 3.

Step 3: To convert the picture fuzzy uncertainties into real-valued coefficients, apply a standard Picture Fuzzy Score Function [11] defined in subsection 2.12. After the defuzzification of all fuzzy transportation costs, the solid crisp transportation problem will be as follow:

Minimize Z $= \sum_{i=1}^{m} \sum_{j=1}^{n} \sum_{k=1}^{t} S(\tilde{c}_{ijk})\, x_{ijk}$

Subject to

$$\sum_{j=1}^{n} \sum_{k=1}^{t} x_{ijk} = a_i, \quad i = 1,2,\dots,m$$

$$\sum_{i=1}^{m} \sum_{k=1}^{t} x_{ijk} = b_j, \quad j = 1,2,\dots,n$$

$$\sum_{i=1}^{m} \sum_{j=1}^{n} x_{ijk} \leq e_k, \quad k = 1,2,\dots,t$$

$$x_{ijk} \geq 0$$

Step 4: **S**olve the above linear programming problem using the simplex method or software tools to find the optimal value of x_{ijk}^*

5. NUMERICAL EXAMPLE

In this section, a numerical example of a Picture Fuzzy Solid Transportation Problem is presented to demonstrate the applicability and efficiency of the proposed method. Consider an industrial supply chain consisting of three manufacturing sources (S_1, S_2, S_3), four regional distribution markets (D_1, D_2, D_3, D_4) and two available modes of conveyance (K_1 : Trucks), (K_2 : Trains). The goal is to minimize the transportation cost. The supply capacity of three sources are $a_1 = 30, a_2 = 40,\ a_3 = 30$. The demand requirements of four destinations are $b_1 = 20, b_2 = 25,\ b_3 = 35,\ b_4 = 20$ and the conveyance capacities are $e_1 = 60,\ e_2 = 50$. The data of unit picture fuzzy transportation cost is shown in the table below.

ISSN (O) 2278-1021, ISSN (P) 2319-5940
International Journal of Advanced Research in Computer and Communication Engineering
Impact Factor 8.471 ⁜ Peer-reviewed & Refereed journal ⁜ Vol. 15, Issue 3, March 2026
DOI: 10.17148/IJARCCE.2026.153153

		Transportation Mode (k)	Destinations D_1	D_2	D_3	D_4
Sources	S_1	K_1 : Trucks	$\tilde{\square}_{\square\square\square} = (0.5, 0.2, 0.2)$	$\tilde{\square}_{\square\square\square} = (0.6, 0.1, 0.1)$	$\tilde{\square}_{\square\square\square} = (0.4, 0.2, 0.3)$	$\tilde{\square}_{\square\square\square} = (0.7, 0.1, 0.2)$
		K_2 : Trains	$\tilde{\square}_{\square\square\square} = (0.6, 0.1, 0.3)$	$\tilde{\square}_{\square\square\square} = (0.4, 0.2, 0.2)$	$\tilde{\square}_{\square\square\square} = (0.5, 0.2, 0.1)$	$\tilde{\square}_{\square\square\square} = (0.3, 0.4, 0.3)$
	S_2	K_1 : Trucks	$\tilde{\square}_{\square\square\square} = (0.4, 0.3, 0.2)$	$\tilde{\square}_{\square\square\square} = (0.5, 0.2, 0.1)$	$\tilde{\square}_{\square\square\square} = (0.6, 0.1, 0.2)$	$\tilde{\square}_{\square\square\square} = (0.3, 0.2, 0.4)$
		K_2 : Trains	$\tilde{\square}_{\square\square\square} = (0.5, 0.2, 0.2)$	$\tilde{\square}_{\square\square\square} = (0.7, 0.1, 0.1)$	$\tilde{\square}_{\square\square\square} = (0.4, 0.2, 0.3)$	$\tilde{\square}_{\square\square\square} = (0.6, 0.1, 0.2)$
	S_3	K_1 : Trucks	$\tilde{\square}_{\square\square\square} = (0.7, 0.0, 0.1)$	$\tilde{\square}_{\square\square\square} = (0.4, 0.2, 0.2)$	$\tilde{\square}_{\square\square\square} = (0.5, 0.1, 0.3)$	$\tilde{\square}_{\square\square\square} = (0.6, 0.2, 0.1)$
		K_2 : Trains	$\tilde{\square}_{\square\square\square} = (0.3, 0.2, 0.4)$	$\tilde{\square}_{\square\square\square} = (0.5, 0.3, 0.1)$	$\tilde{\square}_{\square\square\square} = (0.6, 0.1, 0.2)$	$\tilde{\square}_{\square\square\square} = (0.4, 0.2, 0.2)$

