

Fuzzy Expert system for the Impact of Climate Change in Indian Agriculture

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Abstract: Fuzzy Expert system is potent tool to mimic the human way of thinking and solve the problem when there is full uncertainty in it. The goal of this paper is to frame the fuzzy expert system to examine the impact of climate change in the Indian Agriculture. Agriculture is the basis of Indian economy and agriculture is utterly relying on the environment. If there is any undesirable change in the environment, it leads to a lot of unpleasant impact on the agriculture. Climate change can easily interrupt the food availability and affect the food quality.

Keywords: Linguistic variable, Fuzzy Number, Fuzzy Expert system, Climate Change, Agriculture.

1. Introduction:

Expert System is the division of applied artificial intelligence, it is well used to take an expert view in the absence of a human expertise [18]. Due to the absence of expert in a particular field, FES will solve the real world complex problem (Zadeh, 1965) [19]. It was first introduced by Kandel (Kandel, 1992) [9]. It is an intelligent tool and capable of making decisions and dealing with ambiguous data. FES improved the excellence, effectiveness and quality in recent years. FES has been applied in many real world problems such as medical diagnosis, agricultural problem to deal the vagueness by mimic the human way of thinking [18]. In 1998, Hayo M.G. et.al, proposed a fuzzy expert system to compute an indicator of “Ipest” which reflects an expert perception of the potential environmental impact by applying pesticides in the field [7]. In 2000, Roussel, O et.al has revealed very large differences with respect to overall effect of pesticide within each of the three crops and its environmental conditions [12]. In 2006, Duque et.al constructed a fuzzy inference system (FIS) to assess water quality index with the fuzzy reasoning [5]. In 2009, Reshmidevi, et.al, presented a GIS-integrated fuzzy rule-based inference system to assess the land suitability for agrarian watersheds by incorporating both land potential and surface water potential [11].

In 2010, Guillaume, S and Charnomordic, B presented fuzzy inference system profession (FisPro), which is illustrated through three real world applications. FisPro is constructed to respond precisely the needs of interpretable FIS and learning [6]. Rajaram, T., Das, A proposed a fuzzy rule based model for the interactions of sustainability components in an agro-ecosystem for the typical agricultural village in southern India [10]. In 2012, Amindoust et.al, reviewed to decide the sustainable supplier selection indicators. Then, they have suggested a new ranking method for FIS [1]. Sattler, C presented to depict a modeling approach for the ex-ante evaluation of farming practices with regard to their hazard for several single-species biodiversity indicators (Sattler, 2012) [14]. Yelapure, and Kulkarni explained the need of expert system in agriculture and review of various expert systems in agriculture (Yelapure, 2012) [17]. In 2013, Dubey, S

et.al., presented a review of various fuzzy expert systems in agriculture over the last two decades [4].

In 2014, Djatkov, D., et.al, developed a fuzzy expert system for evaluating and improving the efficiency of agricultural biogas plants in more consistent and systematic manner [3]. Sami, M et.al., constructed fuzzy inference system, considered to be the suitable, uncomplicated and effective tool for the Environmental comprehensive evaluation of agrarian frameworks at the farm level (Sami, 2014) [13]. Tagarakis, A et.al aimed to the present study to develop and validate a fuzzy expert system to categorize grape quality based on selected grape features and to produce a total grape quality map and confirm its spatial significance by comparing with soil and yields (Tagarakis, 2014) [16]. In 2015, Cavallaro, F proposed a synthetic index based on a fuzzy inference system to evaluate the sustainability of production and use of crops devoted for energy purposes (Cavallaro, 2015) [2]. Jasutkar and Khan, presented a paper to review of fuzzy inference system is used worldwide for impact assessment of environment (Jasutkar, 2015) [8]. In 2016, Semeraro, T et.al constructed a model by integrating the multi-criteria analysis and Fuzzy Expert System (FES) for GIS environment in order to recognize and map potential “hotspots” of fire vulnerability, where fire security measures can be undertaken in advance [15]. From this review, it is perceived that a fuzzy expert system may be designed for the impact of climate change in the Indian agriculture because Agriculture is the basis of Indian economy and agriculture is utterly relying on the environment. If there is any undesirable change in the environment, it leads to a lot of unpleasant impact on the agriculture.

2. Theoretical Background

Definition 2.1 A fuzzy set $\tilde{A}$ is a subset of a universe of discourse X , which is characterized by a membership function $\mu_{\tilde{A}}(x)$ representing a mapping $\mu_{\tilde{A}}: X \rightarrow [0,1]$. The function value of $\mu_{\tilde{A}}(x)$ is called the membership value, which represents the degree of truth that x is an element of fuzzy set $\tilde{A}$.

