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An Application of Fuzzy Programming Approach in Agriculture: A Case Study of Willow Wicker Cultivation in Kashmir

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SUMMARY

This paper deals with decision making problems, where a fuzzy linear programming (FLP) approach with triangular and trapezoidal membership functions is used for optimal allocation of land for different crops such as rice, maize and willow wicker, locally known as *Veer Kani* in Kashmir, with respect to various factors. The solution of conversion of FLP into crisp multiobjective linear programming problems has been considered. Also, mean and median of triangular fuzzy numbers are considered to compare the results.

Keywords: Fuzzy linear programming, Triangular membership function, Trapezoidal membership function, Maximizing income, Fuzzy set, Crop combination..

1. INTRODUCTION

In real life situations, a linear programming model involves parameters whose values are not known but they are assigned by experts. These assigned values are not exact and the decision maker has to deal with uncertainties that are described by the manufacturer. Fuzzy linear programming (FLP) models in which the parameters are known only partially to some degree of precision is studied. Agriculture is mostly dominated by smallholding farmers; one of their main problem is how to utilize their land most effectively so that their profit is maximized. Even the farmers have good skill in plantation but face many decision-making problems on what and when should be planted. One of the main factors to these problems is cost fluctuation and product cost. These fluctuations are due to many reasons. Some farmers grow plants based on the current market prices or on a traditional basis. In this paper a methodology to solve the fuzzy linear programming (FLP) problem with trapezoidal and triangular membership is considered, to optimize the profit of the farmers with their available resources. In this study three crops, rice, maize and willow wicker are considered. In literature, linear programming has been used as a tool to obtain optimal results discussed by Alsheikh and Ahmad (2002). Radhakrishnan (1962) and Krishna (1963) proposed the linear programming technique for determining the optimal farming planning. Linear Programming model for a farm resource allocation is used by Felix and Jadith (2010). Mohamadand Said (2010) used the mathematical programming approach to maximize the total returns at the end of the planning horizon. Keith Butterworth (1985) suggested that in the current economic climate, linear programming (LP) could be well worth reconsidering as a maximizing technique in farm planning. Annetts and Audsley (2002) developed an LP model to consider a wide range of farming situation, which allows maximization of profit. Hazzel and Norton (1986) pointed out with the use of traditional methods, farmers have relied on experience and competition with neighbors to make their decisions. Igwe *et al.* (2011) and Lone *et al.* (2014) used LP technique to determine the optimum enterprise combination. Higgins *et al.* (2004) suggested, maintaining the production efficiency in

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agricultural planning is a fundamental activity in business profitability because it can increase returns of an operation with low additional costs. The first mathematical formulation of fuzziness was pioneered by Zadeh (1965). Several authors use different methods to solve the various types of FLP problems. Fuzzy methods have been developed in virtually all branches of decision-making problems which can be found in Tamiz (1996), Zimmermann (1991), Lone *et al.* (2016) and Ross (1995). Senthilkumar and Rajendran (2010) solve the FLPP with fuzzy variables inthe parametric form. Orlovsky (1980) made a numerous attempts to explore the ability of afuzzy set theory to become a useful tool for adequate mathematical analysis of real world problems.

Some Basic Definitions

(1) Let U be the universal set and if $\tilde{A}$ is a set of ordered pairs $\tilde{A} = \{(x, \mu_{\tilde{A}}(x)) | R \in U\}$ then $\tilde{A}$ is called fuzzy set, where $\mu_{\tilde{A}}(x)$ is the membership function.

(2) Membership: membership function means to represent whether an element x is involved in the set say A or not. For a set A, we define membership function of μ_A such as

$$\mu_A = \begin{cases} 1 & \text{if and only if } x \in A \\ 0 & \text{if and only if } x \notin A \end{cases}$$

In a fuzzy set each element is mapped to [0, 1] membership function

$$\mu_A : x \to [0, 1]$$

Where [0,1] means real number between 0 and 1(including 0 and 1).

