The Scientific Temper (2024) Vol. 15 (3): 2473-2477
E-ISSN: 2231-6396, ISSN: 0976-8653
Doi: 10.58414/SCIENTIFICTEMPER.2024.15.3.10
https://scientifictemper.com/
RESEARCH ARTICLE

An optimal fuzzy inventory model for rice farming using lagrangean method

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Abstract

Rice is the staple diet for millions of people in Asia and around the globe. Nowadays, Farmers are facing many challenges in the field because the soil's fertility is declining, it is growing harder for farmers to cultivate their land. Numerous elements, such as soil erosion, salinity, Poor Nutrient Management and temperature variations, have an impact on soil fertility. Rainwater runs swiftly across upland soils, making it difficult for farmers to hold on to the moisture in the soil. Now, it is time to rethink the cropping patterns based on agroclimatic zones. India is the leading producer of Rice crops. It is one of the major food crops that provide nourishment for millions of people every day. This paper aims to investigate the fuzzy production-related factors for one acre of rice farming. Various costs are fuzzified as trapezoidal fuzzy numbers and deffuzzified by using the beta distribution method. This proposed model is to determine the optimal solution using lagrangean method. A numerical example is concluded.

Keywords: Erratic, Irrigation, Paddy Field, Unreliable.

Introduction

Agriculture enabled to produce of food. In India, The primary source of income is agriculture. In India, One of the most popular grain crops is rice, which is an essential part of the Indian diet. Major rice production states in India such as Assam, Andhra Pradesh, Bihar, Chhattisgarh, Orissa, Haryana, Kerala, Punjab, Telangana, Tamil Nadu, Uttar Pradesh, West Bengal. Although there are certain machinery available for planting and harvesting the rice crop, the traditional methods of farming and harvesting rice are still used. Paddy and rice are often confused by people. Paddy refers to rice that is still protected by the brown hull. Paddy fields and rice paddies are other names for rice fields. More rice is consumed in the south of India than everywhere else. In addition to using rice for normal culinary purposes, its husk can be utilized to make rice brain oil. In addition to being a good source of fiber, niacin, calcium, vitamin D, iron, riboflavin, and thiamine, rice also has no cholesterol. Furthermore, rice brain oil enhances cardiovascular health and aids in the prevention of cancer, high blood pressure, and chronic constipation. Site selection is a critical step in farming. A hot, humid atmosphere is necessary for the successful cultivation of rice. The crop needs to be kept at a temperature between 200 and 400°C for the duration of its life. In rice farming, timely harvesting is crucial to prevent grain shedding. As soon as 45 days have passed since the seeds were sown, a rice field must be weed-free. Early or medium varieties should be harvested 26 to 30 days after blooming, and field paddy should be harvested when the moisture level of the rice grain is between 20 and 25%.

Rice cultivation in a water scarcity environment is explained in T. P. Tuong and B. A. M. Bouman's (2003) paper. Aldo Ferrero and Nguu Van Nguyen (2006) investigated overcoming the obstacles to rice production worldwide. Bonney and Jaber (2017) highlighted the cost of transportation and emissions as well as how essential inventory planning is to the environment. Richard Paul (2017) and Saswatik Tripathy (2018) examined paddy cultivation in Madurai district. Agri farming (2020) outlined the issues Indian Farmers Face. Bernard A. (2020) explained the uses of rice-growing waste materials like husks and straws. SITCO (2021) Challenges Faced by Indian Rice Producers - Scientific Agriculture Solutions to Increase Yield. Muhammad Farooq (2022) investigated Increasing the sustainability of methods

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How to cite this article: Bridgette, S. I., Jeyakumari, R. S. (2024). An optimal fuzzy inventory model for rice farming using lagrangean method. The Scientific Temper, **15**(3):2473-2477.

Doi: 10.58414/SCIENTIFICTEMPER.2024.15.3.10

Source of support: Nil

Conflict of interest: None.

Received: 15/07/2024 **Accepted:** 20/08/2024 **Published** : 10/09/2024

for producing rice. In Odacherry village, Thiruvarur district, I. Sowndariya1 (2022) analyzed the difficulties farmers had when trying to cultivate paddy.

Definitions

Fuzzy Set

A fuzzy set $\tilde{A}$ is the set of ordered pairs $\tilde{A} = \{(x, \mu_{\tilde{A}}(x)) : x \in X\}$.
The mapping

$\mu_{\tilde{A}} : X \to [0,1]$ is membership function of $x \in X$ in $\tilde{A}$.

Beta distribution method

The crisp real number $\mu_{\tilde{\beta}}$ is the following relation

$\tilde{\beta} = (a, b, c, d)$. Let $\mu_{\tilde{\beta}}$ be generalized trapezoidal fuzzy number.

$$\mu_{\tilde{\beta}} = \frac{2a + 7b + 7c + 2}{18}$$

Arithmetic Operation

Suppose $\tilde{R} = (r_1, r_2, r_3, r_4)$ *and* $\hat{S} = (s_1, s_2, s_3, s_4)$ are two trapezoidal fuzzy numbers then,

- $\tilde{R} \oplus \tilde{S} = (r_1 + s_1, r_2 + s_2, r_3 + s_3, r_4 + s_4,)$.
- $\tilde{R} \otimes \hat{S} = (r_1 s_1, r_2 s_2, r_3 s_3, r_4 s_4)$
- $\tilde{R} \ominus \tilde{S} = (r_1 - s_4, r_2 - s_3, r_3 - s_2, r_4 - s_1)$
- $\tilde{R} \oslash \tilde{S} = \left(\frac{r_1}{s_4}, \frac{r_2}{s_3}, \frac{r_3}{s_2}, \frac{r_4}{s_1}\right)$
- $\alpha \geq 0, \alpha \otimes \tilde{R} = (\alpha r_1, \alpha r_2, \alpha r_3, \alpha r_4)$

