A New Approach for Solving a Heptagonal Intuitionistic Fuzzy Transportation Problem by Using Proposed Method

N. Parveen¹, K. Prabu²*, V. Sangeetha³

Research scholar, PG and Research Department of Mathematics, Sun Arts and Science College, Keeranoor, Tiruvannamalai, Tamilnadu¹

Assistant Professor, PG and Research Department of Mathematics, Sun Arts and Science College, Keeranoor, Tiruvannamalai, Tamilnadu²,³

Abstract

In this paper, we approach the transportation problem whose supplies and demands are in intuitionistic fuzzy number. We formulate and utilize the heptagonal intuitionistic fuzzy number to deal with uncertainty. We discuss about the new ranking function for intuitionistic fuzzy number. Finally, we approach an algorithm for finding the optimal solution of heptagonal intuitionistic fuzzy transportation problem with relevant numerical example.

Keywords: Intuitionistic Fuzzy Number (IFN), Heptagonal Intuitionistic Fuzzy Number (HpIFN), Heptagonal Intuitionistic Fuzzy Transportation Problem (HpIFTP).

Mathematical Subject Classification: 90B06

1 INTRODUCTION

Fuzzy set theory was first introduced by L.A. Zadeh [1] in 1965. Fuzzy set is an extension of the classical set theory. Fuzzy set was handled by degree of membership. In real life, there is uncertainty in every situation. L. A. Zadeh introduced a methodology for fuzzy set theory which is very useful to decision maker for making correct decision in uncertain situation. The fuzzy set theory used in many areas like Linguistics, Decision making and Clustering etc.

The Transportation Problem (TP) is a special type of Linear Programming Problem (LPP) where the main objective is to minimize the cost of distribution (i.e.) minimize the cost of transportation of a product from a number of plants or sources or manufacturing to a number of destinations or warehouse. Because of its special structure the usual simplex method is not suitable for solving transportation problem. These problems require special method of solution. The Transportation Problem has two phase, first one is Initial Basic Feasible Solution (IBFS) and second one is Optimal Solution. The first phase can be obtained by many methods like North-West Corner Method (NWCM), Least Cost Method (LCM), Vogel’s Approximation Method (VAM) etc. The second phase is obtained by Stepping Stone Method (SSM), Modified Distribution (MODI), Method and Best Candidate Method (BCM) etc.

K. Attanssov a Bulgarian mathematician (1986) [2] pointed that it is better or more efficient to use intuitionistic fuzzy set other than the fuzzy set to deals with vagueness. The major advantage of intuitionistic fuzzy set is it gives the degree of membership value (acceptance) and degree of non-membership value (non-acceptance).

and P. S. Kumar (2012) [5] find out a new algorithmic approach for solving intuitionistic fuzzy transportation problem and also find out the initial basic feasible solution for IFTP. The transportation problem has at least one of the parameter (cost, demand, and supply) or all of the parameter in intuitionistic fuzzy number then the problem is called Intuitionistic Fuzzy Transportation Problem (IFTP).

In this paper, we introduced Heptagonal Intuitionistic Fuzzy Number (\(H_pIFN\)) in a particular way. The concept of heptagonal number with membership function value and representation and ranking of fuzzy number with Ambiguity index was investigated by K. Rathi and S. Balamohan (2014) [14]. Heptagonal Fuzzy Number (\(H_pFN\)) is very useful in characterize the linguistic parameter. Heptagonal fuzzy number has seven numbers which is very useful for uncertainty involved in transportation problem that can be characterized by \(H_pFN\). Many authors develop the uses of \(H_pFN\) in linear programming. Namarta and N. I. Thakur (2017) [12] introduced how to ranking the \(H_pFN\) using incentre of centroids. They layout algorithm for ranking of \(H_pFN\).

Recently new fuzzy number are formed and arithmetic operation are discussed by many authors. A. M. Shapique (2017) [16] discussed about the arithmetic operation on \(H_pFN\). Transportation problem gives more efficient when we use fuzzy parameters in transportation problem. Dr. A. S. Sudha and S. Karunambigai (2017) [13] solved a transportation problem using \(H_pFN\) by Russells method. A. Thomas and S. Jose (2019) [15] obtained a algorithm for \(H_pFN\) by Intuitionistic Fuzzy Transportation Problem using Vogel’s approximation Method and obtained initial basic feasible solution in \(H_pIFN\).

