FUZZY MATRIX ANALYSIS - SOLAR ENERGY

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ABSTRACT:

This paper gives a brief survey on the solar energy Production in various states. The method of application of Combined Effective Time Dependent Data (CETD) Matrix, Average Time Dependent Data (ATD) Matrix, and Refined Time Dependent Data (RTD) Matrix which are fuzzy models are studied using fuzzy matrices.

The effects and objectives of data's using the concept of mean and Standard deviation.

Key Words: Fuzzy matrix, ATD matrix, RTD matrix, CETD matrix.

I. Introduction:

Decision making is an act to choose the correct option between two or more alternatives. There are many techniques used to improve decision making process, Fuzzy plays a vital role in solving decision making problem in different complicated aspect.

L.A Zadeh (1965) introduced fuzzy set in the year 1965. Fuzzyness can be showed in many ways. Membership function is one of the most useful representation in fuzzy set theory. It depends upon the nature and shape of the membership function. A fuzzy number is thus a special case of normalized fuzzy set of the real line and convex.

Fuzzy numbers is also an extension of real numbers. It is a generalization of regular, real number. It does not refer to one single value but rather to a connected set of possible values. Each element has its own weight between 0 to 1 and this weight is called the membership function.

Fuzzy matrix plays a vital role in scientific development. Thomason (1977) introduced fuzzy matrix, who discussed the convergence of power sequence of fuzzy matrix(1988,1994) was discussed by several authors. Two new operators on fuzzy matrices was defined by Madhumangal Pal (2004) .

"Fuzzy matrix theory and applications" book was written by A.R. Meenakshi (1944). "Special fuzzy matrices for social scientists" (2007) and "Elementary fuzzy matrix theory and fuzzy models for social scientists" written by Vasantha Kandasamy et.al. Fuzzy membership matrix in medical diagonosis decision making problem developed by Elizabeth and Sujatha (2013).

The objective of the Paper is to establish various fuzzy matrices and different techniques used to solve fuzzy matrices. Here, all the fuzzy matrices like RTD matrix, ATD Matrix, CETD Matrix Comparison Matrix, fuzzy triangular matrix and the techniques to solve the fuzzy matrices are investigated. Also all these fuzzy matrices are applied in real life problems.

II. Preliminaries:

Definition 2.1

If $\hat{X}$ is a collection of objects generically denoted by x, then a **fuzzy set** $\hat{A}$ in $\hat{X}$ is a set of ordered pairs $\hat{X} = \{(\hat{x}, \mu_{\hat{A}}(x)) : x \in \hat{X}\}$ Where $\boldsymbol{\mu_{\hat{A}}(x)}$ is the **membership function** which maps $\hat{X}$ to a real number in the interval $[0, 1]$.

$$\mu_{\hat{A}}(x) : \hat{X} \to [0, 1]$$

Definition 2.2

An $m \times n$ matrix $\hat{A} = (a_{ij}), 1 \leq i \leq m, 1 \leq j \leq n$ is said to be a **fuzzy matrix** if where $a_{ij} \in$ [0,1].

First input the raw data. This data gives the matrix representation.

Convert the raw data matrix into average time dependent matrix by dividing each entry of the raw data matrix with the width of the respective class interval

Calculate the mean and standard deviation of every column in the ATD matrix by using the formula Mean = $\frac{\Sigma x}{n}$ and Standard deviation = $\sqrt{\frac{\Sigma x^2}{n} - \left(\frac{\Sigma x}{n}\right)^2}$

Convert the ATD (Average Time Dependent) Matrix into (Referred Time Dependent) RTD Matrix. This is also termed as the entries are 1 0, &-1 by using the formula

$$\begin{cases} a_{ij} \leq (\mu_j - \alpha * \sigma_j) \; then \; e_{ij} = -1 \; else \\ a_{ij} \in (\mu_j - \alpha * \sigma_j, \mu_j + \alpha * \sigma_j) \; then \; e_{ij} = 0 \; else \\ a_{ij} \geq (\mu_j + \alpha * \sigma_j) \; then \; e_{ij} = 1 \; else \end{cases}$$

Obtain the CETD Matrix (combined effective time dependent) data matrix and the corresponding row sum by adding all the ATD matrix.

III. APPLICATION IN PRODUCTION OF SOLAR ENERGY BY USING CETD MATRIX

3.0 Introduction

Solar energy is that the energy that we get from the Sun ands converted into thermal and electricity. This is one of the best example of renewable energy because it will be available at the sun always remain. Solar energy is free from pollution because while producing the solar energy there will be appearing no pollution. It has the maintenance level is inexpensive.

