International Journal of Mathematical Sciences and Applications
Vol. 1 No. 2 (May, 2011)

www.ijmsa.yolasite.com

APPLICATION OF FUZZY MATRICES IN THE ANALYSIS OF PROBLEMS ENCOUNTERED BY THE COFFEE CULTIVATORS IN KODAI HILLS

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ABSTRACT

In this article the authors attempted to identify the various problems encountered by the coffee cultivators and to ascertain the group of coffee cultivators (based on land holding) worst affected by such problems.

INTRODUCTION

To describe situations mathematically which are vague or fuzzy in nature Zadeh [3], introduced the theory of fuzzy sets. Fuzzy relations and fuzzy relational equations have important applications in pattern classification, clustering, fuzzy information retrieval, preference and so on. In system models based on fuzzy sets, one often uses fuzzy matrices to define fuzzy relations.

"A fuzzy matrix is a matrix with elements having values in the fuzzy interval". In this article, the unit interval [0,1] and the interval [–1,1] are called fuzzy intervals [3].

The coffee industry of India is the sixth largest producer of coffee in the world. Indian coffee is said to be the finest coffee grown in the shade rather than direct sunlight anywhere in the world. Three southern states of South India (Karnataka, Kerala and Tamil Nadu) account for 98 % of coffee production in India. Well known

varieties of coffee grown are the Arabica and Robusta. In the study area Arabica variety is grown. Coffee is a labour-intensive crop and in Kodai Hills coffee is grown under monsoon rainfall conditions. As the coffee contributes significantly for the national economy and the growers face many hardships in coffee cultivation, a research has been conducted to study the problems encountered by them and inferences were drawn using fuzzy matrices.

Application of Fuzzy Matrices

In order to analyse the problems encountered by the coffee cultivators, an interview schedule was administered to 100 coffee cultivators in the following three different villages of Kodai Hills, Tamilnadu and were asked to respond to each problem : (i) Pannaikadu (50 cultivators) (ii) Thandikudi (30 cultivators) and (iii) Mangalamkombu (20 cultivators).

The list of problems encountered by them are as follows :

P_1 - Monsoon failures and unseasonal rains

P_2 - Destruction of crops by pests, birds and animals.

P_3 - Labour shortage

P_4 - High cost of labour, pesticides and fertilizers.

P_5 - Difficulties in curing process

P_6 - Storage problem

P_7 - Unstable selling prices of coffee seeds

P_8 - Lack of holding power in case of price decrease

P_9 - Inconsistent yield

P_{10} - Low margin of profit

Description of the Problems

P_1 - Sufficient rain is needed during the period of blossom. Otherwise it will affect the yield. After the period of blossom heavy rains, if any, will wash the flowers and ultimately affect the yield.

P_2 - Pest attack and destruction by wild birds and animals, especially monkeys cause damage to the crop.

P_3 - Migration of labour force to urban centres results shortage of labour.

P_4 - Cost of labour increases due to shortage of labour. The price of pesticides and fertilizers are always in the increasing trend.

P_5 - After the raw coffee beans are picked, the process involved in crushing, washing and drying the coffee beans is very difficult.

P_6 - Sufficient storage place is needed to store the dried coffee beans till it is sold. But many cultivators do not have the required space.

P_7 - At present there is no standard price for the dried coffee beans. The price is subject to heavy fluctuations depending on the demand in both the National and International markets.

P_8 - In order to meet the financial requirements of domestic expenses and cultivation activities, the cultivators sell at any price and are not in a position to hold the stock expecting a rise in price.

P_9 - Due to various factors the yield varies from year to year which cannot be predicted.

P_{10} - The difference between the sales revenue and production cost is marginal.

A Village in the Study Area

Coffee Plant

Bunch of Coffee Flowers

Ripened Coffee Beans

Based on their land holding (in acres) the respondents were grouped into six categories as detailed below:

Land holding (In acres)	Number of respondents
1-5	20
6-10	20
11-15	20
16-20	20
21-30	10

31-40	10

By taking the above six categories as rows and the number of respondents suffering due to each of the ten problems as columns, a 6 x 10 initial raw data matrix called Time Dependent Matrix (TD Matrix) [1] was formed.