2 PRELIMINARIES

2.1 Crisp set

Let \(A\) be a set defined on the universal set \(X\) is said to be a crisp set which is defined by the characteristic function that assigns either a value of 0 or 1 to each element of the universe. Crisp set is also called as “classical set” or “ordinary set”.

2.2 Fuzzy Set

Let \(A\) be a set defined on the universal set \(X\) is said to be fuzzy set \(\tilde{A}\) then it can be written as a set of ordered pairs. (i.e.) \(\tilde{A} = \{ (x, \mu_{\tilde{A}}(x) : x \in X \} \).

Where \(\mu_{\tilde{A}}(x)\) is a membership function from \(X\) to \([0,1]\) and \(\mu_{\tilde{A}}(x) \in [0,1]\).

2.3 Normal Fuzzy Set

A fuzzy set \(\tilde{A}\) is said to be normal fuzzy set then there exist a element \(x \in X\) such that \(\mu_{\tilde{A}}(x) = 1\) (ie) the height of the fuzzy set is of value 1.

2.4 Support of Fuzzy set

The support of a fuzzy set \(\tilde{A}\) is a crisp set that contains all the element of \(X\) which have membership value strictly greater than zero.

\[ Sup(\tilde{A}) = \{ x : \mu_{\tilde{A}}(x) > 0, x \in X \} \]

2.5 Fuzzy Number

If a fuzzy set \(\tilde{A}\) which is defined on the universal set of real number \(R\) is said to be a Fuzzy Number (FN) then its membership function \(\mu_{\tilde{A}}(x)\) satisfies the following conditions

(i) There exist \(x \in R\) such that \(\mu_{\tilde{A}}(x) = 1\).

(ii) For all \(x, y \in R, \lambda \in [0,1]\) we have

\[ \mu_{\tilde{A}}(\lambda x + (1 - \lambda)y) \geq \min(\mu_{\tilde{A}}(x), \mu_{\tilde{A}}(y)) \]
\( \mu_A(x) \) is a piecewise continuous function.

(iii) For all \( \alpha \in [0,1] \), \( \alpha - cut \) of \( \tilde{A} \) is a closed interval.

2.6 Intuitionistic Fuzzy Set

A fuzzy set \( \tilde{A} \) defined on the universal set \( X \) is said to be Intuitionistic Fuzzy Set (IFS) then it can be written as a set of ordered triples

\[ \tilde{A}^l = \{ (x, \mu_A(x), V_A(x)) : x \in X \} \]

Where \( \mu_A(x) \) and \( V_A(x) \) are membership and non-membership function of \( x \in X \) in \( \tilde{A} \). \( \mu_A(x), V_A(x) : X \to [0,1] \) and \( 0 \leq \mu_A(x) + V_A(x) \leq 1, \forall x \in X \).

2.7 Intuitionistic Fuzzy Number

If a fuzzy set \( \tilde{A} \) which is defined on the universal set of real number \( R \) is said to be a Intuitionistic Fuzzy Number (IFN) then its membership and non-membership function satisfies the following condition

(i) There exist \( x \in R \) such that \( \mu_A(x) = 1, V_A(x) = 0 \).

(ii) For all \( x, y \in R, \lambda \in [0,1] \) we have

\[ \mu_A(x)(\lambda x + (1 - \lambda)y) \geq \min(\mu_A(x), \mu_A(y)), \]

\[ V_A(\lambda x + (1 - \lambda)y) \leq \max(V_A(x), V_A(y)) \]

(iii) \( \mu_A(x) \) and \( V_A(x) \) are piecewise continuous function.

