# Prediction of Rainfall Characteristics Based on Fuzzy Expert System

**U. Ramya Devi, K. Uma**

***Abstract:*** ***Rainfall prediction is one of the most extremely important and trickiest job in the modern world because, Rain is the lifeblood of human survival, of life on our planet. Gorgeous beauty of fuzzy logic was described by various author for prediction in various field. In this work, fuzzy logic is applied in proposing a model to predict rainfall percentage with parameters. Fuzzy Expert System inputs(parameter) include the temperature, humidity, wind speed , Dew point etc., with Output as rainfall Percentage .Here we develop a new model as RPFES Model to predict rainfall percentage for particular geographical location of Tamil Nadu. There are four steps for developing RPFES Model : The first step is Fuzzification process by triangular membership function for representing the input variables and output variables. The next step is Fuzzy Inference with Fuzzy Rules the method applied in this research work are Root Sum Square (RSS). The Root Sum Square of drawing inference was employed to infer the data from the fuzzy rules developed and finally we move to Defuzzification process for getting Rainfall percentage by individually. From RPFES Model, Individual Person get the Rainfall Prediction as Percentage with purely by Fuzzy Logic and not by Metrological Center. Weather Prediction is the major essential and challenging operational responsibilities which are carried out by meteorological services all over the world.***

***Keywords: Fuzzy Logic, Root sum Square, RPFES Model, Triangular.***

## I. INTRODUCTION

Meteorological Prediction is quite, more essential, challenging and also demanding operational tasks carried out by meteoric services all over the world . In the past, India was severe drought and flooding. These problems are expected to increase steadily and damage to the economy, agriculture, and subsistence. Predicting the rainfall at different time scales is important to both short-term and long-term planning in agricultural production for successful crop selection and crop rotation planning. An accurate and timely rainfall Prediction is crucial for reservoir operation and flooding prevention. " In the short term, this requires a good idea of the upcoming season. In the long term, it needs realistic projections of scenarios of future variability and change" [1]. Historically Rainfall prediction is too complex problem for climatologist and individual person.

## II. RPFES METHODOLOGY

RPFES – Rainfall Prediction with Fuzzy Expert System has the methodology as follows. The aggregation of Fuzzy Expert System are given in the Figure 1.

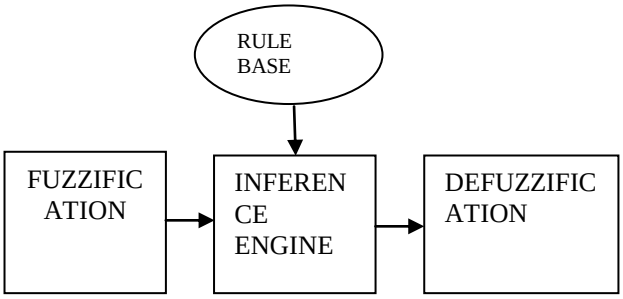


**FIGURE:1 AGGREGATION OF FUZZY EXPERT SYSTEM**

### A. Fuzzification

The real scalar value is to be converted into a new fuzzy value is the Main methodology for Fuzzification processes. During Fuzzification processes, Triangular fuzzifier are used for the RPFES Method. With the help of climatologist both input and output parameters are described with four linguistic variable L (Low), M (Moderate), H (High), VH (Very High) .The process of fuzzification is started here with transferring data with the following equation. By the method of triangular membership function, the linguistic variables are analysed and the degree of membership function ranging from 0 to 1 as shown in equation 1 to 4 below . with the help of climatologist, the newly created formulas are,

$$\mu_{Low}(X) = \begin{cases} 0 & if\ x \le 0.1 \\ \frac{x-0.1}{0.2} & if\ 0.1 \le x \le 0.3 \\ \frac{0.2-x}{0.1} & if\ 0.2 \le x \le 0.3 \\ 0 & if\ x \ge 0.2 \end{cases} \quad \text{------ (1)}$$

$$\mu_{Moderate}(X) = \begin{cases} 0 & if\ x \le 0.3 \\ \frac{x-0.3}{0.3} & if\ 0.3 \le x \le 0.6 \\ \frac{0.45-x}{0.15} & if\ 0.45 \le x \le 0.6 \\ 0 & if\ x \ge 0.45 \end{cases} \quad \text{---------- (2)}$$

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$$\mu_{High}(X) = \begin{cases} 0 & if\ x \le 0.5 \\ \frac{x-0.6}{0.2} & if\ 0.6 \le x \le 0.8 \\ \frac{0.7-x}{0.1} & if\ 0.7 \le x \le 0.8 \\ 0 & if\ x \ge 0.7 \end{cases}$$