Definition 2.2 A fuzzy set $\tilde{A}$ defined on the set of real numbers R is said to be a fuzzy number and its membership function $\tilde{A}: R \rightarrow [0,1]$ has the following characteristics,

- (i) $\tilde{A}$ is convex.

$$\mu_{\tilde{A}}(\lambda x_1 + (1-\lambda)x_2) \geq \min(\mu_{\tilde{A}}(x_1), \mu_{\tilde{A}}(x_2)), \forall x \in [x_1, x_2], \lambda \in [0,1].$$
- (ii) $\tilde{A}$ is normal if $\max \mu_{\tilde{A}}(x) = 1$.
- (iii) $\tilde{A}$ is piecewise continuous.

Definition 2.3 The α -cut of the fuzzy set $\tilde{A}$ of the universe of discourse X is defined as $\tilde{A}_{\alpha} = \{x \in X / \mu_{\tilde{A}}(x) \geq \alpha\}$, where $\alpha \in [0,1]$.

Definition 2.4 A triangular fuzzy number $\tilde{N}$ can be defined as a triplet (l, m, r) and the membership function $\mu_{\tilde{N}}(x)$ is defined as:

$$\mu_{\tilde{N}}(x) = \begin{cases} 0 & x < l \\ \left(\frac{x-l}{m-l}\right) & l \leq x \leq m \\ \left(\frac{r-x}{r-m}\right) & m \leq x \leq r \\ 0 & x > r \end{cases}$$

Where l, m, r are real numbers and $l \leq m \leq r$.

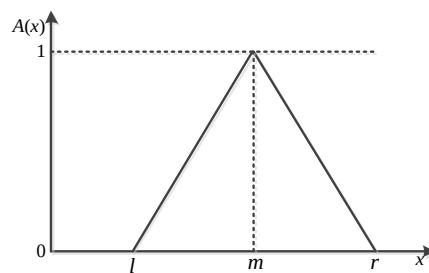


Figure-1: Triangular Fuzzy Number

Definition 2.5 A trapezoidal fuzzy number $\tilde{A}$ can be defined as (a_1, a_2, a_3, a_4) and the membership function is defined as

$$\mu_{\tilde{A}}(x) = \begin{cases} \left(\frac{x-a_1}{a_2-a_1}\right) & a_1 \leq x \leq a_2 \\ 1 & a_2 \leq x \leq a_3 \\ \left(\frac{a_3-x}{a_4-a_3}\right) & a_3 \leq x \leq a_4 \\ 0 & a_1 \leq 0 \text{ \& } a_4 \geq 0 \end{cases}$$

Where a_1, a_2, a_3, a_4 are real numbers $a_1 \leq a_2 \leq a_3 \leq a_4$.

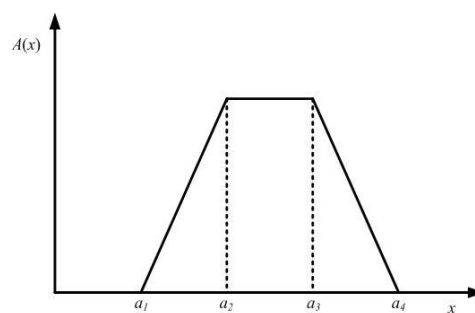


Figure 2: Trapezoidal Fuzzy Number

3. Problem Description:

Agriculture is an important sector of the Indian economy. If there is any undesirable change in the environment, it leads to a lot of unpleasant impact on the agriculture. Climate change can easily interrupt the availability and the quality of the food. For instance, increases in global temperatures, alter extreme weather events and reductions in water availability may all lead in to less agricultural yield. Increasing temperatures can contribute to wastage of things and contamination as well. The followings are major issues faced by Indian agriculture, rise in temperature, weather disasters, freshwater availability, monsoon level, species extinction, spread of new diseases and deforestation. Therefore, this present study aims to construct the expert system for analyzing the impact of climate change in the Indian agriculture.

In this system, we have seven input variables such as Rise in Temperature, Weather Disasters, Fresh Water Availability, Monsoon Level, Species Extinction, Spread of New Diseases, Deforestation, and one output Agriculture Productivity, which are classified and provided a the suitable membership function using triangular and trapezoidal fuzzy number.

A₁-Rise in Temperature (°C):

Temperatures are certain to go up further. Average surface temperature is increasing due to emission of greenhouse gases in the atmosphere. Temperature is one of the vital variables influencing crop production.

We have divided Rise in Temperature into five fuzzy sets as follows:

Very Low (VL)	≤ 20
Low (L)	15 to 25
Medium (M)	22 to 30
High (H)	28 to 40
Very High (VH)	≥ 35

Table 1: Classification of Age Rise in Temperature

The suitable membership functions of the above classifications are given below:

$$\mu_{VL}(x) = \begin{cases} 1, & x \leq 0 \\ \frac{20-x}{20}, & 0 < x < 20 \\ 0, & x \geq 20 \end{cases}, \quad \mu_L(x) = \begin{cases} 0, & x \leq 15 \text{ and } x \geq 25 \\ \frac{x-15}{5}, & 15 < x \leq 20 \\ \frac{25-x}{5}, & 20 < x < 25 \end{cases}$$

$$\mu_M(x) = \begin{cases} 0, & x \leq 22 \text{ and } x \geq 30 \\ \frac{x-22}{4}, & 22 < x \leq 26 \\ \frac{30-x}{4}, & 26 < x < 30 \end{cases}, \quad \mu_H(x) = \begin{cases} 0, & x \leq 28 \text{ and } x \geq 40 \\ \frac{x-28}{7}, & 28 < x \leq 35 \\ \frac{40-x}{5}, & 35 < x < 40 \end{cases}$$

$$\mu_{VH}(x) = \begin{cases} 0, & x \leq 35 \\ \frac{x-35}{25}, & 35 < x < 60 \\ 1, & x \geq 60 \end{cases}$$