Land holding (In acres)	P_1	P_2	P_3	P_4	P_5	P_6	P_7	P_8	P_9	P_{10}
1-5	20	9	8	7	6	9	7	10	17	18
6-10	20	11	15	15	14	17	12	15	18	19
11-15	20	12	18	16	19	18	13	17	19	19
16-20	20	9	12	10	14	13	12	16	19	18
21-30	10	4	6	5	6	5	5	6	7	8
31-40	10	3	3	4	5	3	5	6	6	7

The initial raw data matrix has been converted into the Average Time Dependent Matrix (ATD Matrix) [1] (a_{ij}) by dividing each entry with the width of the respective class-interval.

ATD MATRIX

Land holding (In acres)	P_1	P_2	P_3	P_4	P_5	P_6	P_7	P_8	P_9	P_{10}
1-5	4.00	1.80	1.60	1.40	1.20	1.80	1.40	2.00	3.40	3.60
6-10	4.00	2.20	3.00	3.00	2.80	3.40	2.40	3.00	3.60	3.80
11-15	4.00	2.40	3.60	3.20	3.80	3.60	2.60	3.40	3.80	3.80
16-20	4.00	1.80	2.40	2.00	2.80	2.60	2.40	3.20	3.80	3.60
21-30	1.00	0.40	0.60	0.50	0.60	0.50	0.50	0.60	0.70	0.80
31-40	1.00	0.30	0.30	0.40	0.50	0.30	0.50	0.60	0.60	0.70

The average (μ_j) and standard deviation (σ_j) of every column were worked out as follows :

Average	3.00	1.48	1.92	1.75	1.95	2.03	1.63	2.13	2.65	2.72
Standard Deviation	1.55	0.91	1.32	1.20	1.37	1.42	0.97	1.28	1.56	1.53

Using the average (μ_j), Standard Deviation (σ_j) and a parameter α from the interval [0, 1], a fuzzy matrix called the Refined Time Dependent Data Matrix (RTD Matrix) [1] was formed. The RTD matrix with entries e_{ij}, where $e_{ij} \in \{-1, 0, 1\}$, was formed using the following formula [1] :

If $a_{ij} \leq (\mu_j - \alpha^* \sigma_j)$ then $e_{ij} = -1$

else if $a_{ij} \in (\mu_j - \alpha^* \sigma_j, \mu_j + \alpha^* \sigma_j)$ then $e_{ij} = 0$

else if $a_{ij} \geq (\mu_j + \alpha^* \sigma_j)$ then $e_{ij} = 1$, where a_{ij}'s are entries of Average Time Dependent Matrix.

By varying the parameter $\alpha \in [0, 1]$, any number of Refined Time Dependent Data Matrices can be obtained. Three of such matrices obtained were as follows:

RTD Matrix for α = 0.25 **Row sum matrix**

$$\begin{pmatrix} 1 & 1 & 0 & -1 & -1 & 0 & 0 & 0 & 1 & 1 \\ 1 & 1 & 1 & 1 & 1 & 1 & 1 & 1 & 1 & 1 \\ 1 & 1 & 1 & 1 & 1 & 1 & 1 & 1 & 1 & 1 \\ 1 & 1 & 1 & 0 & 1 & 1 & 1 & 1 & 1 & 1 \\ -1 & -1 & -1 & -1 & -1 & -1 & -1 & -1 & -1 & -1 \\ -1 & -1 & -1 & -1 & -1 & -1 & -1 & -1 & -1 & -1 \end{pmatrix} \qquad \begin{pmatrix} 2 \\ 10 \\ 10 \\ 9 \\ -10 \\ -10 \end{pmatrix}$$

RTD Matrix for α = 0. 50 **Row sum matrix**

$$\begin{pmatrix} 1 & 0 & 0 & 0 & -1 & 0 & 0 & 0 & 0 & 1 \\ 1 & 1 & 1 & 1 & 1 & 1 & 1 & 1 & 1 & 1 \\ 1 & 1 & 1 & 1 & 1 & 1 & 1 & 1 & 1 & 1 \\ 1 & 0 & 0 & 0 & 1 & 0 & 1 & 1 & 1 & 1 \\ -1 & -1 & -1 & -1 & -1 & -1 & -1 & -1 & -1 & -1 \\ -1 & -1 & -1 & -1 & -1 & -1 & -1 & -1 & -1 & -1 \end{pmatrix} \qquad \begin{pmatrix} 1 \\ 10 \\ 10 \\ 6 \\ -10 \\ -10 \end{pmatrix}$$