  $\alpha < 0, \alpha \otimes \tilde{S} = (\alpha s_1, \alpha s_2, \alpha s_3, \alpha s_4)$

Notations

D – Demand
Q – Order Quantity
h_c – Holding Cost
L – Cost of land
S - Cost of sowing
P – Machinery cost for ploughing
C_s – Labour cost for digging, filling, and seedling
F- Cost of fertilizer
L_c – Labour cost
I – Cost of Irrigation
M – Machinery cost
F_c – cost of fencing
S_p – Cost of solar plant
C_p-Cost of pesticides
H – Labour cost for harvesting
W – Cost of weedicides
t_d – Distance travelled
E_t – Emission due to transportation
A_v – average velocity
T_c -Total cost
$\tilde{T_c}$- Fuzzy total cost
Q^*- Optimal order quantity

Assumption

- Demand is constant
- Shortages are not permitted
- Transportation cost is utilised to shift the seeds, fertilizers and pesticides.
- Machinery cost is used for rice dehusking
- Procedures for growing rice organically are followed.

Crisp and Fuzzy Sense

Crisp Sense

We deal a rice farming in crisp sense and EOQ can be provided by the following equation.

$$T_c = \frac{D}{Q}\left[L + S + P + C_s + I + M + S_p + F_c + H + (F + L_c) + (C_p + L_c) + (W + L_c) + \frac{E_t t_d}{A_v}\right] + \frac{Q h_c}{2} \quad (1)$$

$$\frac{\partial T_c}{\partial Q} = 0$$

$\Rightarrow$ -

$$\frac{D}{Q^2}\left[L + S + P + C_s + I + M + S_p + F_c + H + (F + L_c) + (C_p + L_c) + (W + L_c) + \frac{E_t t_d}{A_v}\right] + \frac{h_c}{2} = 0$$

$$Q = \sqrt{\frac{2D\left[L+S+P+C_s+I+M+S_p+F_c+H+(F+L_c)+(C_p+L_c)+(W+L_c)+\frac{E_t t_d}{A_v}\right]}{h_c}} \quad (2)$$

Fuzzy Sense

The parameters $D, L, S, P, C_s, I, M, S_p, F_c, H, F, L_c, C_p, W, h_c, E_t$, t_d are fuzzified using trapezoidal fuzzy numbers and defuzzifing the model using beta distribution method.

$\tilde{L} = (l_1, l_2, l_3, l_4)$, $\tilde{S} = (s_1, s_2, s_3, s_4)$, $\tilde{P} = (p_1, p_2, p_3, p_4)$, $\tilde{C_s} = (c_{s_1}, c_{s_2}, c_{s_3}, c_{s_4})$

$\tilde{I} = (i_1, i_2, i_3, i_4)$, $\tilde{M} = (m_1, m_2, m_3, m_4)$, $\tilde{S_p} = (s_{p_1}, s_{p_2}, s_{p_3}, s_{p_4})$, $\tilde{F_c} = (f_{c_1}, f_{c_2}, f_{c_3}, f_{c_4})$,

$\tilde{H} = (h_1, h_2, h_3, h_4)$, $\tilde{F} = (f_1, f_2, f_3, f_4)$, $\tilde{L_c} = (l_{c_1}, l_{c_2}, l_{c_3}, l_{c_4})$, $\tilde{C_p} = (c_{p_1}, c_{p_2}, c_{p_3}, c_{p_4})$,

$\tilde{W} = (w_1, w_2, w_3, w_4)$, $\tilde{h_c} = (h_{c_1}, h_{c_2}, h_{c_3}, h_{c_4})$,

$\tilde{D} = (d_1, d_2, d_3, d_4)$, $\tilde{E_t} = (e_{t_1}, e_{t_2}, e_{t_3}, e_{t_4})$, $\tilde{t_d} = (t_{d_1}, t_{d_2}, t_{d_3}, t_{d_4})$

Let the fuzzy total cost can be written as:

$$T_c = \frac{\tilde{D}}{Q}\left[\tilde{L} + \tilde{S} + \tilde{P} + \tilde{C_s} + \tilde{I} + \tilde{M} + \tilde{S_p} + \tilde{F_c} + \tilde{H} + (\tilde{F} + \tilde{L_c}) + (\tilde{C_p} + \tilde{L_c}) + (\tilde{W} + \tilde{L_c}) + \frac{\tilde{E_t}\tilde{t_d}}{\tilde{A_v}}\right] + \frac{Q\tilde{h_c}}{2}$$