(3) A fuzzy set $\tilde{A}$ is normal if $\mu_{\tilde{A}}(x) = 1$.

(4) A fuzzy set $\tilde{A}$ is convex if and only if $x_1, x_2 \in U$

$$\mu_{\tilde{A}}\{\lambda x_1 + (1-\lambda)x_2\} \geq \min\{\mu_{\tilde{A}}(x_1), \mu_{\tilde{A}}(x_1)\}, \ \lambda \in [0,1].$$

(5) If a fuzzy set is convex and normalized, and its membership function is defined in R and piecewise continuous, it is called fuzzy number. Fuzzy number (fuzzy set) represents a real number interval whose boundary is fuzzy.

(6) A fuzzy number $\tilde{A}$ is called L/R fuzzy number if its membership function satisfies the following properties:

(i) $\mu_{\tilde{A}}(x)$ is continuous function from R to the closed interval [0,1].

(ii) $\mu_{\tilde{A}}(x)$ is strictly decreasing for all $x \in [a_3, a_4]$.

(iii) $\mu_{\tilde{A}}(x)$ is strictly increasing for all $x \in [a_1, a_2]$.

(iv) $\mu_{\tilde{A}}(x) = 1$ m, or all $x \in [a_2, a_3]$.

A fuzzy number is denoted by $\tilde{A} = [a_1, a_2, a_3, a_4]$ where a_1, a_2, a_3, a_4 are real numbers. The parametric form of a fuzzy number is an ordered pair of functions $(a^L(\alpha), a^R(\alpha))$, where, α lies between 0 and 1, and $(a^L(\alpha) \leq a^R(\alpha))$. $a^L(\alpha)$ and $a^R(\alpha)$, are continuous non-decreasing bounded left function and continuous non-increasing bounded right function over closed interval [0,1] respectively. In practical fuzzy mathematical programming problem, interval numbers, trapezoidal fuzzy numbers and triangular fuzzy numbers are most commonly used; also they can be easily specified by the decision maker.

A fuzzy number $\tilde{A}$ is said to be a trapezoidal fuzzy number denoted by $(a_1, a_2, a_3, a_4 : w)$ if its membership is given by

$$\mu_{\tilde{A}}(x) = \left.\begin{matrix} \dfrac{(x-a_1)}{a_2 - a_1}, & a_1 \leq x \leq a_2 \\ 1 & , \ a_2 \leq x \leq a_3 \\ \dfrac{(a_4 - x)}{a_4 - a_3}, & a_3 \leq x \leq a_4 \\ 0 & \text{elesewhere} \end{matrix}\right\} \quad (1)$$

A fuzzy number $\tilde{A}$ is said to be a triangular fuzzy number denoted by (a_1, a_2, a_3) if its membership is given by

$$\mu_{\tilde{A}}(x) = \left.\begin{matrix} \dfrac{(x-a_1)}{a_2 - a_1}, & a_1 \leq x \leq a_2 \\ 1 & , \ x = a_2 \\ \dfrac{(a_3 - x)}{a_3 - a_2}, & a_2 \leq x \leq a_3 \\ 0 & \text{elesewhere} \end{matrix}\right\} \quad (2)$$

Properties

(i) A trapezoidal fuzzy number $\tilde{A} = [a_1, a_2, a_3, a_4]$ is said to be zero trapezoidal fuzzy number if $a_1 = a_2 = a_3 = a_4 = 0$.

(ii) A trapezoidal fuzzy number $\tilde{A} = [a_1, a_2, a_3, a_4]$ is said to be non-negative trapezoidal fuzzy number if $a_1 - a_3 \geq 0$.

(iii) Two trapezoidal fuzzy number $\tilde{A} = [a_1, a_2, a_3, a_4]$ and $\tilde{B} = [b_1, b_2, b_3, b_4]$ is said to be equal if $a_1 = b_1$, $a_2 = b_2$, $a_3 = b_3$ and a $a_4 = b_4$.

(iv) Addition and subtraction between fuzzy numbers become atrapezoidal fuzzy number.