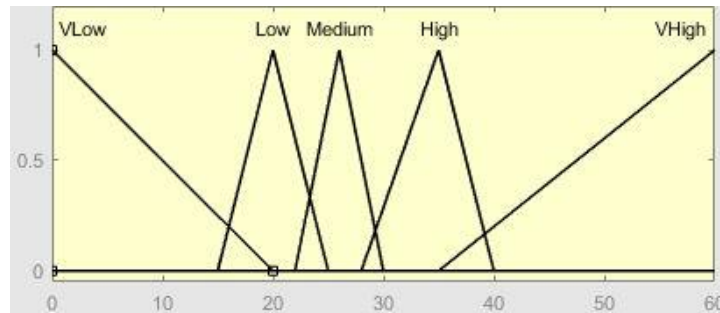


Figure 3: Classification of Age Rise in Temperature

A₂-Weather Disasters (%):

Agricultural impacts on natural events and disasters includes such as Flood, Drought, Earthquakes, Windstorms Destruction. Floods create land as vulnerable for agricultural production until waters move away, where as hurricanes washout arable land or permanently increase its salinity through storm surges and flash floods. Drought impacts on crops growth and development of soil moisture, root growth, shoot growth.

We have divided Weather Disasters into five fuzzy sets as follows:

Very Low (VL)	≤ 20
Low (L)	15 to 30
Medium (M)	25 to 40
High (H)	35 to 60
Very High (VH)	≥ 50

Table 2: Classification of Weather Disasters (%)

The suitable membership functions of the above classifications are given below:

$$\mu_{VL}(x) = \begin{cases} 0, & x < 0 \text{ and } x \geq 20 \\ 1, & 0 \leq x \leq 5 \\ \frac{20-x}{15}, & 5 < x < 20 \end{cases}, \quad \mu_L(x) = \begin{cases} 0, & x \leq 15 \text{ and } x \geq 30 \\ \frac{x-15}{5}, & 15 < x < 20 \\ 1, & 20 \leq x \leq 23 \\ \frac{30-x}{7}, & 23 < x < 30 \end{cases}$$

$$\mu_M(x) = \begin{cases} 0, & x \leq 25 \text{ and } x \geq 40 \\ \frac{x-25}{5}, & 25 < x < 30 \\ 1, & 30 \leq x \leq 33 \\ \frac{40-x}{7}, & 33 < x < 40 \end{cases}, \quad \mu_H(x) = \begin{cases} 0, & x \leq 35 \text{ and } x \geq 60 \\ \frac{x-35}{7}, & 35 < x < 42 \\ 1, & 42 \leq x \leq 50 \\ \frac{60-x}{10}, & 50 < x < 60 \end{cases}$$

$$\mu_{VH}(x) = \begin{cases} 0, & x \leq 50 \\ \frac{x-50}{10}, & 50 < x < 60 \\ 1, & x \geq 60 \end{cases}$$

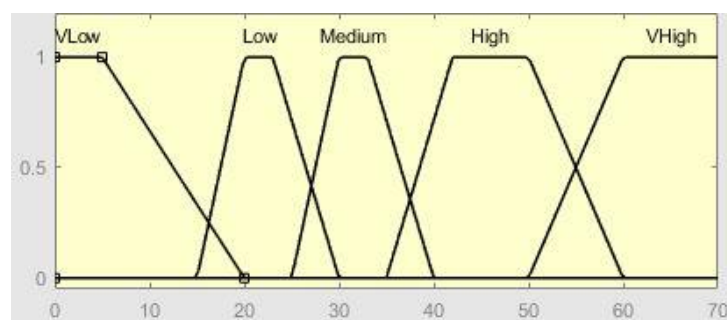


Figure 4: Classification of Weather Disasters (%)

A3-Fresh Water Availability (%)

India is facing a decrease in available water resources that has implications on India's agriculture sector. India's total water supply totally depends on groundwater resources, which is also a cause of anxiety.