(iv) For all \( \alpha \in [0,1] \), \( \alpha - cut \) of \( \tilde{A} \) is a closed interval.

\[ \mu_A(x) = \begin{cases} (l(x), x \in [p_1, p_2]) & \text{if } l(x) = 0, x = p_2 \\ (r(x), x \in [p_2, p_3]) & \text{if } r(x) \leq 0, x \leq p_2 \\ 0, & \text{Otherwise} \end{cases} \]

\[ V_A(x) = \begin{cases} (l'(x), x \in [p_1', p_2']) & \text{if } l'(x) = 0, x = p_2' \\ (r'(x), x \in [p_2', p_3']) & \text{if } r'(x) \leq 0, x \leq p_2' \\ 1, & \text{Otherwise} \end{cases} \]

Where \( l(x) \) and \( l'(x) \) are increasing and decreasing function in \([p_1, p_2]\) and \([p_1', p_2']\) respectively and \( r(x) \) and \( r'(x) \) are decreasing and increasing function in \([p_2, p_3]\) and \([p_2', p_3']\) respectively.

2.8 Heptagonal Fuzzy Number (\( H_pFN \))

A fuzzy number \( \tilde{H} \) is said to be a \( H_pFN \) then its membership function is defined by

\[ \mu_{\tilde{H}}(x) = \begin{cases} 0 & \text{if } x < p_1 \\ \frac{1}{2} \frac{x-p_1}{p_2-p_1} & \text{if } x \in [p_1, p_2] \\ \frac{1}{2} & \text{if } x \in [p_2, p_3] \\ \frac{1}{2} + \frac{1}{2} \frac{x-p_3}{p_4-p_3} & \text{if } x \in [p_3, p_4] \\ 1 & \text{if } x = p_4 \\ \frac{1}{2} + \frac{1}{2} \frac{p_5-x}{p_5-p_4} & \text{if } x \in [p_4, p_5] \\ \frac{1}{2} & \text{if } x \in [p_5, p_6] \\ \frac{1}{2} \frac{p_7-x}{p_7-p_6} & \text{if } x \in [p_6, p_7] \\ 0 & \text{if } x > p_7 \end{cases} \]
here \( p_1, p_2, p_3, p_4, p_5, p_6, p_7 \) are real numbers and satisfies the condition
\[
p_1 \leq p_2 \leq p_3 \leq p_4 \leq p_5 \leq p_6 \leq p_7.
\]
It is denoted by \( \tilde{H} = (p_1, p_2, p_3, p_4, p_5, p_6, p_7) \).

2.8.1 The graphical representation of \( H_{pFN} \)

![Graphical representation of \( H_{pFN} \)](image)

2.9 Heptagonal Intuitionistic Fuzzy Number (\( H_{pIFN} \))

An intuitionistic fuzzy number is said to be a \( H_{pIFN} \) then its membership and non-membership function is defined by

\[
\mu_{\tilde{H}}(x) = \begin{cases} 
0 & ; x < p_1 \\
\frac{1}{2} \left( \frac{x-p_1}{p_2-p_1} \right) & ; x \in [p_1, p_2] \\
\frac{1}{2} & ; x \in [p_2, p_3] \\
\frac{1}{2} + \frac{1}{2} \left( \frac{x-p_3}{p_4-p_3} \right) & ; x \in [p_3, p_4] \\
1 & ; x = p_4 \\
\frac{1}{2} + \frac{1}{2} \left( \frac{p_5-x}{p_5-p_4} \right) & ; x \in [p_4, p_5] \\
\frac{1}{2} & ; x \in [p_5, p_6] \\
\frac{1}{2} \left( \frac{p_6-x}{p_7-p_6} \right) & ; x \in [p_6, p_7] \\
0 & ; x > p_7 
\end{cases}
\]

and
\[V_H(x) = \begin{cases} 
1 & ; x < p_1' \\
1 - \frac{1}{2} \left( \frac{x-p_1'}{p_2'-p_1'} \right) & ; x \in [p_1', p_2'] \\
\frac{1}{2} & ; x \in [p_2', p_3'] \\
\frac{1}{2} \left( \frac{p_4-x}{p_4-p_3'} \right) & ; x \in [p_3', p_4] \\
0 & ; x = p_4 \\
\frac{1}{2} \left( \frac{x-p_4}{p_5'-p_4} \right) & ; x \in [p_4, p_5'] \\
\frac{1}{2} & ; x \in [p_5', p_6'] \\
\frac{1}{2} + \frac{1}{2} \left( \frac{x-p_6'}{p_7'-p_6'} \right) & ; x \in [p_6', p_7'] \\
1 & ; x > p_7' 
\end{cases} \]