(v) Multiplication, division, and inverse need not be a trapezoidal fuzzy number.

(vi) Minimum and Maximum of fuzzy number is not always in the form of a trapezoidal fuzzy number.

(vii) The results from addition or subtraction between triangular fuzzy numbers result also triangular fuzzy numbers.

(vii) The results from multiplication or division are not triangular fuzzy numbers.

(ix) The minimum or maximum operation does not give a triangular fuzzy number (TFN). But we often assume that the operational results of multiplication or division to be TFNs as approximation values.

Fuzzy Linear Programming Problem (FLPP)

Consider the following linear programming model

$$\left.\begin{aligned} Max\,Z &= C\tilde{X} \\ \text{subject to} & \\ A\tilde{X} &\leq \tilde{B} \\ \tilde{X} &\geq 0 \end{aligned}\right\} \tag{3}$$

Where $C = 1 \times n$ vector of components, $\tilde{B} = n \times 1$ a vector of all crisp values, $\tilde{X}$ is a decision variable vector and $A = m \times n$ matrix of coefficients. The fuzzy coefficients are determined in such a way that the fuzzy output has the minimum fuzzy at a target degree of belief h or α. The parameter h can be chosen by the decision maker and represents the desired degree of belief. The value of h is between 0 and 1. If the degree of confidence (or degree of belief) is set to zero, then the assumed model is extremely compatible with the data. If the degree of confidence is set to higher h =1, then the assumed model is extremely incompatible with the data and the upper and lower fuzzy bounds are widened in order to embed all the observations at the h-level set.

For finding optimal solution of the FLPP, we define some definitions as

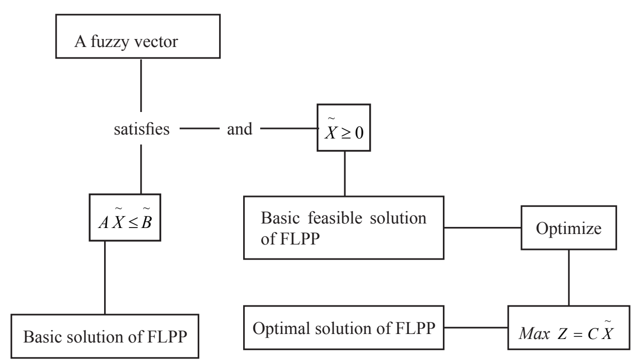
(i) A fuzzy vector $\tilde{X}$ is a basic solution of the FLPP if it satisfies set of constraints ($A\tilde{X} \leq \tilde{B}$).

(ii) A fuzzy vector $\tilde{X}$ is a feasible solution of the FLPP if it satisfies set of constraints ($A\tilde{X} \leq \tilde{B}$) non-negativity condition $\tilde{X} \geq 0$.

(iii) A feasible solution of the fuzzy vector $\tilde{X}$ that optimizes the objective function $Z = C\tilde{X}$ is the optimal solution to the FLPP.

(iv) The value of the objective function provided by the optimal solution is called an optimal value.

Diagrammatically the above definitions can be represented as



(v) Let $\sum_j^n a_{ij}\tilde{x}_j \leq \tilde{b}_i$, where $\tilde{b}_i \geq 0$ be the i^{th} fuzzy constraint of a fuzzy linear programming problem than a fuzzy variable $\tilde{S}_i$ such that $\tilde{S}_i \geq 0$ and $\sum_j^n a_{ij}\tilde{x}_j + \tilde{S}_i = \tilde{b}_i$ is called fuzzy slack variable.

(vi) Let $\sum_{j}^{n} a_{ij} \tilde{x}_j \geq \tilde{b}_i$, where $\tilde{b}_i \geq 0$ be the i^{th} fuzzy constraint of a fuzzy linear programming problem than a fuzzy variable $\tilde{S}_i$ such that $\tilde{S}_i \geq 0$ and $\sum_{j}^{n} a_{ij} \tilde{x}_j - \tilde{S}_i = \tilde{b}_i$ is called fuzzy surplus variable.