---------- (3)

$$\mu_{Very\ High}(X) = \begin{cases} 0 & if\ x \le 0.8 \\ \frac{x-0.8}{0.2} & if\ 0.8 \le x \le 1.0 \\ \frac{0.9-x}{0.1} & if\ 0.9 \le x \le 1.0 \\ 0 & if\ x \ge 1.0 \end{cases}$$

---------- (4)

### B. Fuzzy Rule Formation

After fuzzification here, we create new fuzzy rules. The new fuzzy rules are based on IF – THEN statement. IF is said to be an Antecedent and THEN part is said to be an consequent

*IF – THEN structure :*

IF ( condition 1 AND 2 AND 3 AND …… n)
THEN ( final condition)

Knowledge base are constructed by fuzzy rules in fuzzy expert system. Now, we construct 28 new fuzzy rules for this method. Newly created fuzzy rules are assembled by climatologist. The rule base for Rainfall has Rainfall(RF), Temperature(T), Humidity(H), Wind Speed(WS), Pressure(P), Dew Point(DP), Drizzle(D), Mountain(R), Sea Shore(SS),Rain Fall Conclusion(RFC) as input parameters and Rain Fall Conclusion(RFC) as an output parameters to the system. Input parameters were used to develop 28 rules for the knowledge base (rule base) of rainfall prediction. sample rules for determining the Rainfall percentage are shown in Table 1.

### C. Fuzzy Inference Generation

The RPFES inference engine will make use of forward chaining reasoning, it would make use of the facts given by the person to predict the Rainfall Percentage. For our research, we apply fuzzy logical AND to evaluate the composite firing strength of the rules. The degree of truth (R) of the fuzzy rules are determined for each rule by evaluating the nonzero minimum values using the AND operator. The Root Sum Square (RSS) which is an inference engine technique applied in this research. RSS is given by the formula in equation (5):

$$\sqrt{\sum_{i=1}^{n} R_i^2} = \sqrt{(R_1^2 + R_2^2 + R_3^2 + \cdots .. + R_n^2)}$$

---------- (5)

Where $R_1^2 + R_2^2 + R_3^2 + \cdots .. + R_n^2$ are strength values of different rules which share the same conclusion. .
i.e R = value of firing rule of the problem.

### D. Defuzzification

After the fuzzy inference process, a single crisp output value as a result, which is to be obtained by defuzzifying the aggregated fuzzy set.The center-of-gravity (CoG) often uses discrete variables so that CoG, Y can be approximated to overcome its disadvantage as shown in equation (6)

$$COG(Y') = \frac{\sum \mu_Y(x_i) x_i}{\sum \mu_Y(x_i)}$$ ---------- (6)

$\mu_Y(x_i)$ = Membership value in the Membership function

$x_i$ = Center of Membership function the Rainfall Percentage.

### E. RPFES Algorithm

Step 1 : Person self analyzing of surrounding climatic factors
Step 2: Search the Knowledge base for the Climatic factors.
Step 3: weighting factors (wf) (the associated degree of intensity) wf = 1, 2, 3, 4
Where 1 as L- Low , 2 as M - Moderate, 3 as H- High, 4 as VH - Very High.
Step 4: Next we move towards fuzzy IF THEN rules ( 28 Rules are Evaluated)
Step 5: Trace with fuzzy input with the respective weighting factors
Step 6 : Rule Base Evaluation
Step 7 : we move towards Firing strength of the rules and the degree of truth
Step 8 : After firing rules, Defuziffication method.(i.e Center of Gravity Method) are applied.
Step 9 : Intensity of the Rainfall
Step 10: Fuzzy Rainfall Prediction i.e we get Getting current percentage of Rainfall.

## III. CASE STUDY: TAMIL NADU

**A Tamil Nadu Rainfall :** Tamil Nadu Receive Rainfall from two season Southwest and Northeast Respectively. Winter Rainfall from month of October to December. Generally, the rainy season in Tamil Nadu gets Rainfall about 48 % of total annual Rainfall. Tamil Nadu coastal district get nearly 60% of Rainfall and 40 – 50 % of received Rainfall is get from interior district of the state.


### *B Division Of Tamil Nadu:*

For our Research work, we divide the Tamil Nadu area in to three types of region as
(i) HILL STATION : Kotagiri, Conoor, Udagamandalam,Yercadu.
(ii) BEACHES: Kanniyakumari,Tiruchendur, Kodikkarai, Poompuhar, Muttukadu, Pulicat.
(iii) PLAIN AREA: Thanjavur, Salem, Kanchipuram, Madurai.
When comparing to the three region Hill and Beaches Received High Rainfall when compared to Plain region.