Where \( p_i, p_i' (i = 1,2,3,4,5,6,7) \) are all real number and satisfies

\[p_1' \leq p_1 \leq p_2' \leq p_2 \leq p_3' \leq p_3 \leq p_4 \leq p_5 \leq p_5' \leq p_6 \leq p_6' \leq p_7 \leq p_7'.\]

It is denoted by

\[ \hat{H} = (p_1, p_2, p_3, p_4, p_5, p_6, p_7 ; p_1', p_2', p_3', p_4, p_5', p_6', p_7') \]

2.9.1 The graphical representation of \( H_{IFN} \)
3 ARITHMETIC OPERATIONS ON $H_p$IFN

Let $\bar{A} = (p_1, p_2, p_3, p_4, p_5, p_6, p_7; p_1', p_2', p_3', p_4, p_5, p_6', p_7')$ and $\bar{B} = (q_1, q_2, q_3, q_4, q_5, q_6, q_7; q_1', q_2', q_3', q_4, q_5', q_6', q_7')$ then the following arithmetic operations are

(1) Addition

\[
\bar{A} \oplus \bar{B} = (p_1 + q_1, p_2 + q_2, p_3 + q_3, p_4 + q_4, p_5 + q_5, p_6 + q_6, p_7 + q_7; \ p_1' + q_1', p_2' + q_2', p_3' + q_3', p_4 + q_4, p_5' + q_5', p_6' + q_6', p_7' + q_7')
\]

(2) Subtraction

\[
\bar{A} \ominus \bar{B} = (p_1 - q_1, p_2 - q_2, p_3 - q_3, p_4 - q_4, p_5 - q_5, p_6 - q_6, p_7 - q_7; \ p_1' - q_1', p_2' - q_2', p_3' - q_3', p_4 - q_4, p_5' - q_5', p_6' - q_6', p_7' - q_7')
\]

(3) Scalar Multiplication

$k\bar{A} = (kp_1, kp_2, kp_3, kp_4, kp_5, kp_6, kp_7; kp_1', kp_2', kp_3', kp_4, kp_5, kp_6', kp_7')$ if $k > 0$

$k\bar{A} = (kp_1, kp_2, kp_3, kp_4, kp_5, kp_6, kp_7; kp_1', kp_2', kp_3', kp_4, kp_5, kp_6', kp_7')$ if $k < 0$

(4) Multiplication

\[
\bar{A} \otimes \bar{B} = \left( l_1, l_2, l_3, l_4, l_5, l_6, l_7; \ l_1', l_2', l_3', l_4, l_5', l_6', l_7' \right)
\]

Where

\[
\begin{align*}
l_1 &= \text{Min}(p_1q_1, p_1q_2) & l_1' &= \text{Min}(p_1'q_1', p_1'q_2') \\
l_2 &= \text{Min}(p_2q_2, p_2q_6) & l_2' &= \text{Min}(p_2'q_2', p_2'q_6') \\
l_3 &= \text{Min}(p_3q_3, p_3q_5) & l_3' &= \text{Min}(p_3'q_3', p_3'q_5') \\
l_4 &= p_4q_4 & l_4' &= \text{Min}(p_4'q_4', p_4'q_4) \\
l_5 &= \text{Max}(p_5q_3, p_5q_5) & l_5' &= \text{Max}(p_5'q_3', p_5'q_5') \\
l_6 &= \text{Max}(p_6q_2, p_6q_6) & l_6' &= \text{Max}(p_6'q_2', p_6'q_6') \\
l_7 &= \text{Max}(p_7q_1, p_7q_7) & l_7' &= \text{Max}(p_7'q_1', p_7'q_7')
\end{align*}
\]