Step 1: Formulate the PFSTP by using above data

$$\textbf{Minimize } \tilde{Z} = (0.5, 0.2, 0.2)x_{111} + (0.6, 0.1, 0.1)\,x_{121} + (0.4, 0.2, 0.3)x_{131} + (0.7, 0.1, 0.2)x_{141} + (0.4, 0.3, 0.2)x_{211} + (0.5, 0.2, 0.1)x_{221} + (0.6, 0.1, 0.2)x_{231} + (0.3, 0.2, 0.4)x_{241} + (0.7, 0.0, 0.1)x_{311} + (0.4,0.2,0.2)\,x_{321} + (0.5, 0.1, 0.3)x_{331} + (0.6, 0.2, 0.1)x_{341} + (0.6, 0.1, 0.3)x_{112} + (0.4, 0.2, 0.2)x_{122} + (0.5, 0.2, 0.1)x_{132} + (0.3, 0.4, 0.3)x_{142} + (0.5, 0.2, 0.2)x_{212} + (0.7, 0.1, 0.1)x_{222} + (0.4, 0.2, 0.3)x_{232} + (0.6, 0.1, 0.2)x_{242} + (0.3, 0.2, 0.4)x_{312} + (0.5, 0.3, 0.1)x_{322} + (0.6, 0.1, 0.2)x_{332} + (0.4, 0.2, 0.2)x_{342}$$

Subject to

$$x_{111} + x_{112} + x_{121} + x_{122} + x_{131} + x_{132} + x_{141} + x_{142} = 30,$$

$$x_{211} + x_{212} + x_{221} + x_{222} + x_{231} + x_{232} + x_{241} + x_{242} = 40,$$

$$x_{311} + x_{312} + x_{321} + x_{322} + x_{331} + x_{332} + x_{341} + x_{342} = 30,$$

$$x_{111} + x_{112} + x_{211} + x_{212} + x_{311} + x_{312} = 20,$$

International Journal of Advanced Research in Computer and Communication Engineering
Impact Factor 8.471 ⵋ Peer-reviewed & Refereed journal ⵋ Vol. 15, Issue 3, March 2026
DOI: 10.17148/IJARCCE.2026.153153

$x_{121}+x_{122}+x_{221}+x_{222}+x_{321}+x_{322}=25,$

$x_{131}+x_{132}+x_{231}+x_{232}+x_{331}+x_{332}=35,$

$x_{141}+x_{142}+x_{241}+x_{242}+x_{341}+x_{342}=20,$

$$\sum_{i=1}^{3}\sum_{j=1}^{4} x_{ij1} \leq 60$$

$$\sum_{i=1}^{3}\sum_{j=1}^{4} x_{ij2} \leq 50$$

$x_{ijk} \geq 0, \quad i=1,2,3 \;\&\; j=1,2,3,4 \;\&\; k=1,2$

Step 2: (a) Total crisp supply is equal to total crisp demand

i.e., $a_1+a_2+a_3=30+40+30=100$, $b_1+b_2+b_3+b_4=20+25+35+20=100$

(b) $\sum_{k=1}^{2} e_k > \sum_{i=1}^{m} a_i \text{ or } (\sum_{j=1}^{n} b_j) \implies 60+50>100$

then it is a balanced PFSTP.

Step 3: Use score function [11] to convert PFNs into crisp

Like $S(\widetilde{c_{111}})=S(0.5,0.2,0.2)=0.5-0.2+\frac{1}{2}(0.2)=0.40$

After using score function the solid transportation problem becomes as

Minimize $Z=0.40\,x_{111}+\mathbf{0.55}\,x_{121}+\mathbf{0.20}\,x_{131}+\mathbf{0.55}\,x_{141}+\mathbf{0.35}\,x_{211}+\mathbf{0.50}\,x_{221}+\mathbf{0.45}\,x_{231}+$

$\mathbf{0.0}\,x_{241}+\mathbf{0.60}\,x_{311}+0.30\,x_{321}+\mathbf{0.25}\,x_{331}+\mathbf{0.60}\,x_{341}+\mathbf{0.35}\,x_{112}+\mathbf{0.30}\,x_{122}+\mathbf{0.50}\,x_{132}+\mathbf{0.20}\,x_{142}$