$\tilde{T_c} =$

$$\frac{d_1}{Q}\left[l_1 + s_1 + p_1 + c_{s_1} + i_1 + m_1 + s_{p_1} + f_{c_1} + h_1 + (f_1 + l_{c_1}) + (c_{p_1} + l_{c_1}) + (w_1 + l_{c_1}) + \frac{e_{t_1} t_{d_1}}{a_v}\right] + \frac{Q h_{c_1}}{2},$$
$$\frac{d_2}{Q}\left[l_2 + s_2 + p_2 + c_{s_2} + i_2 + m_2 + s_{p_2} + f_{c_2} + h_2 + (f_2 + l_{c_2}) + (c_{p_2} + l_{c_2}) + (w_2 + l_{c_2}) + \frac{e_{t_2} t_{d_2}}{a_v}\right] + \frac{Q h_{c_2}}{2},$$
$$\frac{d_3}{Q}\left[l_3 + s_3 + p_3 + c_{s_3} + i_3 + m_3 + s_{p_3} + f_{c_3} + h_3 + (f_3 + l_{c_3}) + (c_{p_3} + l_{c_3}) + (w_3 + l_{c_3}) + \frac{e_{t_3} t_{d_3}}{a_v}\right] + \frac{Q h_{c_3}}{2},$$
$$\frac{d_4}{Q}\left[l_4 + s_4 + p_4 + c_{s_4} + i_4 + m_4 + s_{p_4} + f_{c_4} + h_4 + (f_4 + l_{c_4}) + (c_{p_4} + l_{c_4}) + (w_4 + l_{c_4}) + \frac{e_{t_4} t_{d_4}}{a_v}\right] + \frac{Q h_{c_4}}{2}$$

By Beta distribution method, we get

$$\begin{aligned}
B(\tilde{T_c}) = \frac{1}{18}\Bigg[2\Bigg(\frac{d_1}{Q}\Bigg[& l_1 + s_1 + p_1 + c_{s_1} + i_1 + m_1 + s_{p_1} + f_{c_1} + h_1 + (f_1 + l_{c_1}) + (c_{p_1} + l_{c_1}) \\
&+ (w_1 + l_{c_1}) + \frac{e_{t_1} t_{d_1}}{a_v}\Bigg] + \frac{Q h_{c_1}}{2}\Bigg) \\
&+ 7\Bigg(\frac{d_2}{Q}\Bigg[l_2 + s_2 + p_2 + c_{s_2} + i_2 + m_2 + s_{p_2} + f_{c_2} + h_2 + (f_2 + l_{c_2}) + (c_{p_2} + l_{c_2}) \\
&+ (w_2 + l_{c_2}) + \frac{e_{t_2} t_{d_2}}{a_v}\Bigg] + \frac{Q h_{c_2}}{2}\Bigg) \\
&+ 7\Bigg(\frac{d_3}{Q}\Bigg[l_3 + s_3 + p_3 + c_{s_3} + i_3 + m_3 + s_{p_3} + f_{c_3} + h_3 + (f_3 + l_{c_3}) + (c_{p_3} + l_{c_3}) \\
&+ (w_3 + l_{c_3}) + \frac{e_{t_3} t_{d_3}}{a_v}\Bigg] + \frac{Q h_{c_3}}{2}\Bigg) \\
&+ + 2\Bigg(\frac{d_4}{Q}\Bigg[l_4 + s_4 + p_4 + c_{s_4} + i_4 + m_4 + s_{p_4} + f_{c_4} + h_4 + (f_4 + l_{c_4}) + (c_{p_4} + l_{c_4}) \\
&+ (w_4 + l_{c_4}) + \frac{e_{t_4} t_{d_4}}{a_v}\Bigg] + \frac{Q h_{c_4}}{2}\Bigg)\Bigg]
\end{aligned} \quad (3)$$

$$\frac{\partial B(\widetilde{T}_c)}{\partial Q} = 0 \Rightarrow Q = \sqrt{\frac{\begin{array}{c}2[(2l_1d_1+7l_2d_2+7l_3d_3+2l_4d_4)+(2s_1d_1+7s_2d_2+7s_3d_3+2s_4d_4)+(2p_1d_1+7p_2d_2+7p_3d_3+2p_4d_4)+\\(2c_{s_1}d_1+7c_{s_2}d_2+7c_{s_3}d_3+2c_{s_4}d_4)+(2i_1d_1+7i_2d_2+7i_3d_3+2i_4d_4)+(2m_1d_1+7m_2d_2+7m_3d_3+2m_4d_4)+\\(2s_{p_1}d_1+7s_{p_2}d_2+7s_{p_3}d_3+2s_{p_4}d_4)+(2f_{c_1}d_1+7f_{c_2}d_2+7f_{c_3}d_3+2f_{c_4}d_4)+(2h_1d_1+7h_2d_2+7h_3d_3+2h_4d_4)+\\(2(f_1+l_{c_1})d_1+7(f_2+l_{c_2})d_2+7(f_3+l_{c_3})d_3+2(f_4+l_{c_4})d_4)+(2(c_{p_1}+l_{c_1})d_1+7(c_{p_2}+l_{c_2})d_2+7(c_{p_3}+l_{c_3})d_3+2(c_{p_4}+l_{c_4})d_4)]\\+(2(w_1+l_{c_1})d_1+7(w_2+l_{c_2})d_2+7(w_3+l_{c_3})d_3+2(w_4+l_{c_4})d_4)+\left(\frac{2e_{t_1}t_{d_1}d_1+7e_{t_2}t_{d_2}d_2+7e_{t_3}t_{d_3}d_3+2e_{t_4}t_{d_4}d_4}{a_v}\right)\end{array}}{2h_{c_1}+7h_{c_2}+7h_{c_3}+2h_{c_4}}} \quad (4)$$

Hence, equation (3) is the fuzzy total cost and equation (4) is the fuzzy economic quantity.