We have divided Fresh Water Availability into five fuzzy sets as follows:

Very Low (VL)	≤ 2.5
Low (L)	1 to 4
Medium (M)	3 to 5
High (H)	4.5 to 7
Very High (VH)	≥ 6.5

Table 3: classification of Fresh Water Availability (%)

The suitable membership functions of the above classifications are given below,

$$\mu_{VL}(x) = \begin{cases} 1, & x \leq 0 \\ \frac{2.5-x}{2.5}, & 0 < x < 2.5 \\ 0, & x \geq 2.5 \end{cases}, \quad \mu_L(x) = \begin{cases} 0, & x \leq 1 \text{ and } x \geq 4 \\ \frac{x-1}{1.5}, & 1 < x < 2.5 \\ \frac{4-x}{1.5}, & 2.5 < x < 4 \end{cases}$$

$$\mu_M(x) = \begin{cases} 0, & x \leq 3 \text{ and } x \geq 5 \\ x-3, & 3 < x < 4 \\ 5-x, & 4 < x < 5 \end{cases}, \quad \mu_H(x) = \begin{cases} 0, & x \leq 4.5 \text{ and } x \geq 7 \\ \frac{x-4.5}{1.5}, & 4.5 < x < 6 \\ 7-x, & 6 < x < 7 \end{cases}$$

$$\mu_{VH}(x) = \begin{cases} 0, & x \leq 6.5 \\ \frac{x-6.5}{3.5}, & 6.5 < x < 10 \\ 1, & x \geq 10 \end{cases}$$

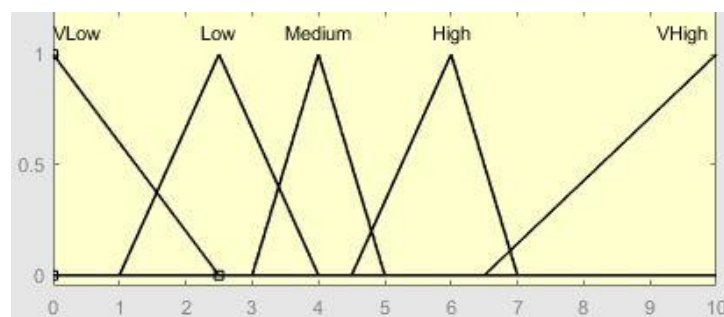


Figure 5: Classification of Fresh Water Availability (%)

A4-Monsoon Level (mm)

An increase (decrease) in rainfall is generally associated with an increase (decrease) in agriculture production. Monsoon rains continue to be important in determining the levels of agricultural output in India.

We have divided Monsoon Level into five fuzzy sets as follows:

Very Low (VL)	≤ 200
Low (L)	100 to 650
Medium (M)	500 to 1200
High (H)	900 to 2200
Very High (VH)	≥ 1800

Table 4: Classification of Monsoon Level (mm)

The suitable membership functions of the above classifications are given below,

$$\mu_{VL}(x) = \begin{cases} 0, & x < 0 \text{ and } x \geq 200 \\ 1, & 0 \leq x \leq 100 \\ \frac{200-x}{100}, & 100 < x < 200 \end{cases}, \quad \mu_L(x) = \begin{cases} 0, & x \leq 100 \text{ and } x \geq 650 \\ \frac{x-100}{100}, & 100 < x < 200 \\ 1, & 200 \leq x \leq 400 \\ \frac{650-x}{150}, & 400 < x < 650 \end{cases}$$

$$\mu_M(x) = \begin{cases} 0, & x \leq 500 \text{ and } x \geq 1200 \\ \frac{x-500}{100}, & 500 < x < 600 \\ 1, & 600 \leq x \leq 900 \\ \frac{1200-x}{300}, & 900 < x < 1200 \end{cases}, \quad \mu_H(x) = \begin{cases} 0, & x \leq 900 \text{ and } x \geq 2200 \\ \frac{x-900}{500}, & 900 < x < 1400 \\ 1, & 1400 \leq x \leq 1700 \\ \frac{2200-x}{500}, & 1700 < x < 2200 \end{cases}$$

$$\mu_{VH}(x) = \begin{cases} 0, & x \leq 1800 \\ \frac{x-1800}{300}, & 1800 < x < 2100 \\ 1, & x \geq 2100 \end{cases}$$

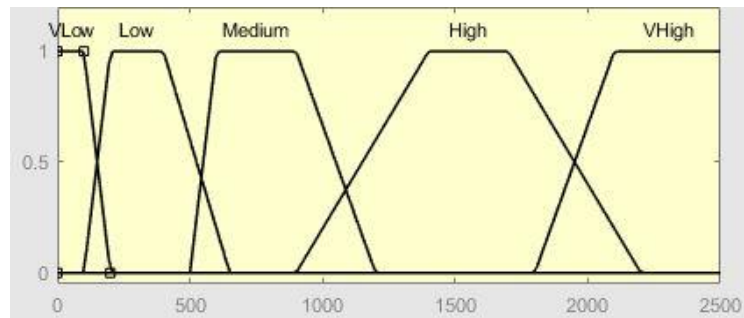


Figure 6: Classification of Monsoon Level (mm)

A5-Species Extinction (%)

By using the pesticides and toxic fertilizers, agriculture affects our ecosystems through the reduction of certain species of plants and animals. Use of pesticides, chemical fertilizers, energy supplements, and grazing are other factors for species extinction.