4 RANKING OF $H_p$IFN

Consider an $H_p$IFN $\bar{H} = (p_1, p_2, p_3, p_4, p_5, p_6, p_7; p_1', p_2', p_3', p_4, p_5', p_6', p_7')$ then the magnitude of $\bar{H}$ is defined by

\[
\text{Mag}(\bar{H}) = \frac{(p_1 + p_2 + p_3 + p_4 + p_5 + p_6 + p_7 + p_1' + p_2' + p_3' + p_4 + p_5' + p_6' + p_7')}{7}
\]

5 ORDERING OF $H_p$IFN

Let $\bar{A} = (p_1, p_2, p_3, p_4, p_5, p_6, p_7; p_1', p_2', p_3', p_4, p_5', p_6', p_7')$ and $\bar{B} = (q_1, q_2, q_3, q_4, q_5, q_6, q_7; q_1', q_2', q_3', q_4, q_5', q_6', q_7')$ be two $H_p$IFN then the ordering of $H_p$IFN is given by

(1) $\bar{A} > \bar{B} \iff \text{Mag}(\bar{A}) > \text{Mag}(\bar{B})$

(2) $\bar{A} < \bar{B} \iff \text{Mag}(\bar{A}) < \text{Mag}(\bar{B})$

(3) $\bar{A} = \bar{B} \iff \text{Mag}(\bar{A}) = \text{Mag}(\bar{B})$
6 MATHEMATICAL FORMULATION OF IFTP

Let us consider an intuitionistic fuzzy transportation problem with m sources (Origins) and n destination (warehouse). Let us consider $\tilde{C}_{i,j} = (c_{1ij}, c_{2ij}, c_{3ij} ; c_{1ij}', c_{2ij}', c_{3ij}')$ be the intuitionistic fuzzy transportation cost of one unit of product or commodity from the $i^{th}$ source to the $j^{th}$ destination.

Let $\tilde{p}_i = (p_{1i}, p_{2i}, p_{3i} ; p_{1i}', p_{2i}', p_{3i}')$ be the commodity available at the $i^{th}$ source plant. Let $\tilde{q}_j = (q_{1j}, q_{2j}, q_{3j} ; q_{1j}', q_{2j}', q_{3j}')$ be the commodity required at the $j^{th}$ demand destination. Let $\tilde{x}_{ij} = (x_{1ij}, x_{2ij}, x_{3ij} ; x_{1ij}', x_{2ij}', x_{3ij}')$ be the commodity transported from $i^{th}$ source to $j^{th}$ destination. Then Transportation problem is given by

$$\text{Min } 2^l = \sum_{i=1}^{m} \sum_{j=1}^{n} \tilde{c}_{i,j} \times \tilde{x}_{i,j}.$$ 

Such that

$$\sum_{j=1}^{n} \tilde{x}_{i,j} = \tilde{p}_i \text{ where } i = 1,2,...,m$$

$$\sum_{i=1}^{m} \tilde{x}_{i,j} = \tilde{q}_j \text{ where } j = 1,2,...,n$$

Where $\tilde{x}_{i,j} \geq 0 ; i = 1,2,...,m , j = 1,2,...,n$

The Table for transportation problem represented by

<table>
<thead>
<tr>
<th>Source</th>
<th>IFD$_1$</th>
<th>IFD$_2$</th>
<th>....</th>
<th>IFD$_n$</th>
<th>Availability $(\tilde{p}_i)$</th>
</tr>
</thead>
<tbody>
<tr>
<td>IFS$_1$</td>
<td>$\tilde{x}_{11}$</td>
<td>$\tilde{x}_{12}$</td>
<td>....</td>
<td>$\tilde{x}_{1n}$</td>
<td>$\tilde{p}_1$</td>
</tr>
<tr>
<td>IFS$_2$</td>
<td>$\tilde{x}_{21}$</td>
<td>$\tilde{x}_{22}$</td>
<td>....</td>
<td>$\tilde{x}_{2n}$</td>
<td>$\tilde{p}_2$</td>
</tr>
<tr>
<td>...</td>
<td>...</td>
<td>...</td>
<td>....</td>
<td>...</td>
<td>...</td>
</tr>
<tr>
<td>IFS$_m$</td>
<td>$\tilde{x}_{m1}$</td>
<td>$\tilde{x}_{m2}$</td>
<td>....</td>
<td>$\tilde{x}_{mn}$</td>
<td>$\tilde{p}_m$</td>
</tr>
</tbody>
</table>

| Requirement | $\tilde{q}_1$ | $\tilde{q}_2$ | .... | $\tilde{q}_n$ | $\sum \tilde{p}_i = \sum \tilde{q}_j$ |

7 ALGORITHM FOR INTUITIONISTIC FUZZY VOGEL’S APPROXIMATION METHOD (IFVAM)

**Step-1:** Consider the transportation problem whose parameters such as cost, demand, supply are in intuitionistic fuzzy number.