Lagrangean method

Let the fuzzy order quantity $\tilde{q} = (q_1, q_2, q_3, q_4)$

$\tilde{T}_c =$

$$\frac{d_1}{q_4}\left[l_1+s_1+p_1+c_{s_1}+i_1+m_1+s_{p_1}+f_{c_1}+h_1+(f_1+l_{c_1})+(c_{p_1}+l_{c_1})+(w_1+l_{c_1})+\frac{e_{t_1}t_{d_1}}{a_v}\right]+\frac{q_1h_{c_1}}{2},$$
$$\frac{d_2}{q_3}\left[l_2+s_2+p_2+c_{s_2}+i_2+m_2+s_{p_2}+f_{c_2}+h_2+(f_2+l_{c_2})+(c_{p_2}+l_{c_2})+(w_2+l_{c_2})+\frac{e_{t_2}t_{d_2}}{a_v}\right]+\frac{q_2h_{c_2}}{2}$$
$$\frac{d_3}{q_2}\left[l_3+s_3+p_3+c_{s_3}+i_3+m_3+s_{p_3}+f_{c_3}+h_3+(f_3+l_{c_3})+(c_{p_3}+l_{c_3})+(w_3+l_{c_3})+\frac{e_{t_3}t_{d_3}}{a_v}\right]+\frac{q_3h_{c_3}}{2}$$
$$\frac{d_4}{q_1}\left[l_4+s_4+p_4+c_{s_4}+i_4+m_4+s_{p_4}+f_{c_4}+h_4+(f_4+l_{c_4})+(c_{p_4}+l_{c_4})+(w_4+l_{c_4})+\frac{e_{t_4}t_{d_4}}{a_v}\right]+\frac{q_4h_{c_4}}{2}$$

By Beta distribution method,

$$B(\widetilde{T_c}) = \frac{1}{18}\Big[2\Big(\frac{d_1}{q_4}\Big[l_1+s_1+p_1+c_{s_1}+i_1+m_1+s_{p_1}+f_{c_1}+h_1+(f_1+l_{c_1})+(c_{p_1}+l_{c_1})+(w_1+l_{c_1})+\frac{e_{t_1}t_{d_1}}{a_v}\Big]+\frac{q_1h_{c_1}}{2}\Big)+7\Big(\frac{d_2}{q_3}\Big[l_2+s_2+p_2+c_{s_2}+i_2+m_2+s_{p_2}+f_{c_2}+h_2+(f_2+l_{c_2})+(c_{p_2}+l_{c_2})+(w_2+l_{c_2})+\frac{e_{t_2}t_{d_2}}{a_v}\Big]+\frac{q_2h_{c_2}}{2}\Big)+7\Big(\frac{d_3}{q_2}\Big[l_3+s_3+p_3+c_{s_3}+i_3+m_3+s_{p_3}+f_{c_3}+h_3+(f_3+l_{c_3})+(c_{p_3}+l_{c_3})+(w_3+l_{c_3})+\frac{e_{t_3}t_{d_3}}{a_v}\Big]+\frac{q_3h_{c_3}}{2}\Big)+2\Big(\frac{d_4}{q_1}\Big[l_4+s_4+p_4+c_{s_4}+i_4+m_4+s_{p_4}+f_{c_4}+h_4+(f_4+l_{c_4})+(c_{p_4}+l_{c_4})+(w_4+l_{c_4})+\frac{e_{t_4}t_{d_4}}{a_v}\Big]+\frac{q_4h_{c_4}}{2}\Big)\Big]$$

$0 < q_1 \le q_2 \le q_3 \le q_4,$

It written as $q_2 - q_1 \ge 0, q_3 - q_2 \ge 0, q_4 - q_3 \ge 0, q_1 > 0.$

Step 1

Differentiate partially with respect to q_1, q_2, q_3, q_4 and equate to zero.

$q_1 =$

$$\sqrt{\frac{2\left[2d_4l_1+2d_4s_1+2d_4p_1+2d_4c_{s_1}+2d_4i_1+2d_4m_1+2d_4s_{p_1}+2d_4f_{c_1}+2d_4h_1+2d_4(f_1+l_{c_1})+2d_4(c_{p_1}+l_{c_1})+2d_4(w_1+l_{c_1})+\frac{2d_4e_{t_1}t_{d_1}}{a_v}\right]}{(2h_{c_1})}}$$

$q_2 =$

$$\sqrt{\frac{2\left[7d_3l_3+7d_3s_3+7d_3p_3+7d_3c_{s_3}+7d_3i_3+7d_3m_3+7d_3s_{p_3}+7d_3f_{c_3}+7d_3h_3+7d_3(f_3+l_{c_3})+7d_3(c_{p_3}+l_{c_3})+7d_3(w_3+l_{c_3})+\frac{7d_3e_{t_3}t_{d_3}}{a_v}\right]}{(7h_{c_2})}}$$

$q_3 =$

$$\sqrt{\frac{2\left[7d_2l_2+7d_2s_2+7d_2p_2+7d_2c_{s_2}+7d_2i_2+7d_2m_2+7d_2s_{p_2}+7d_2f_{c_2}+7d_2h_2+7d_2(f_2+l_{c_2})+7d_2(c_{p_2}+l_{c_2})+7d_2(w_2+l_{c_2})+\frac{7d_2e_{t_2}t_{d_2}}{a_v}\right]}{(7h_{c_3})}}$$

$q_4 =$

$$\sqrt{\frac{2\left[2d_1l_1+2d_1s_1+2d_1p_1+2d_1c_{s_1}+2d_1i_1+2d_1m_1+2d_1s_{p_1}+2d_1f_{c_1}+2d_1h_1+2d_1(f_1+l_{c_1})+2d_1(c_{p_1}+l_{c_1})+2d_1(w_1+l_{c_1})+\frac{2d_1e_{t_1}t_{d_1}}{a_v}\right]}{(2h_{c_4})}}$$

$0 < q_1 \le q_2 \le q_3 \le q_4$

It is not attain the optimum.