(viii) Consider the system $A\tilde{X} = \tilde{B}$ with $\tilde{X} \geq 0$, where A is $m \times n$ matrix of rank m. Let the columns of A corresponding to fuzzy variables $\tilde{X}_{\lambda_1}, \tilde{X}_{\lambda_2}, \ldots, \tilde{X}_{\lambda_m}$ are linearly independent and then $\tilde{X}_{\lambda_1}, \tilde{X}_{\lambda_2}, \ldots, \tilde{X}_{\lambda_m}$ are called fuzzy basic variables and the remaining $(m - n)$ variables are called non-basic variables.

Now, we have already discussed that fuzzy numbers can be written in parametric form as an ordered pair of functions. Here for a triangular fuzzy number $B = (b_1, b_2, b_3)$, we have

$$\frac{b_1^{\alpha} - b_1}{b_2 - b_1} = \alpha, \ \frac{b_2 - b_3^{\alpha}}{b_3 - b_2} = \alpha$$

Writing in parametric form

$$B = (\alpha(b_2 - b_1) + b_1, b_3 - \alpha(b_3 - b_2)), \ 0 \leq \alpha \leq 1.$$

Similarly, we can write the trapezoidal fuzzy number B = (b_1, b_2, b_3) in parametric form as

$$B = (\alpha(b_2 - b_1) + b_1, b_4 - \alpha(b_4 - b_3)), \ 0 \leq \alpha \leq 1.$$

For different values of α the FLPP can be divided into several auxiliary FLPPs and each of them becomes crisp linear programming problem; i.e. at each value of α we obtain a crisp linear programming problem. The problem (3) can be written in parametric form as

$$\left.\begin{array}{l} \text{Maximize } Z = c_1(x_1^L, x_1^R) + \ldots + c_n(x_n^L, x_n^R) \\ \text{subject to} \\ a_{h1}(x_1^L, x_1^R) + \ldots + a_{hn}(x_n^L, x_n^R) \leq (b_h^L, b_h^R) \\ X_j^L, X_j^R \geq 0. \text{ For all } h = 1, 2, \ldots, m \text{ and } j = 1, 2, \ldots, n. \end{array}\right\} \quad (4)$$

Problem Formulation

The information regarding cropping pattern was collected through an interview in the District Ganderbal of state Jammu and Kashmir and it was found that the major crops grown are Rice, Maize, Willow Wicker. In this investigation the considered household has

Table 1. Five-year plan of the crop plantation

Year	Resources/activities	Rice (acre)	Maize (acre)	Willow wicker(acre)	RHS(constraints)
1st	Crop land*	2	2	2	≤ around 6
	No. of Laborers	120	74	320	≤ around 530
	Capital available*	60000	40000	170000	≤around 270000
	Gross Income*	56800	57000	9600	
2nd	Crop land	2	2	2	≤ around 6
	No. of Laborers	120	74	74	≤ around 530
	Capital available	60000	40000	170000	≤ around 270000
	Gross Income	56800	57000	52000	
3rd	Crop land	2	2	2	≤ around 6
	No. of Laborers	120	74	84	≤ around 530
	Capital available	60000	40000	170000	≤ around 270000
	Gross Income	56800	57000	82800	
4th	Crop land	2	2	2	≤ around 6
	No. of Laborers	120	74	94	≤ around 530
	Capital available	60000	40000	170000	≤ around 270000
	Gross Income	56800	57000	112000	
5th	Crop land	2	2	2	≤ around 6
	No. of Laborers	120	74	108	≤ around 530
	Capital available	60000	40000	170000	≤ around 270000
	Gross Income	56800	57000	150000	

*Crop land is in acres and ,Capital available and Gross income is in Rs.

around 6 acres of land that is used forgrowing Rice, Maize and Willow wicker. The household: (i) expect to get a maximum gross income, (ii) interested in cropping combination that helps them to maximize their net profit. In this study, a five-year plan of the crop plantation was considered and is given in Table 1.