We have divided Species Extinction into five fuzzy sets as follows:

Very Low (VL)	≤ 1.4
Low (L)	1 to 3.8
Medium (M)	3 to 5.2
High (H)	4.5 to 7.6
Very High (VH)	≥ 6

Table 5: Classification of Species Extinction (%)

The suitable membership functions of the above classifications are given below,

$$\mu_{VL}(x) = \begin{cases} 1, & x \leq 0 \\ \frac{1.4-x}{1.4}, & 0 < x < 1.4 \\ 0, & x \geq 1.4 \end{cases}, \quad \mu_L(x) = \begin{cases} 0, & x \leq 1 \text{ and } x \geq 3.8 \\ x-1, & 1 < x \leq 2 \\ \frac{3.8-x}{1.8}, & 2 < x < 3.8 \end{cases}$$

$$\mu_M(x) = \begin{cases} 0, & x \leq 3 \text{ and } x \geq 5.2 \\ x-3, & 3 < x \leq 4 \\ \frac{5.2-x}{1.2}, & 4 < x < 5.2 \end{cases}, \quad \mu_H(x) = \begin{cases} 0, & x \leq 4.5 \text{ and } x \geq 7.6 \\ x-4.5, & 4.5 < x \leq 5.5 \\ \frac{7.6-x}{2.1}, & 5.5 < x < 7.6 \end{cases}$$

$$\mu_{VH}(x) = \begin{cases} 0, & x \leq 6 \\ \frac{x-6}{2}, & 6 < x < 8 \\ 1, & x \geq 8 \end{cases}$$

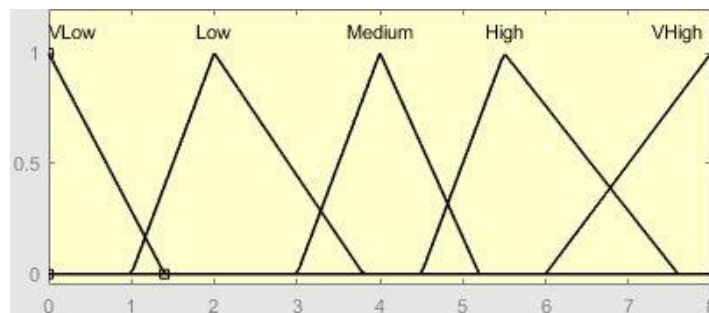


Figure 7: Classification of Species Extinction (%)

A6-Spread of New Diseases (%)

Diseases have a harmful effect on crops and impact on market access and agricultural production. Diseases incorporate small scale creatures, ailment specialists, infectious agents, parasites and hereditary issues.

We have divided Spread of Diseases into five fuzzy sets as follows:

Very Low (VL)	≤ 10
Low (L)	5 to 20
Medium (M)	15 to 25
High (H)	20 to 30
Very High (VH)	≥ 25

Table 6 : Classification of Spread of New Diseases (%)

The suitable membership functions of the above classifications are given below,

$$\mu_{VL}(x) = \begin{cases} 1, & x \leq 0 \\ \frac{10-x}{10}, & 0 < x < 10 \\ 0, & x \geq 10 \end{cases}, \quad \mu_L(x) = \begin{cases} 0, & x \leq 5 \text{ and } x \geq 20 \\ \frac{x-5}{8}, & 5 < x \leq 13 \\ \frac{20-x}{7}, & 13 < x < 20 \end{cases}$$

$$\mu_M(x) = \begin{cases} 0, & x \leq 15 \text{ and } x \geq 25 \\ \frac{x-15}{5}, & 15 < x \leq 20 \\ \frac{25-x}{5}, & 20 < x < 25 \end{cases}, \quad \mu_H(x) = \begin{cases} 0, & x \leq 20 \text{ and } x \geq 30 \\ \frac{x-20}{5}, & 20 < x \leq 25 \\ \frac{30-x}{5}, & 25 < x < 30 \end{cases}$$

$$\mu_{VH}(x) = \begin{cases} 0, & x \leq 25 \\ \frac{x-25}{10}, & 25 < x < 35 \\ 1, & x \geq 35 \end{cases}$$

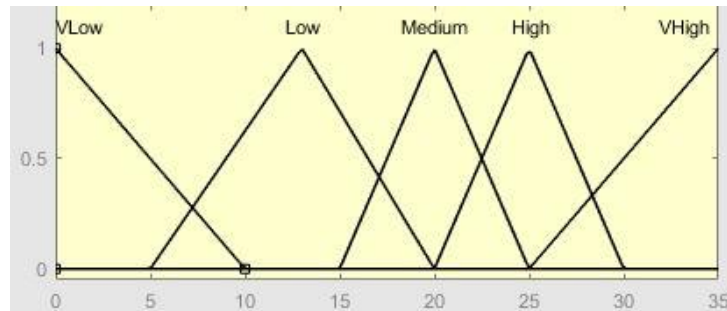


Figure 8: Classification of Spread of New Diseases (%)

A7-Deforestation (%)

Deforestation is the destruction of forest into industrial areas. Loss of biodiversity occurs due to deforestation. Deforestation is one of the reasons for global warming. It will also reduce the agriculture productivity.