Step 2

Fix k = 1

Let inequality condition $q_2 - q_1 \ge 0$ written in equality $q_2 - q_1 = 0$

$$L(q_1, q_2, q_3, q_4, \lambda) = F(T_{\tilde{c}}) - \lambda(q_2 - q_1) \quad (5)$$

$\frac{\partial L}{\partial q_1} = 0 \Rightarrow$

$$\frac{1}{18}\left[\frac{2h_{c_1}}{2} - \frac{1}{q_1^2}\left(2d_4l_1+2d_4s_1+2d_4p_1+2d_4c_{s_1}+2d_4i_1+2d_4m_1+2d_4s_{p_1}+2d_4f_{c_1}+2d_4h_1+2d_4(f_1+l_{c_1})+2d_4(c_{p_1}+l_{c_1})+2d_4(w_1+l_{c_1})+\frac{2d_4e_{t_1}t_{d_1}}{a_v}\right)\right]+\lambda = 0 \quad (6)$$

$\frac{\partial L}{\partial q_2} = 0 \Rightarrow$

$$\frac{1}{18}\left[\frac{7h_{c_2}}{2} - \frac{1}{q_2^2}\left(7d_3l_3+7d_3s_3+7d_3p_3+7d_3c_{s_3}+7d_3i_3+7d_3m_3+7d_3s_{p_3}+7d_3f_{c_3}+7d_3h_3+7d_3(f_3+l_{c_3})+7d_3(c_{p_3}+l_{c_3})+7d_3(w_3+l_{c_3})+\frac{7d_3e_{t_3}t_{d_3}}{a_v}\right)\right]-\lambda = 0 \quad (7)$$

$\frac{\partial L}{\partial q_3} = 0$

$$\Rightarrow \frac{1}{18}\left[\frac{7h_{c_3}}{2} - \frac{1}{q_3^2}\left(7d_2l_2+7d_2s_2+7d_2p_2+7d_2c_{s_2}+7d_2i_2+7d_2m_2+7d_2s_{p_2}+7d_2f_{c_2}+7d_2h_2+7d_2(f_2+l_{c_2})+7d_2(c_{p_2}+l_{c_2})+7d_2(w_2+l_{c_2})+\frac{7d_2e_{t_2}t_{d_2}}{a_v}\right)\right] = 0 \quad --(8)$$

$\frac{\partial L}{\partial q_4} = 0$

$$\Rightarrow \frac{1}{18}\left[\frac{2h_{c_4}}{2} - \frac{1}{q_4^2}\left(2d_1l_1+2d_1s_1+2d_1p_1+2d_1c_{s_1}+2d_1i_1+2d_1m_1+2d_1s_{p_1}+2d_1f_{c_1}+2d_1h_1+2d_1(f_1+l_{c_1})+2d_1(c_{p_1}+l_{c_1})+2d_1(w_1+l_{c_1})+\frac{2d_1e_{t_1}t_{d_1}}{a_v}\right)\right] = 0 \quad --(9)$$

$$\frac{\partial L}{\partial \lambda} = 0 \Rightarrow -(q_2 - q_1) = 0 \quad (10)$$

(6) + (7) and from the equation (10)

$q_1 = q_2 =$

$$\sqrt{\frac{\begin{array}{c}2[(7l_3d_3+2l_4d_4)+(7s_3d_3+2s_4d_4)+(7p_3d_3+2p_4d_4)+(7c_{s_3}d_3+2c_{s_4}d_4)+(7i_3d_3+2i_4d_4)+(7m_3d_3+2m_4d_4)\\+(7s_{p_3}d_3+2s_{p_4}d_4)+(7f_{c_3}d_3+2f_{c_4}d_4)+(7h_3d_3+2h_4d_4)+(7(f_3+l_{c_3})d_3+2(f_4+l_{c_4})d_4)+\\(7(c_{p_3}+l_{c_3})d_3+2(c_{p_4}+l_{c_4})d_4)+(7(w_3+l_{c_3})d_3+2(w_4+l_{c_4})d_4)+\left(\frac{7e_{t_3}t_{d_3}d_3+2e_{t_4}t_{d_4}d_4}{a_v}\right)\end{array}}{2h_{c_1}+7h_{c_2}}}$$

$q_3 =$

$$\sqrt{\frac{2\left[7d_2l_2+7d_2s_2+7d_2p_2+7d_2c_{s_2}+7d_2i_2+7d_2m_2+7d_2s_{p_2}+7d_2f_{c_2}+7d_2h_2+7d_2(f_2+l_{c_2})+7d_2(c_{p_2}+l_{c_2})+7d_2(w_2+l_{c_2})+\frac{7d_2e_{t_2}t_{d_2}}{a_v}\right]}{(7h_{c_3})}}$$

$q_4 =$

$$\sqrt{\frac{2\left[2d_1l_1+2d_1s_1+2d_1p_1+2d_1c_{s_1}+2d_1i_1+2d_1m_1+2d_1s_{p_1}+2d_1f_{c_1}+2d_1h_1+2d_1(f_1+l_{c_1})+2d_1(c_{p_1}+l_{c_1})+2d_1(w_1+l_{c_1})+\frac{2d_1e_{t_1}t_{d_1}}{a_v}\right]}{(2h_{c_4})}}$$

$q_1 = q_2 > q_3 > q_4$

It is not satisfy the optimum.