Solution Procedure

Let x_1, x_2 and x_3 are decision variables.

x_1 = area required for rice crop.

x_2 = area required for maize crop.

x_3 = area required for willow wicker crop.

The LP model for first year is given by:

Problem - 1:
Max $z = 56800\, x_1 + 57000\, x_2 + 9600\, x_3$
Subjected to
$2\, x_1 + 2\, x_2 + 2\, x_3 \le 6$
$120\, x_1 + 74\, x_{2+} + 320\, x_3 \le 530$
$60000\, x_1 + 40000\, x_{2+} + 170000\, x_3 \le 270000$
x_1, x_2 and $x_3 \ge 0$

FLP Problem - 1 with a triangular membership function can be written as

Max $z = 56800\, x_1 + 57000\, x_2 + 9600\, x_3$
Subjected to
$2\, x_1 + 2\, x_2 + 2\, x_3 \le (5, 6, 7)$
$120\, x_1 + 74\, x_{2+} + 320\, x_3 \le (220, 230, 240)$
$60000\, x_1 + 40000\, x_2 + 170000\, x_3 \le (260000, 270000, 280000)$
x_1, x_2 and $x_3 \ge 0$

Converting this FLPP into a crisp multi objective linear programming problem

Maximize $Z^1 = 56800\, x_1^L + 57000\, x_2^L + 9600\, x_3^L$ and
Maximize $Z^2 = 56800\, x_1^R + 57000\, x_2^R + 9600\, x_3^R$
Subject to
$o \le \alpha \le 1$
$2\, x_1^L + 2\, x_2^L + 2\, x_3^L \le \alpha + 5$
$2\, x_1^R + 2\, x_2^R + 2\, x_3^R \le 7 - \alpha$
$120\, x_1^L + 74\, x_2^L + 320\, x_3^L \le 10\, \alpha + 520$
$120\, x_1^R + 74\, x_2^R + 320\, x_3^R \le 540 - 10\, \alpha$
$60000\, x_1^L + 40000\, x_2^L + 170000\, x_3^L \le 10000\alpha + 260000$
$60000\, x_1^R + 40000\, x_2^R + 170000\, x_3^R \le 280000 - 10000\alpha$
$x_1^L, x_2^L, x_3^L, x_1^R, x_2^R, x_3^R \ge 0$

FLP Problem-1 with a trapezoidal membership function can be written as

Max $z = 56800\, x_1 + 57000\, x_2 + 9600\, x_3$
Subjected to
$2\, x_1 + 2\, x_2 + 2\, x_3 \le (4, 5, 6, 7)$
$120\, x_1 + 74\, x_{2+} + 320\, x_3 \le (210, 220, 230, 240)$
$60000\, x_1 + 40000\, x_{2+} + 170000\, x_3 \le (255000, 260000, 270000, 280000)$
x_1, x_2 and $x_3 \ge 0$

Converting this FLPP into a crisp multi objective linear programming problem

Maximize $Z^1 = 56800\, x_1^L + 57000\, x_2^L + 9600\, x_3^L$ and
Maximize $Z^2 = 56800\, x_1^R + 57000\, x_2^R + 9600\, x_3^R$
Subject to
$o \le \alpha \le 1$
$2x_1^L + 2x_2^L + 2x_3^L \le \alpha + 4$
$2x_1^R + 2x_2^R + 2x_3^R \le 7 - \alpha$
$120x_1^L + 74x_2^L + 320x_3^L \le 10\, \alpha + 510$
$120x_1^R + 74x_2^R + 320x_3^R \le 540 - 10\, \alpha$
$60000x_1^L + 40000x_2^L + 170000x_3^L \le 5000\, \alpha + 255000$
$60000x_1^R + 40000x_2^R + 170000x_3^R \le 280000 - 10000\alpha$
$x_1^L, x_2^L, x_3^L, x_1^R, x_2^R, x_3^R \ge 0$
$x_1^L, x_2^L, x_3^L, x_1^R, x_2^R, x_3^R \ge 0.$