By compare the other resources solar energy need fewer labor source. Even in a cold season continuously get power supply with supported by solar panel's. Solar power consist various ways like as - Ground Mounted, Roof Top, Hydro Power etc.,

This chapter reveals the production of solar power to obtain which states of India produce maximum amount of solar power by using the method of CETD Matrix.

3.1 Materials and Methods

The time series data on production of solar power in India (state wise) has been collected from the period 2017 to 2021 covering 5 years.

The performance of the solar power has been discussed with the help of fuzzy matrix by using CETD Matrix.

3.2 An illustrative Example for the Algorithm discussed in preliminaries

To analyse the production of solar power energy Rajasthan, Punjab, Gujarat, Maharashtra, Delhi, Tamil Nadu, Andhra Pradesh, West Bengal and Karnataka were taken under Nine attributes and make it as a initial raw data.

The years has taken as the column attributes in the first step. So the intial raw data matrix is of order 9×10.

Step 1: Input the raw data matrix

Years / States	March 2017	March 2018	March 2019	March 2020	March 2021
Rajasthan	1,317.64	1,812.93	3,226.79	5,732.58	4,454.70
Punjab	545.43	793.95	905.62	959.50	1,117.99
Gujarat	1,158.5	1,249.37	2,440.13	4,430.82	7,806.80
Maharashtra	430.46	452.37	1, 633.54	2,289.97	2,753.30
Delhi	38.78	40.27	126.89	192.97	211.12
Tamil Nadu	1,590.97	1,691.83	2,575.22	4, 475.21	5,690.79
Andhra Pradesh	979.65	1,767.23	3,085.68	4,203.00	4,390.48
West Bengal	23.07	26.14	75.95	149.84	176.00
Karnataka	327.53	1,027.84	6,095.56	7,355.17	7,597.92

Table 3.1 Intial Raw data Matrix of entries in the MW (Megawatt)

Step 2: Convert the raw data matrix into average time dependent matrix by dividing 10 and the result shown in table 3.2.

Years / States	March 2017	March 2018	March 2019	March 2020	March 2021
Rajasthan	131.764	181.293	322.679	573.258	445.470
Punjab	54.543	79.395	90.562	95.950	111.799
Gujarat	1158.5	124.937	244.013	443.082	780.680
Maharashtra	43.046	45.237	163.354	228.997	275.330
Delhi	3.878	4.027	12.689	19.297	21.112

Tamil Nadu	159.097	169.183	257.522	447.521	569.079
Andhra Pradesh	97.965	176.723	308.568	420.300	439.048
West Bengal	2.307	2.614	7.595	14.984	17.600
Karnataka	32.753	102.784	609.556	735.517	759.792

Table 3.2 the ATD Matrix of table 3.1 entries in the MW (Megawatt)

Step 3: Calculate the Mean and standard deviation of every column in the ATD Matrix by using formula

Mean = $\frac{\sum x}{n}$ and standard deviation = $\sqrt{\frac{\sum x^2}{n} - \left(\frac{\sum x}{n}\right)^2}$.

	March 2017	**March 2018**	**March 2019**	**March 2020**	**March 2021**
Mean μ	71.18	98.4	224.0	330.9	379.3
Standard Deviation σ	56.91	70.7	187.1	210.9	293.9

Table 3.3 Mean and Standard deviation of ATD Matrix

Step 4: Convert the ATD Matrix into RTD Matrix.

This matrix is also termed as fuzzy matrix as the entries are 1, 0 &-1 by using

the formula $\begin{cases} a_{ij} \le (\mu_j - \alpha * \sigma_j) \; then \; e_{ij} = -1 \; else \\ a_{ij} \in (\mu_j - \alpha * \sigma_j, \mu_j + \alpha * \sigma_j) \; then \; e_{ij} = 0 \; else \\ a_{ij} \ge (\mu_j + \alpha * \sigma_j) \; then \; e_{ij} = 1 \; else \end{cases}$

The RTD Matrix for $\alpha = 0.2$ **Row Sum Matrix**

$$\begin{bmatrix} 1 & 1 & 1 & 1 & 1 \\ -1 & -1 & -1 & -1 & -1 \\ 1 & 1 & 1 & 1 & 1 \\ -1 & -1 & -1 & -1 & -1 \\ -1 & -1 & -1 & -1 & -1 \\ 1 & 1 & 1 & 1 & 1 \\ 1 & 1 & 1 & 1 & 1 \\ -1 & -1 & -1 & -1 & -1 \\ -1 & 0 & 1 & 1 & 1 \end{bmatrix} \qquad \begin{bmatrix} 5 \\ -5 \\ 5 \\ -5 \\ -5 \\ 5 \\ 5 \\ -5 \\ 2 \end{bmatrix}$$