### *C The Interactive Session:*

The climate change over time are explained by individual person are discussed with fuzzy values in this interactive session.

This is done with 15 person in Tamil Nadu from various districts. Table 2 : allotted weight assigned to the individual person after, interactive session with the proficient climatologist. Among 15 person we give 7 person data about climatic factors.

**Table 2: Weights assigned for Rainfall prediction**

| al person and his | Rainfall | Temperature | Humidity | Wind Speed | Pressure | Dew point | Drizzle | Mountain | Sea Shore |
|---|---|---|---|---|---|---|---|---|---|
| 01 | 3 | 2 | 2 | 3 | 3 | 3 | 3 | - | - |
| 03 | 4 | 2 | 3 | 3 | 1 | 2 | 2 | - | - |
| 04 | 4 | 2 | 4 | 3 | 3 | 2 | 4 | 4 | - |
| 07 | 4 | 2 | 2 | 4 | 3 | 3 | 3 | - | - |
| 08 | 3 | 2 | 3 | 2 | 2 | 1 | 2 | - | 4 |
| 10 | 2 | 2 | 3 | 3 | 4 | 3 | 3 | - | - |
| 12 | 4 | 2 | 3 | 3 | 3 | 2 | 2 | 2 | 2 |

Triangular fuzzy values for climatic change over factors of table 2 are given in Table 3

Person number 03 from Perambalur explain about the climatic factors of himself is as follows

**Table 4: Data from person 03 (Perambalur)**

| ***Parameters*** | ***Lingustic Variables*** | ***Fuzzy Values*** |
|---|---|---|
| Rainfall | 4 | 0.75 |
| Temperature | 2 | 0.25 |
| Humidity | 3 | 0.5 |
| Wind Speed | 3 | 0.5 |
| Pressure | 1 | 0.0 |
| Dew point | 2 | 0.25 |
| Drizzle | 2 | 0.25 |
| Mountain | None | -- |
| Sea shore | None | -- |

We apply RPFES Algorithm for person number 03 from Perambalur presented in table 2.we get the following Result by Twenty (21) rules where fired out for person number 03. i.e. 21 rules generated non-zero minimum values from the fuzzy rule base for Prediction of Rainfall. For each of the linguistic variables: L (Low), M (Moderate), H (High) , VH (Very High) the respective output membership function strength (range: 0-0.75) (i.e) from the possible rules (R01 – R28) are computed using RSS inference technique as shown in equation (7) below:

$L = \sqrt{R_3^2 + R_5^2}$

$= \sqrt{(0.5)^2 + (0.25)^2}$

$=0.5590$

$M = \sqrt{R_8^2 + R_{10}^2 + R_{12}^2 + R_{13}^2}$

$= \sqrt{(0.5)^2 + (0.5)^2 + (0.25)^2 + (0.5)^2}$

$= 1$

$H = \sqrt{R_9^2 + R_{11}^2 + R_{15}^2 + R_{19}^2 + R_{20}^2 + R_{24}^2 + R_{26}^2 + R_{28}^2}$

$= \sqrt{(0.5)^2 + (0.5)^2 + (0.25)^2 + (0.25)^2 + (0.25)^2 + (0.5)^2 + (0.5)^2 + (0.25)^2}$

$= 2$

$VH = \sqrt{R_{16}^2 + R_{18}^2 + R_{21}^2 + R_{22}^2 + R_{23}^2 + R_{25}^2 + R_{27}^2 +}$

$= \sqrt{(0.5)^2 + (0.5)^2 + (0.5)^2 + (0.75)^2 + (0.5)^2 + (0.5)^2 + (0.5)^2}$

$= 1.5$

…….(7)

The final result (fuzzy set) from RSS is taken in to defuzzified to obtain the crisp output. During this process, for our research work we used Discrete COG Technique, we obtain the following result with the equation (7)

$$\text{Crisp Output} = \frac{(0.5590 * 0.2) + (1 * 0.4) + (1.414 * 0.65) + (1.5 * 0.9)}{0.5590 + 1 + 1.414 + 1.5}$$

$=0.62$

$= 62\ \%$

We get 62 % Rainfall availability.

## IV. RESULT AND DISCUSSION

That the person 03 from Perambalur received 62 % of Rainfall availability. Similarly, we enumerate the aggregation results of all fired rules to all other Person are shown in Table 5 and got results that were in the range of predefined limits by the domain climatologist. When compare the rainfall percentage it varies between person to person because of the location they stay.(i.e) Person received 65% rainfall from Nilagiri and normal rainfall as 48 % from Trichy .Also we note that all the parameters are Low we get Low rainfall if it is Moderate means moderate rainfall, it just we get from only fuzzy method as RPFES Model only.