Above we have shown how FLP problem-1 is converted into a crisp multi objective linear programming problem with triangular as well as trapezoidal membership function. Similarly, the problem-2, problem-3, problem-4 and problem-5 are converted into a crisp multi objective linear programming problem with triangular membership function. The results are obtained through LINGO software for different values of α as given in Table 2. In each problem when the decision maker sets the value of α =1, then the optimal value is same as that of median of TFN's. If we consider the problem -1, the optimal solution is one of them(142500, 156750, 171000) and the farmer gets maximum yield by planting Maize crops for 3 acres of land. Similarly for second year the farmer gets maximum yield by planting Maize crop. But for third, fourth and fifth year plan the farmer gets maximum yield by planting Maize and willow crops. Also, in all of the five problems we take mean and median of the triangular fuzzy number (a_1, a_2, a_3), and then compare the results.

The LP model for second year is given by

Problem 2:

$$\text{Max } z = 56800x_1 + 57000x_2 + 52000x_3$$

Subjected to

$$2x_1 + 2x_2 + 2x_3 \le 6$$
$$120x_1 + 74x_{2+} + 74x_3 \le 530$$
$$60000x_1 + 40000x_{2+} + 170000x_3 \le 270000$$
$$x_{1,} x_2 \text{ and } x_3 \ge 0$$

The LP model for third year is given by

Problem 3:

$$\text{Max } z = 56800x_1 + 57000x_2 + 82800x_3$$

Subjected to

$$2x_1 + 2x_2 + 2x_3 \le 6$$
$$120x_1 + 74x_{2+} + 84x_3 \le 530$$
$$60000x_1 + 40000x_{2+} + 170000x_3 \le 270000$$
$$x_{1,} x_2 \text{ and } x_3 \ge 0$$

The LP model for fourth year is given by

Problem 4:

$$\text{Max } z = 56800x_1 + 57000x_2 + 112000x_3$$

Subjected to

$$2x_1 + 2x_2 + 2x_3 \le 6$$
$$120x_1 + 74x_{2+} + 94x_3 \le 530$$
$$60000x_1 + 40000x_{2+} + 170000x_3 \le 270000$$
$$x_{1,} x_2 \text{ and } x_3 \ge 0$$

The LP model for fifth year is given by

Problem 5:

$$\text{Max } z = 56800x_1 + 57000x_2 + 150000x_3$$

Subjected to

$$2x_1 + 2x_2 + 2x_3 \le 6$$
$$120x_1 + 74x_{2+} + 108x_3 \le 530$$
$$60000x_1 + 40000x_{2+} + 170000x_3 \le 270000$$
$$x_{1,} x_2 \text{ and } x_3 \ge 0$$

The aim of the objective function is to maximize profit at the end of the year. In problem-1 willow wicker consumes the maximum number of laborers. But in problem 2, 3, 4, and 5 number of laborers goes on decreasing for willow wicker as shown in Table 1. The problem-1 and 2 provides the increase in gross income in maize only. Similarly problem-3, problem-4 and 5, shows that there is an increase of gross income in both maize and willow wicker but with the loss occurred in rice. After 5years willow wicker shows continuous increase in the gross income. It may be noted that willow wicker is being a perennial crop.

2. RESULT AND DISCUSSION

The optimal solution of the problems can be easily understood from Table 2. If we consider the results of problem-1 it is clear that optimal solution (142500, 156750, and 171000) of the original problem-1 is one of them. If we take the median and mean of TFN's, the farmer gets the maximum profit by using median of the TFN's. It has been shown that the farmer gets the same profit at α=1 and when median of the TFN's is considered. At the end of every year,our aim is to provide the best way of utilization of land so that the farmer can achieve his goal. In Problem-1, the maximum number of laborers is consumed by willow wicker and from the result Table 2; the farmer gets his maximum profit by planting maize crops. Similarly, for the second year the maximum profit can be obtained by planting maize crops. Now, for third year there is a decrease in the number of laborers but with the increase in farmers profit with the optimal strategy of planting maize and willow crops. As already mentioned that willow plants can be removed after 10 or 12 years from planting and the planting again. But the remaining crops can be planted yearly. It has been shown from the result table that after fifth or sixth year the willow crops can provide more and more profit to the farmer. Thus it shows that there is an increasing trend of farmer's profit. The optimal decision to the farmer is to utilize the more land for willow plants instead of wasting land for remaining crops. Also, it can be easily understood from the result table which crop combination provides a maximum profit. From the above study, it is clear that the economy of the state can also be improved by planting the willow wicker crops in agricultural fields.