The RTD Matrix for $\alpha = 0.4$ **Row Sum Matrix**

$$\begin{bmatrix} 1 & 1 & 1 & 1 & 0 \\ 0 & 0 & -1 & -1 & -1 \\ 1 & 0 & 0 & 1 & 1 \\ -1 & -1 & 0 & -1 & 0 \\ -1 & -1 & -1 & -1 & -1 \\ 1 & 1 & 0 & 1 & 1 \\ 1 & 1 & 1 & 1 & 0 \\ -1 & -1 & -1 & -1 & -1 \\ -1 & 0 & 1 & 1 & 1 \end{bmatrix} \qquad \begin{bmatrix} 4 \\ -3 \\ 3 \\ -3 \\ -5 \\ 4 \\ 4 \\ 5 \\ 2 \end{bmatrix}$$

The RTD Matrix for $\alpha = 0.6$ **Row Sum Matrix**

$$\begin{bmatrix} 1 & 1 & 0 & 1 & 0 \\ 0 & 0 & -1 & -1 & -1 \\ 1 & 0 & 0 & 0 & 1 \\ 0 & -1 & 0 & 0 & 0 \\ -1 & -1 & -1 & -1 & -1 \\ 1 & 1 & 0 & 0 & 1 \\ 0 & 1 & 0 & 0 & 0 \\ -1 & -1 & -1 & -1 & -1 \\ -1 & 0 & 1 & 1 & 1 \end{bmatrix} \qquad \begin{bmatrix} 3 \\ -3 \\ 2 \\ -1 \\ -5 \\ 3 \\ 1 \\ 5 \\ 2 \end{bmatrix}$$

The RTD Matrix for $\alpha = 0.8$ **Row Sum Matrix**

$$\begin{bmatrix} 1 & 1 & 0 & 1 & 0 \\ 0 & 0 & 0 & -1 & -1 \\ 0 & 0 & 0 & 0 & 1 \\ 0 & 0 & 0 & 0 & 0 \\ -1 & -1 & -1 & -1 & -1 \\ 1 & 1 & 0 & 0 & 0 \\ 0 & 1 & 0 & 0 & 0 \\ -1 & -1 & -1 & -1 & -1 \\ 0 & 0 & 1 & 1 & 1 \end{bmatrix} \qquad \begin{bmatrix} 3 \\ -2 \\ 1 \\ 0 \\ -5 \\ 2 \\ 1 \\ -5 \\ 3 \end{bmatrix}$$