$+\mathbf{0.40}\,x_{212}+\mathbf{0.65}\,x_{222}+\mathbf{0.20}\,x_{232}+\mathbf{0.45}\,x_{242}+\mathbf{0.0}\,x_{312}+\mathbf{0.55}\,x_{322}+\mathbf{0.45}\,x_{332}+\mathbf{0.30}\,x_{342}$

Subject to

$x_{111}+x_{112}+x_{121}+x_{122}+x_{131}+x_{132}+x_{141}+x_{142}=30,$

$x_{211}+x_{212}+x_{221}+x_{222}+x_{231}+x_{232}+x_{241}+x_{242}=40,$

$x_{311}+x_{312}+x_{321}+x_{322}+x_{331}+x_{332}+x_{341}+x_{342}=30,$

$x_{111}+x_{112}+x_{211}+x_{212}+x_{311}+x_{312}=20,$

$x_{121}+x_{122}+x_{221}+x_{222}+x_{321}+x_{322}=25,$

$x_{131}+x_{132}+x_{231}+x_{232}+x_{331}+x_{332}=35,$

$x_{141}+x_{142}+x_{241}+x_{242}+x_{341}+x_{342}=20,$

$$\sum_{i=1}^{3}\sum_{j=1}^{4} x_{ij1} \leq 60$$

$$\sum_{i=1}^{3}\sum_{j=1}^{4} x_{ij2} \leq 50$$

International Journal of Advanced Research in Computer and Communication Engineering
Impact Factor 8.471 ∺ Peer-reviewed & Refereed journal ∺ Vol. 15, Issue 3, March 2026
DOI: 10.17148/IJARCCE.2026.153153

$x_{ijk} \geq 0, \quad i = 1,2,3 \;\&\; j = 1,2,3,4 \;\&\; k = 1,2$

Step 4: Solve the above linear programming problem using the software tools like MATLAB or LINGO to find the optimal values

$x^*_{131} = 30, \quad x^*_{241} = 20, \quad x^*_{321} = 5, \quad x^*_{232} = 5, \; x^*_{212} = 15, \quad x^*_{312} = 5, \; x^*_{322} = 20,$

$x^*_{342} = 5$ and the minimum transportation cost Z^* = 21 units

6. CONCLUSION

In this paper, a Solid Transportation Problem (STP) has been successfully formulated and solved under a Picture Fuzzy environment. By incorporating a three-dimensional layout consisting of manufacturing sources, regional distribution markets, and distinct modes of conveyance—specifically Trucks and Trains—the model provides a highly realistic framework for modern supply chain networks. Using Picture Fuzzy Numbers (PFNs) allows to handle complex real-world uncertainty, including cases where expert information is positive, neutral, negative, or involves a refusal. To make the problem computationally trackable, a standard Score Function was applied to systematically defuzzify the complex picture fuzzy shipping costs into simple, deterministic crisp values. The efficiency and applicability of this method were validated through a numerical example. Ultimately, this framework serves as a highly practical and stable tool that helps supply chain managers find the cheapest shipping routes quickly and easily. In the future, this method can be expanded to handle shipping multiple different products at the same time.