Results

Table 2. Results of FLPPs for different values of α

Problems	TFNs	α	0	0.5	1	Mean of TFNs	**	Median of TFNs	*
	(5,6, 6.5)	X_1^L	0	0	0	5.83	X_1=0	6	X_1=0
	(520,530,537)	X_2^L	2.50	2.75	3	529	X_2=2.92	230	X_2=3
Problem-1	(260000,270000	X_3^L	0	0	0	269000	X_3=0	270000	X_3=
	277000)	X_1^R	0	0	0		Max z=166155		Max z=171000
		X_2^R	3.25	3.125	3				
		X_3^R	0	0	0				
	Max z^1		142500	156750	171000				
	Max z^2		185250	178125	171000				
	(5,6, 6.5)	X_1^L	0	0	0	5.83	X_1=0	6	X_1=0
	(520,530,537)	X_2^L	2.50	2.75	3	529	X_2=2.92	230	X_2=3
Problem-2	(260000,270000	X_3^L	0	0	0	269000	X_3=0	270000	X_3=0
	277000)	X_1^R	0	0	0		Max z=166155		Max z=171000
		X_2^R	3.25	3.125	3				
		X_3^R	0	0	0				
	Max z^1		142500	156750	171000				
	Max z^2		185250	178125	171000				
	(5,6, 6.5)	X_1^L	0	0	0	5.83	X_1=0	6	X_1=0
	(520,530,537)	X_2^L	1.27	1.55	1.84	529	X_2=1.74	230	X_2=1.84
Problem-3	(260000,270000	X_3^L	1.23	1.19	1.15	269000	X_3=1.72	270000	X_3=1.15
	277000)	X_1^R	0	0	0		Max z=196400		Max z=200769
		X_2^R	2.11	1.98	1.85				
		X_3^R	1.13	1.14	1.15				
	Max z^1		174253	187511	200769				
	Max z^2		214424	207596	200769				
	((5,6, 6.5)	X_1^L	0	0	0	5.83	X_1=0	6	X_1=0
	(520,530,537)	X_2^L	1.27	1.55	1.84	529	X_2=1.74	230	X_2=1.84
	(260000,270000	X_3^L	1.23	1.19	1.15	269000	X_3=1.17	270000	X_3=1.15
Problem-4	277000)	X_1^R	0	0	0		Max z=230632		Max z=234462
		X_2^R	2.12	1.98	1.85				
		X_3^R	1.13	1.14	1.15				
	Max z^1		210192	222326	234462				
	Max z^2		247442	240951	234462				
	(5,6, 6.5)	X_1^L	0	0	0	5.83	X_1=0	6	X_1=0
	(520,530,537)	X_2^L	1.27	1.55	1.85	529	X_2=1.74	230	X_2=1.85
	(260000,270000	X_3^L	1.23	1.92	1.15	269000	X_3=1.72	270000	X_3=1.15
Problem-5	277000)	X_1^R	0	0	0		Max z=275179		Max z=278308
		X_2^R	2.11	1.98	1.85				
		X_3^R	1.13	1.14	1.15				
	Max z^1		256961	267635	278308				
	Max z^2		290411	284359	278308				

** represents the solution of the original problem when mean of TFNs are considered

* represents the solution of the original problem when median of TFNs are considered.

3. CONCLUSION

From the above discussion, it is concluded that how the farmer gets the maximum profit with the use of limited resources when uncertainty arises in real life situations. Therefore we conclude that the optimal strategy for the farmer is to utilize more land for willow wicker to get his maximum profit.

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