Step 3

Fix k = 2

Let consider the inequality $q_2 - q_1 \ge 0$ and $q_3 - q_2 \ge 0$ into an equality $q_3 - q_2 = 0$

and $q_2 - q_1 = 0$.

$$L(q_1, q_2, q_3, q_4, \lambda_1, \lambda_2) = B((\tilde{T}_c) - \lambda_1(q_2 - q_1) - \lambda_2(q_3 - q_2) \quad (11)$$

$\frac{\partial L}{\partial q_1} = 0 \Rightarrow$

$$\frac{1}{18}\left[\frac{2h_{c_1}}{2} - \frac{1}{q_1^2}\left(2d_4l_1+2d_4s_1+2d_4p_1+2d_4c_{s_1}+2d_4i_1+2d_4m_1+2d_4s_{p_1}+2d_4f_{c_1}+2d_4h_1+2d_4(f_1+l_{c_1})+2d_4(c_{p_1}+l_{c_1})+2d_4(w_1+l_{c_1})+\frac{2d_4e_{t_1}t_{d_1}}{a_v}\right)\right]+\lambda_1 = 0 \quad (12)$$

$\frac{\partial L}{\partial q_2} = 0 \Rightarrow$

$$\frac{1}{18}\left[\frac{7h_{c_2}}{2} - \frac{1}{q_2^2}\left(7d_3l_3+7d_3s_3+7d_3p_3+7d_3c_{s_3}+7d_3i_3+7d_3m_3+7d_3s_{p_3}+7d_3f_{c_3}+7d_3h_3+7d_3(f_3+l_{c_3})+7d_3(c_{p_3}+l_{c_3})+7d_3(w_3+l_{c_3})+\frac{7d_3e_{t_3}t_{d_3}}{a_v}\right)\right]-\lambda_1+\lambda_2 = 0 \quad 13)$$

$\frac{\partial L}{\partial q_3} = 0$

$$\Rightarrow \frac{1}{18}\left[\frac{7h_{c_3}}{2} - \frac{1}{q_3^2}\left(7d_2l_2+7d_2s_2+7d_2p_2+7d_2c_{s_2}+7d_2i_2+7d_2m_2+7d_2s_{p_2}+7d_2f_{c_2}+7d_2h_2+7d_2(f_2+l_{c_2})+7d_2(c_{p_2}+l_{c_2})+7d_2(w_2+l_{c_2})+\frac{7d_2e_{t_2}t_{d_2}}{a_v}\right)\right]-\lambda_2 = 0 \quad --(14$$

$\frac{\partial L}{\partial q_4} = 0$

$$\Rightarrow \frac{1}{18}\left[\frac{2h_{c_4}}{2} - \frac{1}{q_4^2}\left(2d_1l_1+2d_1s_1+2d_1p_1+2d_1c_{s_1}+2d_1i_1+2d_1m_1+2d_1s_{p_1}+2d_1f_{c_1}+2d_1h_1+2d_1(f_1+l_{c_1})+2d_1(c_{p_1}+l_{c_1})+2d_1(w_1+l_{c_1})+\frac{2d_1e_{t_1}t_{d_1}}{a_v}\right)\right] = 0 --(15)$$

$$\frac{\partial L}{\partial \lambda_1} = 0 \Rightarrow -(q_2 - q_1) = 0 \text{ and } \frac{\partial L}{\partial \lambda_2} = 0 \Rightarrow -(q_4 - q_3) \quad (16)$$

(12) + (13) + (14) and From the equation (16)

$q_1 = q_2 = q_3 =$

$$\sqrt{\frac{2[(7l_2d_2 + 7l_3d_3 + 2l_4d_4) + (7s_2d_2 + 7s_3d_3 + 2s_4d_4) + (7p_2d_2 + 7p_3d_3 + 2p_4d_4) + (7c_{s_2}d_2 + 7c_{s_3}d_3 + 2c_{s_4}d_4) + (7i_2d_2 + 7i_3d_3 + 2i_4d_4) + (7m_2d_2 + 7m_3d_3 + 2m_4d_4) + (7s_{p_2}d_2 + 7s_{p_3}d_3 + 2s_{p_4}d_4) + (7f_{c_2}d_2 + 7f_{c_3}d_3 + 2f_{c_4}d_4) + (7h_2d_2 + 7h_3d_3 + 2h_4d_4) + (7(f_2 + l_{c_2})d_2 + 7(f_3 + l_{c_3})d_3 + 2(f_4 + l_{c_4})d_4) + (7(c_{p_2} + l_{c_2})d_2 + 7(c_{p_3} + l_{c_3})d_3 + 2(c_{p_4} + l_{c_4})d_4)] + (7(w_2 + l_{c_2})d_2 + 7(w_3 + l_{c_3})d_3 + 2(w_4 + l_{c_4})d_4) + \left(\frac{7e_{t_2}t_{d_2}d_2 + 7e_{t_3}t_{d_3}d_3 + 2e_{t_4}t_{d_4}d_4}{a_v}\right)}{2h_{c_1} + 7h_{c_2} + 7h_{c_3}}}$$

$q_1 = q_2 = q_3 > q_4$.

It is not attain the optimum.