RTD Matrix for α = 0.75 **Row sum matrix**

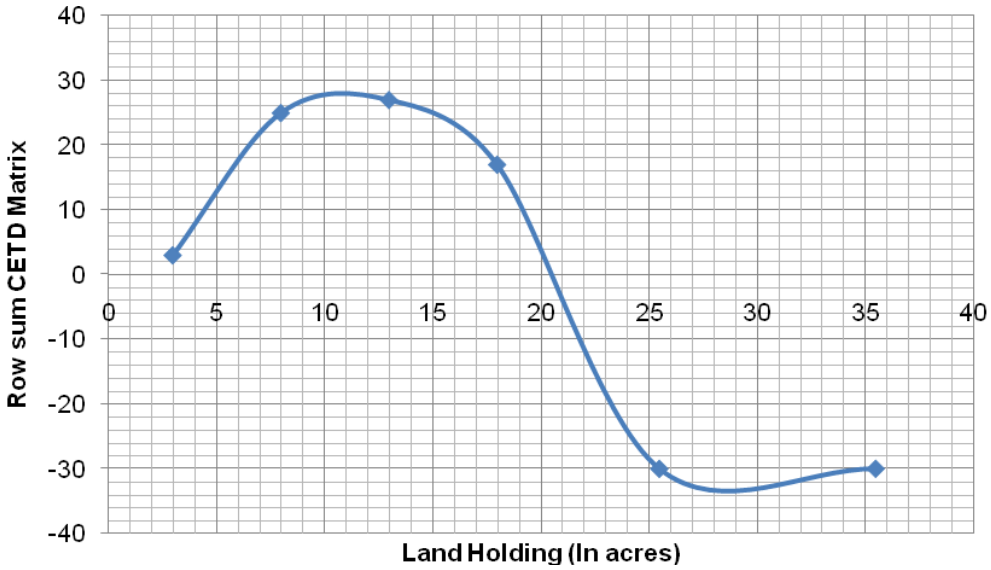
$$\begin{pmatrix} 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 1 & 1 & 1 & 0 & 1 & 1 & 0 & 0 & 0 \\ 0 & 1 & 1 & 1 & 1 & 1 & 1 & 1 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 1 & 1 & 0 & 0 \\ -1 & -1 & -1 & -1 & -1 & -1 & -1 & -1 & -1 & -1 \\ -1 & -1 & -1 & -1 & -1 & -1 & -1 & -1 & -1 & -1 \end{pmatrix} \qquad \begin{pmatrix} 0 \\ 5 \\ 7 \\ 2 \\ -10 \\ -10 \end{pmatrix}$$

By combining all these three matrices, the Combined Effect Time Dependent Data Matrix (CETD Matrix) [1] ,which gives the cumulative effect of all these entries, was obtained as follows :

CETD Matrix **Row sum matrix**

$$\begin{pmatrix} 2 & 1 & 0 & -1 & -2 & 0 & 0 & 0 & 1 & 2 \\ 2 & 3 & 3 & 3 & 2 & 3 & 3 & 2 & 2 & 2 \\ 2 & 3 & 3 & 3 & 3 & 3 & 3 & 3 & 2 & 2 \\ 2 & 1 & 1 & 0 & 2 & 1 & 3 & 3 & 2 & 2 \\ -3 & -3 & -3 & -3 & -3 & -3 & -3 & -3 & -3 & -3 \\ -3 & -3 & -3 & -3 & -3 & -3 & -3 & -3 & -3 & -3 \end{pmatrix} \qquad \begin{pmatrix} 3 \\ 25 \\ 27 \\ 17 \\ -30 \\ -30 \end{pmatrix}$$

The graph as shown below exhibited the group of respondents (based on land holding) worst affected.



Conclusion

From the graph it is observed that the cultivators holding land ranging between 10 acres and 12 acres were worst affected by such problems.

References

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