The Graphical representation of the RTD Matrix at

alpha = 0.2, 0.4, 0.6, 0.8

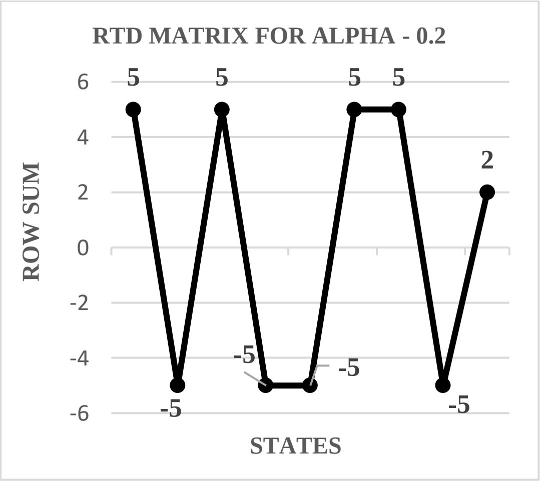

Figure 3.1

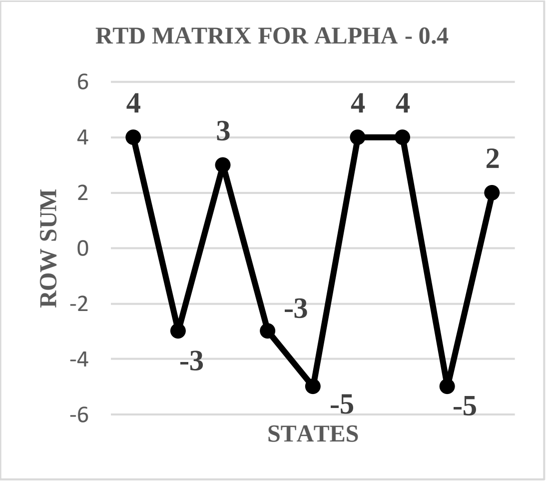

Figure 3.2

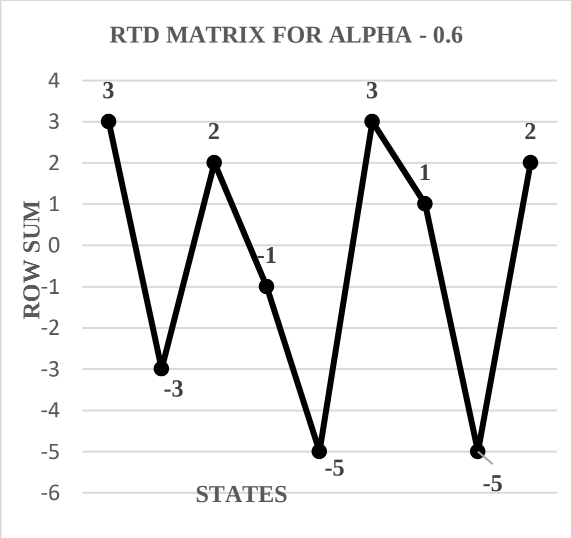

Figure 3.3

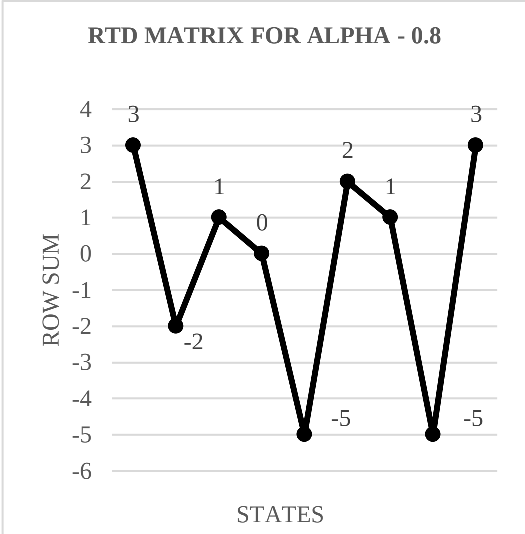

Figure 3.4

Step 5: Obtain the combined effective time dependent data matrix and the corresponding row sum by adding all the ATD Matrix.

The CETD Matrix for $\alpha = 0.8$ **Row Sum Matrix**

$$\begin{bmatrix} 4 & 4 & 2 & 4 & 1 \\ -1 & -1 & -3 & -4 & -4 \\ 3 & 1 & 1 & 2 & 4 \\ -2 & -3 & -1 & -2 & -1 \\ -4 & -4 & -4 & -4 & -4 \\ 4 & 4 & 1 & 2 & 3 \\ 2 & 4 & 2 & 2 & 1 \\ -4 & -4 & -4 & -4 & -4 \\ -3 & 0 & 4 & 4 & 4 \end{bmatrix} \qquad \begin{bmatrix} 15 \\ -13 \\ 11 \\ -9 \\ -20 \\ 14 \\ 11 \\ -20 \\ 9 \end{bmatrix}$$

The Graphical representation of the CETD Matrix

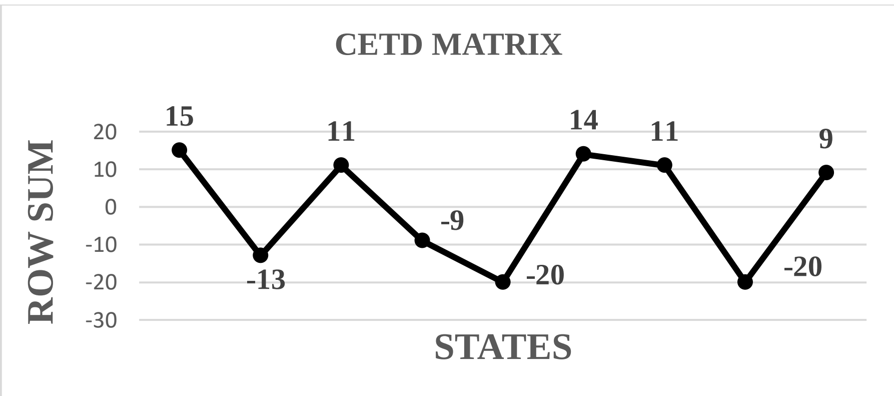

Figure 3.5

Results and Discussion

From the observation of the above graph and CETD matrix shows that the solar power production Punjab, Maharashtra, Delhi and West Bengal have lowest production. Rajasthan and Tamilnadu has high production like wise Andhra Pradesh and Karnataka has medium level production in solar power.

If we concentrate to increase the production of solar panel in the states are Punjab, Maharashtra, Delhi and West Bengal it will be very useful to development of India. The results of the fuzzy matrix model gave the exact result as that obtained experimentally.

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