**Step-2:** To check whether given intuitionistic fuzzy transportation problem is balanced or unbalanced.

**Step-3:** After step-2 is applied transform $H_p IFTP$ into equivalent crisp TP using the ranking of $H_p IFN$. 

1988
Step-4: Now the crisp TP having all its cost, supply, demand are in integers. If not, any one of its cost, supply, and demand are not in integer then rewrite its nearest integer value.

Step-5: Find the blocks having smallest and next smallest transportation cost in each row and write the difference (called penalty) along the side of the table. This is called row penalty.

Step-6: Find the block having smallest and next smallest transportation cost in each column and write the difference (penalty) below the table. This is called column penalty.

Step-7: Select the row or column which has maximum row penalty or column penalty and find the block which has least cost in selected row or column. Allocate the block as maximum possible demand or supply. If there is a tie in selecting of penalties then the select the cell where maximum allocation can be possible.

Step-8: Adjust the supply and demand. Eliminate the row or column which is satisfied.

Step-9: Repeat these step-5 to step-8 until all the demand and supply are satisfied (It value is zero).

8 NUMERICAL EXAMPLE

Consider a Heptagonal Intuitionistic Fuzzy Transportation Problem with three sources and three destinations. Find the minimum cost of total intuitionistic fuzzy transportation in table-8.1.

<table>
<thead>
<tr>
<th>Source</th>
<th>IF $D_1$</th>
<th>IF $D_2$</th>
<th>IF $D_3$</th>
<th>IF Supply</th>
</tr>
</thead>
<tbody>
<tr>
<td>$S_1$</td>
<td>(2,3,4,5,6,7,8,9)</td>
<td>(7,9,10,11,12,13,16)</td>
<td>(4,6,8,9,10,12,14)</td>
<td>(4,6,7,8,9,10,11,12)</td>
</tr>
<tr>
<td>$S_2$</td>
<td>(1,3,5,6,7,8,10,12)</td>
<td>(4,5,6,7,8,9,10,11)</td>
<td>(8,10,11,12,13,14,16,17)</td>
<td>(5,7,8,9,10,11,12,14)</td>
</tr>
<tr>
<td>$S_3$</td>
<td>(2,4,6,8,10,11,14,16)</td>
<td>(8,10,11,12,13,14,16,18)</td>
<td>(1,2,3,4,5,6,7,8,9,10,11,13,15,17)</td>
<td>(10,11,12,13,14,15,17,19)</td>
</tr>
<tr>
<td>IF Demand</td>
<td>(9,11,12,13,14,15,16)</td>
<td>(6,8,9,10,11,12,13,15)</td>
<td>(4,5,6,7,8,9,11,12,13,15)</td>
<td>(3,4,5,7,9,10,12,13,15)</td>
</tr>
</tbody>
</table>

Solution:

Using Step-2 we have to check whether given $H_P$ IFTP is balanced or not.

$$\sum \tilde{p}_i = (19,24,27,30,33,36,40; 16,21,25,30,35,39,44)$$

$$\sum \tilde{q}_j = (19,24,27,30,33,36,40; 16,21,25,30,35,39,44)$$

Hence $\sum \tilde{p}_i = \sum \tilde{q}_j$

The given $H_P$ IFTP is balanced.
By using ranking function, we obtain the crisp value
For \( C_{11} = \frac{2+3+4+5+6+7+8+1+2+3+5+7+8+9}{7} \)
\[ = \frac{70}{7} \]
\[ C_{11} = 10 \]
Similarly we obtain for remaining fuzzy cost. If we get non-integer value, then rewrite it as nearest integer value. We obtain below crisp value in table 8.2