Step 4

Fix k = 3

Let's consider the in equality $q_2 - q_1 \geq 0$,
$q_3 - q_2 \geq 0$ and $q_4 - q_3 \geq 0$ into an equality
$q_3 - q_2 = 0, q_2 - q_1 = 0$ *and* $q_4 - q_3 = 0.$

$$L(q_1, q_2, q_3, q_4, q_5, q_6, \lambda_1, \lambda_2, \lambda_3) = F(T_{\tilde{c}}) - \lambda_1(q_2 - q_1) - \lambda_2(q_3 - q_2) - \lambda_3(q_4 - q_3) \quad (16)$$

$\frac{\partial L}{\partial q_1} = 0 \Rightarrow$

$$\frac{1}{18}\left[\frac{2h_{c_1}}{2} - \frac{1}{q_1^2}\left(2d_4 l_1 + 2d_4 s_1 + 2d_4 p_1 + 2d_4 c_{s_1} + 2d_4 i_1 + 2d_4 m_1 + 2d_4 s_{p_1} + 2d_4 f_{c_1} + 2d_4 h_1 + 2d_4(f_1 + l_{c_1}) + 2d_4(c_{p_1} + l_{c_1}) + 2d_4(w_1 + l_{c_1}) + \frac{2d_4 e_{t_1} t_{d_1}}{a_v}\right)\right] + \lambda_1 = 0 \quad (17)$$

$\frac{\partial L}{\partial q_2} = 0 \Rightarrow$

$$\frac{1}{18}\left[\frac{7h_{c_2}}{2} - \frac{1}{q_2^2}\left(7d_3 l_3 + 7d_3 s_3 + 7d_3 p_3 + 7d_3 c_{s_3} + 7d_3 i_3 + 7d_3 m_3 + 7d_3 s_{p_3} + 7d_3 f_{c_3} + 7d_3 h_3 + 7d_3(f_3 + l_{c_3}) + 7d_3(c_{p_3} + l_{c_3}) + 7d_3(w_3 + l_{c_3}) + \frac{7d_3 e_{t_3} t_{d_3}}{a_v}\right)\right] - \lambda_1 + \lambda_2 = 0 \quad (18)$$

$\frac{\partial L}{\partial q_3} = 0$

$$\Rightarrow \frac{1}{18}\left[\frac{7h_{c_3}}{2} - \frac{1}{q_3^2}\left(7d_2 l_2 + 7d_2 s_2 + 7d_2 p_2 + 7d_2 c_{s_2} + 7d_2 i_2 + 7d_2 m_2 + 7d_2 s_{p_2} + 7d_2 f_{c_2} \quad 7d_2 h_2 + 7d_2(f_2 + l_{c_2}) + 7d_2(c_{p_2} + l_{c_2}) + 7d_2(w_2 + l_{c_2}) + \frac{7d_2 e_{t_2} t_{d_2}}{a_v}\right)\right] - \lambda_2 + \lambda_3 = 0 \quad (19)$$

$\frac{\partial L}{\partial q_4} = 0$

$$\Rightarrow \frac{1}{18}\left[\frac{2h_{c_3}}{2} - \frac{1}{q_4^2}\left(2d_1 l_1 + 2d_1 s_1 + 2d_1 p_1 + 2d_1 c_{s_1} + 2d_1 i_1 + 2d_1 m_1 + 2d_1 s_{p_1} + 2d_1 f_{c_1} + 2d_1 h_1 + 2d_1(f_1 + l_{c_1}) + 2d_1(c_{p_1} + l_{c_1}) + 2d_1(w_1 + l_{c_1}) + \frac{2d_1 e_{t_1} t_{d_1}}{a_v}\right)\right] - \lambda_3 = 0 \quad (20)$$

$$\frac{\partial L}{\partial \lambda_1} = 0 \Rightarrow -(q_2 - q_1) = 0, \frac{\partial L}{\partial \lambda_2} = 0 \Rightarrow -(q_3 - q_4) = 0 \text{ and } \frac{\partial L}{\partial \lambda_3} = 0 \Rightarrow -(q_4 - q_5) = 0 \quad (21)$$

(17) + (18) + (19) + (20) and from the equation (21) we obtain,

$q_1 = q_2 = q_3 = q_4 =$

$$\sqrt{\frac{2[(2l_1d_1 + 7l_2d_2 + 7l_3d_3 + 2l_4d_4) + (2s_1d_1 + 7s_2d_2 + 7s_3d_3 + 2s_4d_4) + (2p_1d_1 + 7p_2d_2 + 7p_3d_3 + 2p_4d_4) + (2c_{s_1}d_1 + 7c_{s_2}d_2 + 7c_{s_3}d_3 + 2c_{s_4}d_4) + (2i_1d_1 + 7i_2d_2 + 7i_3d_3 + 2i_4d_4) + (2m_1d_1 + 7m_2d_2 + 7m_3d_3 + 2m_4d_4) + (2s_{p_1}d_1 + 7s_{p_2}d_2 + 7s_{p_3}d_3 + 2s_{p_4}d_4) + (2f_{c_1}d_1 + 7f_{c_2}d_2 + 7f_{c_3}d_3 + 2f_{c_4}d_4) + (2h_1d_1 + 7h_2d_2 + 7h_3d_3 + 2h_4d_4) + (2(f_1 + l_{c_1})d_1 + 7(f_2 + l_{c_2})d_2 + 7(f_3 + l_{c_3})d_3 + 2(f_4 + l_{c_4})d_4) + (2(c_{p_1} + l_{c_1})d_1 + 7(c_{p_2} + l_{c_2})d_2 + 7(c_{p_3} + l_{c_3})d_3 + 2(c_{p_4} + l_{c_4})d_4)] + (2(w_1 + l_{c_1})d_1 + 7(w_2 + l_{c_2})d_2 + 7(w_3 + l_{c_3})d_3 + 2(w_4 + l_{c_4})d_4) + \left(\frac{2e_{t_1}t_{d_1}d_1 + 7e_{t_2}t_{d_2}d_2 + 7e_{t_3}t_{d_3}d_3 + 2e_{t_4}t_{d_4}d_4}{a_v}\right)}{2h_{c_1} + 7h_{c_2} + 7h_{c_3} + 2h_{c_4}}}$$