We have divided Deforestation into five fuzzy sets as follows:

Very Low (VL)	≤ 0.2
Low (L)	0.1 to 0.6
Medium (M)	0.5 to 1
High (H)	0.8 to 1.3
Very High (VH)	≥ 1.2

Table 7: Classification of Deforestation (%)

The suitable membership functions of the above classifications are given below,

$$\mu_{VL}(x) = \begin{cases} 1, & x \leq 0 \\ \frac{0.2-x}{0.2}, & 0 < x < 0.2 \\ 0, & x \geq 0.2 \end{cases}, \quad \mu_L(x) = \begin{cases} 0, & x \leq 0.1 \text{ and } x \geq 0.6 \\ \frac{x-0.1}{0.3}, & 0.1 < x \leq 0.4 \\ \frac{0.6-x}{0.2}, & 0.4 < x < 0.6 \end{cases}$$

$$\mu_M(x) = \begin{cases} 0, & x \leq 0.5 \text{ and } x \geq 1 \\ \frac{x-0.5}{0.2}, & 0.5 < x \leq 0.7 \\ \frac{1-x}{0.3}, & 0.7 < x < 1 \end{cases}, \quad \mu_H(x) = \begin{cases} 0, & x \leq 0.8 \text{ and } x \geq 1.3 \\ \frac{x-0.8}{0.2}, & 0.8 < x \leq 1 \\ \frac{1.3-x}{0.3}, & 1 < x < 1.3 \end{cases}$$

$$\mu_{VH}(x) = \begin{cases} 0, & x \leq 1.2 \\ \frac{x-1.2}{0.3}, & 1.2 < x < 1.5 \\ 1, & x \geq 1.5 \end{cases}$$

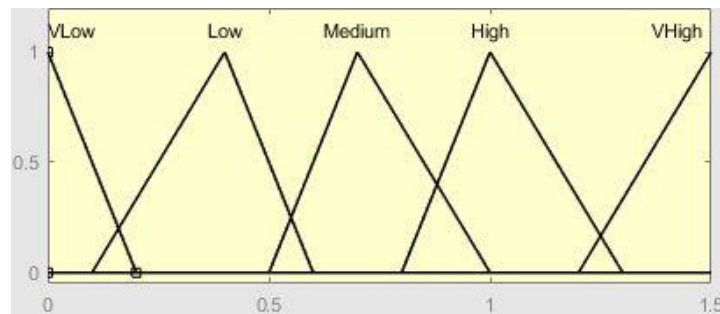


Table 9: Classification of Deforestation (%)

Output Variable

R1-Agriculture Productivity

The productivity of Agricultural is measured as the ratio of agricultural outputs to agricultural inputs. Agriculture production plays most important role in Indian economy and it must be increased.

We have divided Agriculture productivity into five fuzzy sets as follows:

Very Low (VL)	≤ 0.25
Low (L)	0 to 0.5
Medium (M)	0.25 to 0.75
High (H)	0.5 to 1
Very High (VH)	≥ 0.75

Table 8: Classification of Agriculture Productivity

The suitable membership functions of the above classifications are given below,

$$\mu_{VL}(x) = \begin{cases} 1, & x \leq 0 \\ \frac{0.25-x}{0.25}, & 0 < x \leq 0.25 \\ 0, & x \geq 0.25 \end{cases}, \quad \mu_L(x) = \begin{cases} 0, & x \leq 0 \text{ and } x \geq 0.5 \\ \frac{x}{0.25}, & 0 < x \leq 0.25 \\ \frac{0.5-x}{0.25}, & 0.25 < x < 0.5 \end{cases}$$

$$\mu_M(x) = \begin{cases} 0, & x \leq 0.25 \text{ and } x \geq 0.75 \\ \frac{x-0.25}{0.25}, & 0.25 < x \leq 0.5 \\ \frac{0.75-x}{0.25}, & 0.5 < x < 0.75 \end{cases}, \quad \mu_H(x) = \begin{cases} 0, & x \leq 0.5 \text{ and } x \geq 1 \\ \frac{x-0.5}{0.25}, & 0.5 < x \leq 0.75 \\ \frac{1-x}{0.25}, & 0.75 < x < 1 \end{cases}$$

$$\mu_{VH}(x) = \begin{cases} 0, & x \leq 0.75 \\ \frac{x-0.75}{0.25}, & 0.75 < x < 1 \\ 1, & x \geq 1 \end{cases}$$

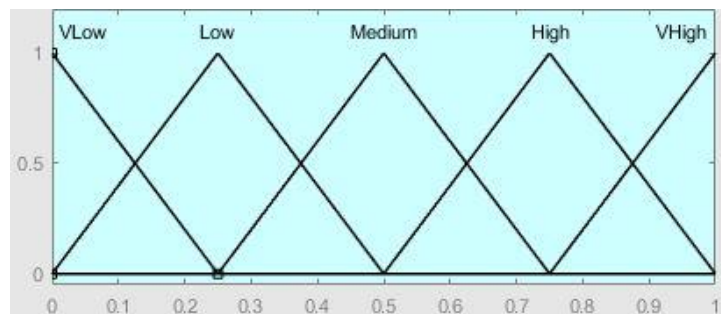


Figure 10: Classification of Agriculture Productivity

4. Algorithm for the Fuzzy Expert System

Step-1 Here, n input factor A_i , $i = 1, 2, \dots, n$ and m outputs R_j , $j = 1, 2, \dots, m$.