**Table-8.2 Crisp Transportation Problem**

<table>
<thead>
<tr>
<th>Destination Source</th>
<th>( D_1 )</th>
<th>( D_2 )</th>
<th>( D_3 )</th>
<th>Supply ((p_i))</th>
</tr>
</thead>
<tbody>
<tr>
<td>( S_1 )</td>
<td>10</td>
<td>22</td>
<td>18</td>
<td>16</td>
</tr>
<tr>
<td>( S_2 )</td>
<td>12</td>
<td>14</td>
<td>24</td>
<td>18</td>
</tr>
<tr>
<td>( S_3 )</td>
<td>16</td>
<td>24</td>
<td>8</td>
<td>26</td>
</tr>
<tr>
<td>Demand ((q_j))</td>
<td>26</td>
<td>20</td>
<td>14</td>
<td></td>
</tr>
</tbody>
</table>

Using step-5 to step-6, we get row penalty and column penalty.

**Table-8.3 IBFS by using Intuitionistic Fuzzy Vogel’s Approximation Method (IFVAM)**

<table>
<thead>
<tr>
<th>Destination Source</th>
<th>( D_1 )</th>
<th>( D_2 )</th>
<th>( D_3 )</th>
<th>Supply ((p_i))</th>
<th>Row penalty</th>
</tr>
</thead>
<tbody>
<tr>
<td>( S_1 )</td>
<td>10</td>
<td>22</td>
<td>18</td>
<td>16</td>
<td>8</td>
</tr>
<tr>
<td>( S_2 )</td>
<td>12</td>
<td>14</td>
<td>24</td>
<td>18</td>
<td>2</td>
</tr>
<tr>
<td>( S_3 )</td>
<td>16</td>
<td>24</td>
<td>8</td>
<td>26</td>
<td>8</td>
</tr>
<tr>
<td>Demand ((q_j))</td>
<td>26</td>
<td>20</td>
<td>14</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Column penalty</td>
<td>6</td>
<td>8</td>
<td>10(\dagger)</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Using step-7 for table-8.3 to identify the maximum possible unit to minimum cost. Now we write the remaining supply in row-3. Since there is no demand in column-3 we eliminate it. We obtain table-8.4.
Table-8.4 IBFS by using Intuitionistic Fuzzy Vogel’s Approximation Method (IFVAM)

<table>
<thead>
<tr>
<th>Source</th>
<th>$D_1$</th>
<th>$D_2$</th>
<th>$D_3$</th>
<th>Supply $(p_i)$</th>
</tr>
</thead>
<tbody>
<tr>
<td>$S_1$</td>
<td>10</td>
<td>22</td>
<td>-</td>
<td>16</td>
</tr>
<tr>
<td>$S_2$</td>
<td>12</td>
<td>14</td>
<td>-</td>
<td>18</td>
</tr>
<tr>
<td>$S_3$</td>
<td>16</td>
<td>24</td>
<td>8(14)</td>
<td>12</td>
</tr>
</tbody>
</table>

Demand $(q_j)$: 26 20 -

We repeating this process from step-5 to step-8. We obtain basic feasible solution for consider problem.

Table-8.5 IBFS by using Intuitionistic Fuzzy Vogel’s Approximation Method (IFVAM)

<table>
<thead>
<tr>
<th>Source</th>
<th>$D_1$</th>
<th>$D_2$</th>
<th>$D_3$</th>
<th>Supply $(p_i)$</th>
</tr>
</thead>
<tbody>
<tr>
<td>$S_1$</td>
<td>10(16)</td>
<td>22</td>
<td>18</td>
<td>-</td>
</tr>
<tr>
<td>$S_2$</td>
<td>12</td>
<td>14(8)</td>
<td>24</td>
<td>-</td>
</tr>
<tr>
<td>$S_3$</td>
<td>16(10)</td>
<td>24(2)</td>
<td>8(14)</td>
<td>-</td>
</tr>
</tbody>
</table>

Demand $(q_j)$: - - -

Min $Z = 10 \times 16 + 14 \times 18 + 16 \times 10 + 24 \times 2 + 8 \times 14$

Min $Z = 732$

The total Transportation cost using IFVAM is 732.

