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Fuzzy Optimization Technique to List the Scavengers Effected for Crude Dumping of Solid Waste

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Abstract*— In this paper we do a systematic analysis to list the scavengers of different age groups those are working daily at wastes landfill site using. The study is done by a vigorous survey method in the landfill site among 653nos scavengers and five different types of common diseases caused by the adverse environmental impact due to crude dumping of wastes in the landfill. All the parametric information and data are analyzed using fuzzy tool to ascertain which age group is actually most sufferer and which one the next. The study is multi-diseases based data analysis and carried out at 'Dhapa Landfill', the main wastes disposal site of Kolkata city. Most of the data are not found crisp rather linguistic and thus uncertainty is the integral part of this case study. To minimize the involvement of uncertainty in the analysis process, concept of fuzzy logic of Prof. Latfi Zadeh [1, 8] is used here for obtaining overall output result more precisely.

***Index Terms*—disease affected matrix, dominating matrix, fuzzy attributes, fuzzy relation, gcv, weighted average, etc.**

I. INTRODUCTION

At Kolkata, the sanitary land fill is not practiced, rather major quantity of the wastes about 3300 MT is being dumped daily in it's Dhapa landfill site openly and makes heap after heap of wastes at present. About 2500 scavengers of different age groups are daily involved for handling and collection of recyclable materials as their economical resources from these wastes of Dhapaa landfill. Due to high exposure in open landfill, all the scavengers are suffering from different diseases like "gastroenteritis", "asthma" , "bronchitis" , "skin diseases" etc[5,7]. The number of scavengers of each age group is not fixed rather fluctuating daily. There is no any official restriction or sanitary and hygienic facilities given to scavengers regarding handling of wastes or their free roaming into the landfill area. As a result all the scavengers are more or less effected by one or more disease(s) due to their such wide exposure in the landfill. Some scavengers of specific age group are more sufferer than other age groups for a specific disease but for another disease they may be less than those age groups [6]. Considering all the diseases in respect to the various age groups, a comparative analysis is made to study which age group ranks top for worst suffering for those diseases under consideration, which ranks second, which ranks third and so on[1,4]. Thus the aim is to select the age group of scavengers out of n alternatives, which are effected by optimal number of each disease. This kind of optimal selection is not a straightforward one because there is no age group, which effect by all types of disease maximum. The study deals with a methodology of fuzzy analysis where comparison of age groups is done bitwise (i.e. independently with respect to each disease) to do the ranking. The technique used is based on the finding out of two basic values, viz.

(i) For how many diseases, an age group dominates (i.e. effected equal or more in comparison with) the Other age groups?

(ii) For how many diseases, an age group is dominated by the other age groups?

Ranking and rating are two important topics in Optimization and Management Technology. We present here a methodology which can be applicable not only to the problems of ranking the age groups of scavengers but to several decision making problems also.

II. PRELIMINARIES

In this section we present some preliminaries which will be useful to our work in the next section

A. Disease Effected Matrix

Consider the collection of all diseases D_1, D_2, D_3, D_4……, D_m and the collection of all age groups of scavengers which are say , A_1, A_2, A_3,……., A_n, then the 'Disease Effected Matrix' is an n x m matrix (e_{ij}), where n is the number of different age groups of scavengers and m is the number of diseases effected by the scavengers and represented like as :

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	D_1	D_2	…	…	D_m
A_1	e_{11}	e_{12}	…	…	e_{1m}
A_2	e_{21}	e_{22}	…	…	e_{2m}
...	…	…	…	…	…
A_n	e_{n1}	e_{n2}	…	…	e_{nm}

The element e_{ij} represents the average number of scavengers affected by the disease D_j of age group A_i.