Step-2 Divide the input factors A_i , $i = 1, 2, \dots, n$ and m outputs factors R_j , $j = 1, 2, \dots, m$ into linguistic terms.

Step-3 Construct the suitable fuzzy membership function for each linguistic terms D_i , R_j using the available information.

Step-4 Develop q If-then rules with aid of expert's (E_i), $i = 1, 2, \dots, k$

(i) Input- Fuzzy strings from R_q and the value of the parameter D_i .

(ii) Calculating the sting strength $w_q = A_1 \wedge A_2 \wedge \dots \wedge A_q$

(iii) $O_p = p^{th}$ rule's consequent fuzzy rules.

$$(iv) \text{Output of the system} = \sum_{p=1}^r \frac{O_p w_p}{w_p}$$

Step-5 Final output would be the required impact.

5. Results and Discussion

Step-1 Choose the 7 input factors rise in temperature, weather disasters, fresh water availability, monsoon level, species extinction, spread of new diseases and deforestation are chosen and the Agriculture productivity is considered as output.

Step-2-3 All the input and output parameters are classified into linguistic term, then, suitable membership functions are constructed using the available information for all the linguistics.

Step-4 Fuzzy Rule based is the most important part in fuzzy expert system and Excellency of results in a fuzzy expert system depends on the fuzzy rules.

Designed system was designed with inference mechanism Mamdani approach. In this system, the logical combination of inputs with AND operation is considered. For defuzzification process, 'centroid' method is used in the designed system. The 3D surface viewer designed on the basis of the rule base.

Case 1: The input variables of agriculture productivity are {(35°C, Rise in Temperature), (35%, Weather Disasters), (4.5%, Fresh Water Availability), (125mm, Monsoon Level), (4%, Species Extinction), (17.5%, Spread of new Diseases), (0.75%, Deforestation)}.

A_1 : Rise in Temperature = {(0, VL), (0, L), (0, M), (1, H), (0, VH)}.

A_2 : Weather Disasters = {(0, VL), (0, L), (1, M), (0, H), (0, VH)}.

A_3 : Fresh Water Availability = {(0, VL), (0, L), (1, M), (0, H), (0, VH)}.

A_4 : Monsoon Level = {(0, VL), (1, L), (0, M), (0, H), (0, VH)}.

A_5 : Species Extinction = {(0, VL), (0, L), (1, M), (0, H), (0, VH)}.

A_6 : Spread of new Diseases = {(0, VL), (0, L), (1, M), (0, H), (0, VH)}.

A_7 : Deforestation = {(0, VL), (0, L), (1, M), (0, H), (0, VH)}.

This is the fuzzy set which represents the state of medium agriculture productivity, whose linguistic string (Very Low (VL), Low (L), Medium (M), High (H), Very High (VH)).

The rule states that if rise in temperature is high and weather disaster is medium and fresh water availability is medium and monsoon level is low and species extinction is medium and spread of new diseases is medium and deforestation is medium then agriculture productivity is medium.

Hence, agriculture productivity is medium level with 0.5 membership grade.



Figure 11: Rule Based system

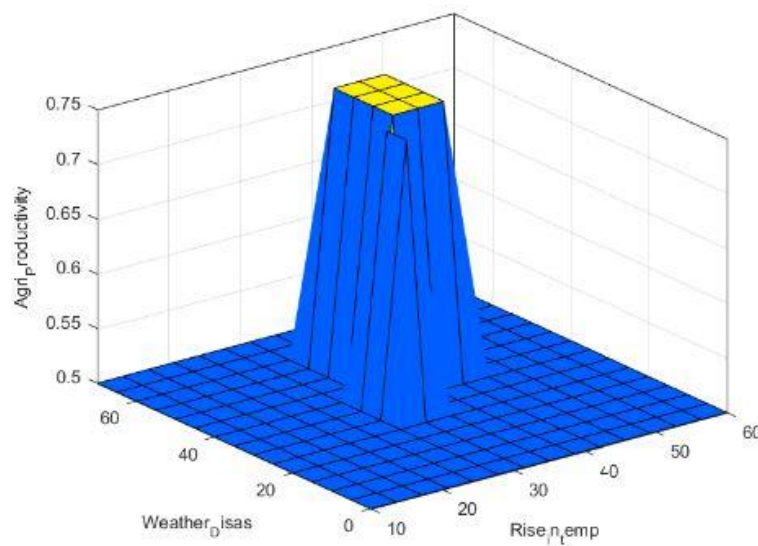


Figure 12: Surface viewer weather disaster and Rise in temperature to Agricultural productivity