Table-8.6 IBFS using Intuitionistic Fuzzy North West Corner (IFNWCM)

<table>
<thead>
<tr>
<th>Source</th>
<th>$D_1$</th>
<th>$D_2$</th>
<th>$D_3$</th>
<th>Supply $(p_i)$</th>
</tr>
</thead>
<tbody>
<tr>
<td>$S_1$</td>
<td>10(16)</td>
<td>22</td>
<td>18</td>
<td>-</td>
</tr>
<tr>
<td>$S_2$</td>
<td>12(10)</td>
<td>14(8)</td>
<td>24</td>
<td>-</td>
</tr>
</tbody>
</table>
Min $Z = 10 \times 16 + 20 \times 10 + 14 \times 8 + 24 \times 12 + 8 \times 14$

$= 792$

The total Transportation cost using IFNWCM is 792.

**Table-8.7 IBFS using Intuitionistic Fuzzy Least Cost Method (IFLCM)**

<table>
<thead>
<tr>
<th>Destination</th>
<th>$D_1$</th>
<th>$D_2$</th>
<th>$D_3$</th>
<th>Supply ($p_i$)</th>
</tr>
</thead>
<tbody>
<tr>
<td>$S_3$</td>
<td>16</td>
<td>24(12)</td>
<td>8(14)</td>
<td>-</td>
</tr>
<tr>
<td>Demand ($q_j$)</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td></td>
</tr>
</tbody>
</table>

Min $Z = 10 \times 16 + 20 \times 10 + 14 \times 8 + 24 \times 12 + 8 \times 14$

$= 792$

The total Transportation cost using IFLCM is 792.

**Table-8.8 Optimum Solution using Intuitionistic Fuzzy MODI Method (IFMODI)**

<table>
<thead>
<tr>
<th>Destination</th>
<th>$D_1$</th>
<th>$D_2$</th>
<th>$D_3$</th>
<th>Supply ($p_i$)</th>
</tr>
</thead>
<tbody>
<tr>
<td>$S_3$</td>
<td>16</td>
<td>24(12)</td>
<td>8(14)</td>
<td>-</td>
</tr>
<tr>
<td>Demand ($q_j$)</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td></td>
</tr>
</tbody>
</table>

Min $Z = 10 \times 16 + 16 \times 10 + 14 \times 18 + 24 \times 2 + 8 \times 14$

$= 732$
The Optimum Solution using IFMODI Method is 732.

9 RESULTS AND DISCUSSION

<table>
<thead>
<tr>
<th>Basic feasible solution</th>
<th>Optimality test</th>
</tr>
</thead>
<tbody>
<tr>
<td>IFNWCM</td>
<td>IFMODI</td>
</tr>
<tr>
<td>792</td>
<td>792</td>
</tr>
<tr>
<td>IFLCM</td>
<td>IFVAM</td>
</tr>
<tr>
<td>792</td>
<td>732</td>
</tr>
<tr>
<td>IFVAM (Proposed method)</td>
<td></td>
</tr>
<tr>
<td>732</td>
<td></td>
</tr>
</tbody>
</table>

The above table represent the solution obtained by IFNWCM, IFLCM, IFVAM and optimality test by IFMODI method. From our investigation and result given in above table, it is clear that our proposed method (IFVAM) is better than other method for solving fuzzy transportation problem.

The solution obtained by our proposed method (IFVAM) is optimal solution for heptagonal intuitionistic fuzzy transportation problem. We can use our proposed method for all type of intuitionistic fuzzy transportation problem for get optimal solution.

Fig 9.1 Graphical Representation

10 CONCLUSION

In this paper, we approach IFVAM method for finding IBFS for given \( H_pIFTP \). We used ranking function for convert IFN into crisp value. We observe that sometime our approach gives direct optimal solution for IFTP and utilize for all type of FTP. The advantage of our approach is easy to understand and easy to apply for solving Fuzzy Transportation Problem occurs in current real-life situation.
REFERENCES


1994