## V. CONCLUSION

Fuzzy Logic is extremely helpful in modelling inexact and complicated systems, what is more fuzzy pure mathematics may be a powerful tool and in scientific world applications of FL have apace enhanced with establishing its utility that ever system involves ambiguous associate degree obscure input variables could increase an final result. RPFES Model predict the Rainfall Percentage of individual data by individual person, without any knowledge of Metrological System . The distribution pattern of rainfall in the state of Tamil Nadu is most uneven and varies considerably from year to year and region to region. The present study deals with rainfall Prediction Percentage of the Tamil Nadu State, which enclosed the spatial distribution and variability through different seasons, and frequency occurrences have been analysed.

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**Table 3: Triangular Fuzzy Numbers for Rainfallprediction.**

| Individual person and his station | Rainfall | Temperature | Humidity | Wind Speed | Pressure | Dew point | Drizzle | Mountain | Sea Shore |
|---|---|---|---|---|---|---|---|---|---|
| 01 | 0.5 | 0.25 | 0.25 | 0.5 | 0.5 | 0.5 | 0.5 | - | - |
| 03 | 0.75 | 0.25 | 0.5 | 0.5 | 0.0 | 0.25 | 0.25 | - | - |
| 04 | 0.75 | 0.25 | 0.75 | 0.5 | 0.5 | 0.25 | 0.75 | 0.75 | - |
| 07 | 0.75 | 0.25 | 0.25 | 0.75 | 0.5 | 0.5 | 0.5 | - | - |
| 08 | 0.5 | 0.25 | 0.5 | 0.25 | 0.25 | 0.0 | 0.25 | - | 0.75 |
| 10 | 0.25 | 0.25 | 0.5 | 0.5 | 0.75 | 0.5 | 0.5 | - | - |
| 12 | 0.75 | 0.25 | 0.5 | 0.5 | 0.5 | 0.25 | 0.25 | 0.25 | 0.25 |

**Table 5 : Prediction of rainfall percentage with RPFES method**

| Individual person and his station | Rainfall | Temperature | Humidity | Wind Speed | Pressure | Dew point | Drizzle | Mountain | Sea Shore | Prediction percentage of Rainfall. |
|---|---|---|---|---|---|---|---|---|---|---|
| 01(Tiruppur) | H | M | M | H | H | H | H | - | - | 57% |
| 02(Trichy) | L | H | L | L | H | L | L | - | - | 48% |
| 03(Perambalur) | VH | M | H | H | L | M | M | - | - | 62% |
| 06(Thanjavur) | H | L | M | M | L | L | M | - | - | 52% |
| 05(Nilagiri) | VH | M | M | H | M | M | H | H | None | 65% |
| 09(Salem) | L | H | L | L | L | L | L | - | - | 30% |

**Table 1 : Fuzzy Rule base for Rainfall Prediction**

| **Rule No** | **If** | | | | | | | | | **Then** |
|---|---|---|---|---|---|---|---|---|---|---|
| | **Rainfall** | **Temperature** | **Humidity** | **Wind Speed** | **Pressure** | **Dew point** | **Drizzle** | **Mountain** | **Sea Shore** | **Conclusion** |
| 1 | L | L | M | H | H | L | L | H | L | L |
| 2 | L | L | M | L | L | L | H | VH | L | M |
| 3 | L | L | M | H | H | L | L | L | H | L |
| 4 | L | L | M | L | L | L | H | L | VH | M |
| 5 | L | M | M | L | H | L | L | L | L | L |
| 7 | L | VH | L | L | H | H | L | L | L | L |
| 8 | M | L | M | H | H | L | L | L | L | M |
| 9 | M | L | M | H | H | L | L | VH | L | H |
| 11 | M | L | M | H | H | L | L | L | VH | H |
| 12 | M | M | M | M | H | H | L | L | L | M |
| 13 | M | H | L | M | H | H | L | L | L | M |
| 14 | H | L | M | M | L | L | H | H | L | H |
| 15 | H | L | M | M | L | L | M | L | L | H |
| 16 | H | L | M | M | L | L | H | VH | L | VH |
| 20 | H | H | L | M | L | L | M | M | M | H |
| 21 | VH | L | H | H | L | L | H | H | M | VH |
| 23 | VH | L | VH | H | L | L | L | M | M | VH |

| | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| 24 | VH | L | H | VH | L | L | L | M | M | H |
| 25 | VH | L | H | H | L | L | L | VH | M | VH |
| 26 | VH | L | H | H | L | L | M | M | H | H |
| 27 | VH | L | H | H | L | L | M | M | VH | VH |
| 28 | VH | M | M | M | L | L | M | M | M | H |