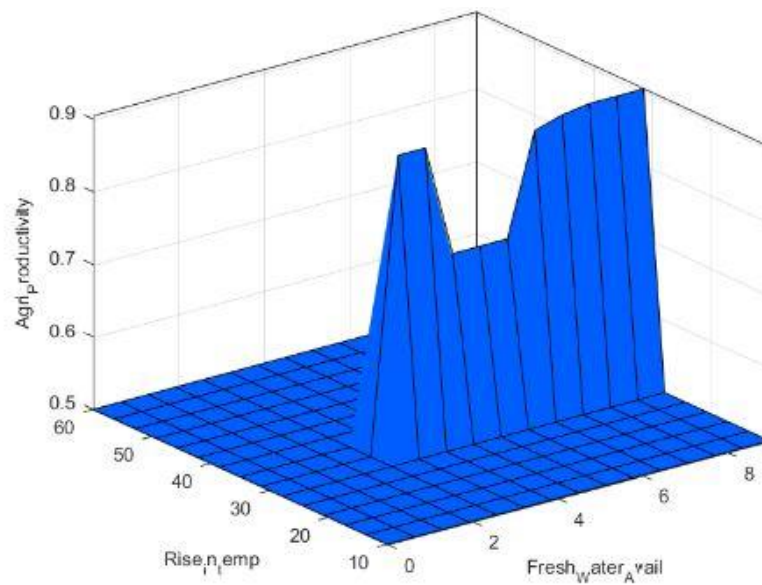


Figure 13: Surface viewer of Rise in Temperature and fresh water availability to Agricultural productivity

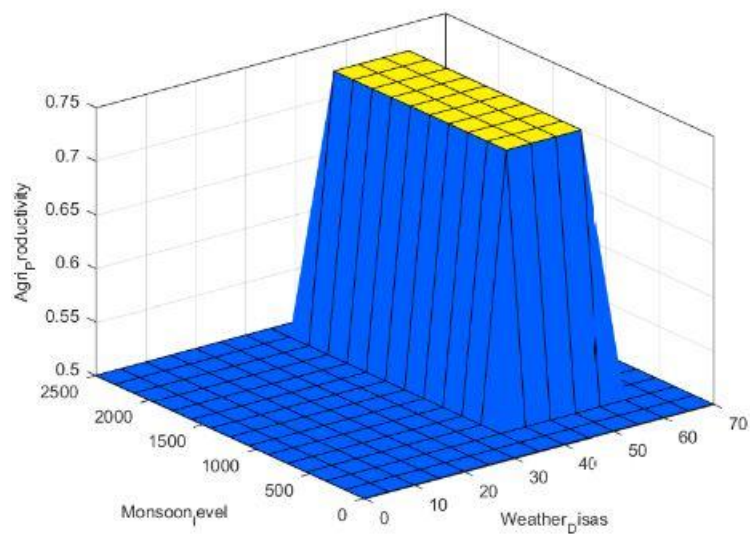


Figure 14: Surface viewer of Monsoon level and weather disaster to Agricultural productivity.

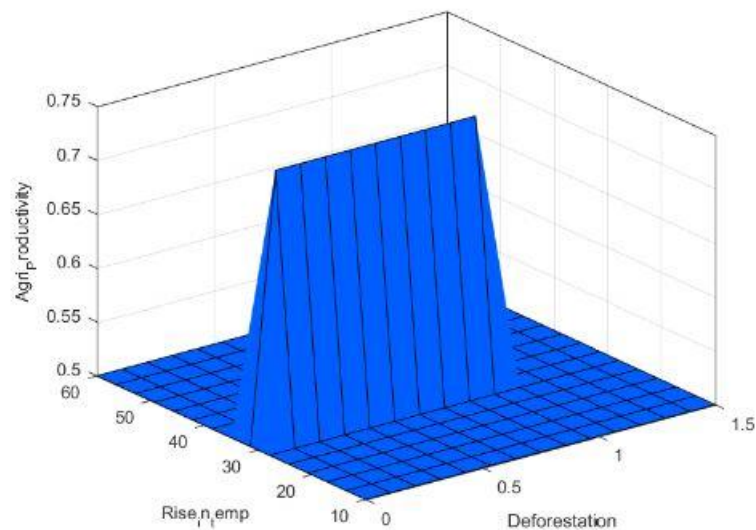


Figure 15: Surface viewer Rise in temperature and deforestation to Agricultural productivity

6. Conclusion

This present study designed Fuzzy Expert System for the Impact of Climate Change in Indian Agriculture. With aid of available information the causes of climate change are considered as the input and the productivity of agriculture is taken as the output. Then, all the input and output are classified with Linguistic term and provided suitable membership functions and derived the certain IF-THEN rules. Later, this system has been tested with the aid of expert under particular environment. Further research can be done of constructing the expert system for analyzing the impact of fertilizer/pesticides on the human health.

7. References

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