REFERENCES

[1]. Aggarwal, S., and Gupta, C. (2016). Sensitivity analysis of solid transportation problem under intuitionistic fuzzy environment using signed distance ranking. *International Journal of Operational Research*, Vol. 27(4), pp. 499–521.
[2]. Atanassov, K.T. (1986). Intuitionistic fuzzy sets. *Fuzzy Sets and Systems*, Vol. 20(1), pp. 87–96.
[3]. Bit, A.K., Biswal, M.P. and Alam, S.S. (1992). Fuzzy programming approach to multicriteria solid transportation problem. *Fuzzy Sets and Systems*, Vol. 50(2), pp. 135–141.
[4]. Chanas, S., Kołodziejczyk, W. and Machaj, A. (1984). A fuzzy approach to the transportation problem. *Fuzzy Sets and Systems*, Vol. 13(3), pp. 211–221.
[5]. Chanas, S. and Kuchta, D. (1996). A concept of the optimal solution of the transportation problem with fuzzy cost coefficients. *Fuzzy Sets and Systems*, Vol. 82(3), pp. 299–305.
[6]. Cuong, B.C. (2014). Picture fuzzy sets. *Journal of Computer Science and Cybernetics*, 30(4), pp. 409–420.
[7]. Ebrahimnejad, A. (2012). A primal-dual method for solving linear programming problems with fuzzy cost coefficients based on linear ranking functions and its applications. *International Journal of Industrial and Systems Engineering*, Vol. 12(2), pp. 119–140.
[8]. Gani, A.N. and Abbas, S. (2013). A new method for solving intuitionistic fuzzy transportation problem. *Applied Mathematical Sciences*, Vol. 7(28), pp. 1357–1365.
[9]. Gani, A.N. and Abbas, S. (2014). Revised distribution method for intuitionistic fuzzy transportation problem. *International Journal of Fuzzy Mathematical Archive*, Vol. 4(2), pp. 96–103.
[10]. Gani, A.N. and Samuel, A.E. (2003). A new method for solving fuzzy transportation problems. *International Journal of Management and Systems*, Vol. 19(1), pp. 53–62.
[11]. Garg, H. (2023). Perfect score function in picture fuzzy set and its applications in decision-making problems. *Journal of Intelligent & Fuzzy Systems*, Vol. 44, pp. 2341-2358.
[12]. Geetha, S. and Selvakumari, K. (2020). Solving picture fuzzy transportation problem using a new ranking function. *International Journal of Analytical and Experimental Modal Analysis*, Vol. 12(11), pp. 346–355.
[13]. Haley, K. B. (1962). The solid transportation problem. *Operations Research*, Vol. 10(4), pp. 448–463.
[14]. Hitchcock, F. L. (1941). The distribution of a product from several sources to numerous localities. *Journal of Mathematics and Physics*, Vol. 20(1-4), pp. 224–230.
[15]. Jana, C. and Nunic, Z. (2024). Picture fuzzy linear programming problems. *Acadlore Transactions on Applied Mathematics and Statistics*, Vol. 2, pp. 22-31.
[16]. Jiménez, F. and Verdegay, J.L. (1998). Uncertain solid transportation problems with the application of genetic algorithms. *Journal of Information Sciences*, Vol. 105(1-4), pp. 139–159.

ISSN (O) 2278-1021, ISSN (P) 2319-5940

International Journal of Advanced Research in Computer and Communication Engineering

Impact Factor 8.471 ⋇ Peer-reviewed & Refereed journal ⋇ Vol. 15, Issue 3, March 2026

DOI: 10.17148/IJARCCE.2026.153153

[17]. Kumar, A. and Kaur, A. (2011). A new approach for solving fuzzy transportation problems using generalized trapezoidal fuzzy numbers. *Applied Soft Computing*, Vol. 11(4), pp. 3801–3811.

[18]. Li, L., Huang, Z., Da, Q. and Hu, J. (2011). A method based on goal programming for solving fuzzy multi-objective transportation problems. *Expert Systems with Applications*, Vol. 38(9), pp. 2108–12111.

[19]. Mahmood, T., Ali, Z., and Khan, Q. (2021). Picture fuzzy N-soft sets and their applications in decision-making problems. *Fuzzy Information and Engineering*, Vol. 13(3), pp. 335–367.

[20]. Mahmoodirad, A., Niroomand, S. and Dehghan, S. (2016). A new method for solving intuitionistic fuzzy transportation problems with shortcomings correction. *Journal of Intelligent & Fuzzy Systems*, Vol. 31(3), pp. 1951–1962.

[21]. Mehmood, A. and Bashir, Z. (2022). Methodology to solve fully picture fuzzy transportation problems using ranking function. *Journal of Computational and Cognitive Engineering*, Vol. 1(4), pp. 182–193.

[22]. Oheigeartaigh, M. (1982). A fuzzy transportation algorithm. *Fuzzy Sets and Systems*, Vol. 8(3), pp. 235–243.

[23]. Singh, S.K. and Yadav, S. P. (2015). A new approach for solving fully fuzzy linear programming problems. *Applied Soft Computing*, Vol 27, pp. 164–173.

[24]. Zadeh, L.A. (1965). Fuzzy sets. *Information and Control*, Vol. 8(3), pp. 338–353.

[25]. Zimmermann, H.J. (1978). Fuzzy programming and linear programming with several objective functions. *Fuzzy Sets and Systems*, Vol. 1(1), pp. 45–55.