B. Membership Value Matrix

This is also an (n x m) matrix (e_{ij}), formulated from the 'Fuzzy Relation' in between the age group (A_i) and the disease (D_j). As for example if the set of collection of all age groups say, $A= \{A_1, A_2, A_3, \ldots\ldots, A_n\}$ and the set of collection of all possible diseases say, $D = \{ D_1, D_2, D_3, \ldots.., D_m \}$, then membership value matrix which comprises of element e_{ij} representing the degree of membership value of effect D_j in the age group of A_i will be

	D_1	D_2	…	…	D_m
A_1	a_{11}	a_{12}	…	…	a_{1m}
A_2	a_{21}	a_{22}	…	…	a_{2m}
...	…	…	…	…	
A_n	a_{n1}	a_{n2}	…	…	a_{nm}

There is no age group (A_i) alone which has maximum membership value for its all possible disease (D_j) rather the degree of membership value may vary or equal with other age groups.

C. Weighted Matrix

The weighted matrix is also like n x m matrix (b_{ij}) and it's each element denotes weighted value of each disease D_j for the age group A_i. The weighted value of $b_{ij} = (a_{ij} \times w_{ij})$ where wij is the weight of the disease to be prefixed by the expert before commencement of case study. So, the weighted matrix could be as below:

	D_1	D_2	…	…	D_m
A_1	b_{11}	b_{12}	…	…	b_{1n}
A_2	b_{21}	b_{22}	…	…	b_{2n}
...	….	…	…	…	…
A_n	b_{n1}	b_{n2}	…	…	b_{nn}

D. Dominating Matrix

This is a n x n square matrix (m_{ij}) constructed from the membership value matrix, where n being the number of different age groups. The element m_{ij} of the matrix denotes the number of disease for which the age group $A_{j\ \text{dominated}}$ by the age group A_i, on the basis of information available in the disease affected matrix. The dominance matrix will be as below:

	A_1	A_2	…	…	A_n	sum
A_1	m_{11}	m_{12}	…	…	m_{1n}	r_1
A_2	m_{21}	m_{22}	…	…	m_{2n}	r_2
…	…	…	…	…	…	…
A_n	m_{n1}	m_{n2}	…	…	m_{nn}	r_n
sum	c_1	c_2	…	…	c_n	

Where, r_i is the row-sum $\sum_{j=1}^{n} m_{ij}$, and c_j is the column-sum $\sum_{j=1}^{n} m_{ji}$, $\forall$ i, j = 1, 2, 3, …., n.

Clearly, $m_{ii} = m$ and $m_{ij} \leq m$, $\forall$ i, j.
In this dominance matrix r_i signifies the number of times the age group A_i dominates all the age groups, and c_j signifies the number of times the age groups A_j is dominated by all.

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E. Gross Comparison Value (gcv)

The gross comparison value (gcv) of the age group A_i is g_i, given by

$$g_i = r_i - c_i, \quad i = 1, 2, 3, \ldots, n.$$

It is clear that the optimal worst age group will be that age group corresponding to which gross comparison value is maximum.

III. METHODOLOGY

In this section we present the methodology of fuzzy analysis. First of all we present some definitions.

A. Fuzzy Sets (FS) and Fuzzy Logic [2,8]

To tackle the uncertainty in the solution of our daily life problems, Prof. Latfi Zadeh first laid the foundation of fuzzy set theory in 1965 by generalization of ordinary crisp set theory. According to the concept of fuzzy set theory, when a statement is completely true then the membership value is 1 and when a statement is completely false the membership value is 0 and when the statement is partially true and partially false then the membership value will be in between 0 and 1. Thus the membership function of a fuzzy sets can take any value form the closed interval [0,1]. It is expressed as the set of ordered pairs like $A = \{ (x_1, \mu_A(x_1)), (x_2, \mu_A(x_2)), \ldots, (x_n, \mu_A(x_n)) \}$, where $\mu_A(x_i)$, is the grade of membership of element x_i in set A. The greater value of $\mu_A(x_i)$, indicates greater the truthness of statement that 'the element x_i belongs to set A'. Now in the whole world this logic has recognized as a most popular name as 'Fuzzy Logic'.