Numerical Example

D = 4000; h_c = 250; L = 2000000; S =1000; P=10000 C_s =5000; F = 4000; L_c = 4000; I =5000; M =9000; F_c =70,000; S_p = 400000; C_p=1000; H = 5000; W =1000; t_d = 500km; E_t =35; A_v =150 km/hr

Solution

Crisp sense

q = 8985.529

Total inventory cost (T_c) = 2,246,382.277

Fuzzy sense

$\tilde{D}$ = (3900, 3950, 4050, 4100); $\widetilde{h_c}$ = (230,240,260,270); $\tilde{L}$ = (1999900, 1999950, 2000050, 2000100); $\widetilde{SS}$ = (900, 950, 1050,1100); $\tilde{P}$=(9800, 9900, 10100, 10200) $\widetilde{C_s}$ = (4900, 4950, 5050, 5100); $\tilde{F}$ = (3900, 3950, 4050, 4100); $\widetilde{L_c}$ = (3900, 3950, 4050, 4100); $\tilde{I}$=(4900, 4950, 5050, 5100); $\tilde{M}$ =(8900, 8950, 9050, 9100); $\widetilde{F_c}$ =(69900, 69950,70050, 70100); $\widetilde{S_p}$=(399900, 399950, 400050, 400100); $\widetilde{C_p}$=(900, 950, 1050, 1100); $\tilde{H}$ = (4900, 4950, 5050, 5100); $\tilde{W}$ =(900, 950, 1050, 1100); t_d = (480, 490, 510, 520); $\widetilde{E_t}$ =(33, 34, 36, 37); $\widetilde{A_v}$ =(140, 145, 155, 160) km/hr

$Q^* = 8985.557$

Fuzzy total inventory cost $\widetilde{T_c}$={2123494.271, 2187060.508, 2305713.14, 2365052.891}

$\widetilde{BT_c}$= 2245917.187

Conclusion

Rice cultivation could turn profitable in just a short period of time with the right field management techniques and irrigation system. Paddy output has substantially grown, although the yield is still lower than that of all other crops. Farmers are achieving more growth in the future by utilising modern technologies like soil and seed testing. Future generations must protect our agriculture, and we must adopt modern technology that is environmentally friendly. Here, the fuzzy parameters are represented by trapezoidal fuzzy numbers, and by using the beta distribution approach to defuzzify the parameters, the fuzzy inventory model provides farmers with the optimal solution while also assisting in environmental preservation. A numerical comparison of crisp and fuzzy sensations was carried out.

References

Ahmad, N., Rehman, A. U., Rehman, A., Ahmad, S., Siddique, K. H. M., & Farooq, M. (2022). Increasing sustainability for rice production systems. *Journal of Cereal Science*, *103*, 103400.

Devi, S. K., & Ponnarasi, T. (2009). An economic analysis of modern rice production technology and its adoption behavior in Tamil Nadu. *Agricultural Economics Research Review*, *22*, 341-347.

Durairaj, M., & Poornappriya, T. S. (2018). Choosing a spectacular Feature Selection technique for telecommunication industry using fuzzy TOPSIS MCDM. *International Journal of Engineering & Technology*, *7*(4), 5856-5861.

Goodman, B. A. (2020). Utilization of waste straw and husks from rice production: A review. *Journal of Bioresources and Bioproducts*, *5*(3), 143-162.

Jothi Sivagnanam, K., & Murugan, K. (2020). Impact of hybrid rice cultivation on farmers' livelihood in Tamil Nadu. *Journal of Land and Rural Studies*, *8*(1), 22-36.

Murugan, K., & Jothi Sivagnanam, K. (2020). Impact of hybrid rice cultivation on production in Tamil Nadu. *Research Journal of Humanities and Social Sciences*, *11*(1), 48-56.

Nguyen, N. V., & Ferrero, A. (2006). Meeting the challenges of global rice production. *Paddy and Water Environment*, *4*(1), 1-9.

Poornappriya, T. S., & Durairaj, M. (2019). High relevancy low redundancy vague set based feature selection method for telecom dataset. *Journal of Intelligent & Fuzzy Systems*, *37*(5), 6743-6760.

Priyadharshini, D., Gopinath, R., & Poornappriya, T. S. (2020). A fuzzy MCDM approach for measuring the business impact of employee selection. *International Journal of Management (IJM)*, *11*(7), 1769-1775.

Rahaman, M. M., Islam, K. S., & Jahan, M. (2018). Rice farmers' knowledge of the risks of pesticide use in Bangladesh. *Journal of Health and Pollution*, *8*(20), 181203.

Richard Paul, V., & Radha Devi, S. (2017). A study on determinants of yield of paddy cultivation with special reference to Madurai District. *International Journal of Current Advanced Research*, *6*(8), 5246-5249.

Sowndariya, I. (2022). A study on the challenges faced by farmers towards paddy cultivation in Odacherry Village, Thiruvarur District. *International Journal of Creative and Research Thoughts*, *10*(5), 2320-2882.

Tripathy, S., Khan, A., & Kumar, T. S. (2018). Understanding of spending and earning of paddy farming in one-acre land under three different practices of Keelamattiyan village, Madurai, Tamil Nadu. *International Journal for Research Trends and Innovation*, *3*(12), 2456-3315.

Vasanthi, R., Sivasankari, B., Gitanjali, J., & Paramasivam, R. (2017). Efficiency analysis of paddy production in tank irrigated systems of Southern Zone in Tamil Nadu, India. *International Journal of Current Microbiology and Applied Sciences*, *6*(6), 1161-1167.

Yuan, L. P. (2004). Hybrid rice technology for food security in the world. In *Keynotes presented at the International Conference on Sustainable Rice Systems*, FAO, Rome, Italy.