B. Fuzzy Relation [8]

Sometimes it also necessitates to assess the quantum evaluation of uncertainty associated with events which is called fuzzy relation. If $X, Y \subseteq R$ be universal sets, then a fuzzy set R is to be called fuzzy relation on $X \times Y$ where $\mu R(x, y)$ is a function of two variables or membership function. Each membership value on $X \times Y$ indiçâtes the dégrée of truthness of the relation of x with y.

Example-1 : Let X be the domain of man = { Ram, Shyam, Madhu} and Y be the domain of behavior = { rude, excellent, good} be two universes then a possible fuzzy relation R on X x Y will be in matrix notation as

$\tilde{R}$	Rude	Excellent	Good
Ram	0.1	0.5	0.8
Shyam	0.2	0.8	1
Madhu	0.7	0	0.1

C. Weighted Averages [a (X)] [3]

Suppose that to each element $x \in X$, there is an associated weight $W_x \in R+$ (set of all non-negative real numbers), then the weighted average of the fuzzy set X is the non-negative number a (X) given by

$$a(X) = \frac{\sum \mu(x) \cdot W_x}{\sum W_x},$$

This weighted average result will give the ultimate numerical value of impact of severity of landfill to the health of that particular age group.

D. Grading of Assessment Output [2,3]

Suppose the overall grading of output results of fuzzy-analysis could be proposed as below:

grade A = Extremely severe, if $.8 < a(X) \leq 1$
grade B = Very Severe, if $.6 < a(X) \leq .8$
grade C = Severe, if $.4 < a(X) \leq .6$
grade D = Moderately mild, if $.2 < a(X) \leq .4$
grade E = Mild, if $0 \leq a(X) \leq .2$.

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IV. CASE-STUDY

The case-study of fuzzy analysis is conducted among 653 scavengers at "Dhapa Landfil Site" of Kolkata city. All scavengers are divided into seven following groups and study of their health condition is carried out for the five common diseases i.e. "gastroenteritis", "asthma" , "bronchitis" , "skin diseases" , and "effected by multiple diseases" etc. Suppose age groups of 653 scavengers are considered as

A_1 = the age group of below 10 years = 92 Nos.
A_2 = the age group of (11-20) years = 107 Nos.
A_3 = the age group of (21-30) years = 117 Nos.
A_4 = the age group of (31-40) years = 117 Nos.
A_5 = the age group of (41-50) years = 76 Nos.
A_6 = the age group of (51-60) years = 86 Nos.
A_7 = the age group of above 60 years = 58 Nos.

The detailed survey data for the different diseases suffered by each age group is tabulated in the form of disease effected matrix for evaluation of membership value matrix next.

	D_1	D_2	D_3	D_4	D_5
A_1	11	9	7	38	27
A_2	19	13	14	28	33
A_3	17	11	31	17	41
A_4	9	15	23	25	45
A_5	4	12	21	10	29
A_6	18	2	8	26	32
A_7	6	3	9	22	18

(Disease Effected Matrix)

Now the job is to calculate the membership value matrix using the concept of fuzzy relation in between two fuzzy sets of A and D, where A = .{ A_1 , A_2, A_3, A_4 , A_5, A_6 , A_7} and D = { D_1, D_2, D_3, D_4, D_5 }.

For fuzzy relation analysis, fuzzy attributes for the set of D are selected as:

D_1 = high health impact for the disease of 'Gastroenteritis'
D_2 = high health impact for the disease of 'Asthma'
D_3 = high health impact for the disease of 'Brochities'
D_4 = high health impact for the disease of 'Skin disease'
D_5 = high health impact for the diseases of 'Effected by multiple of all above' .

and considering the severity of impact of individual disease, the weight of each fuzzy attribute are prefixed like as, for $D_1 = 80$, for $D_2 = 60$, for $D_3 = 70$, for $D_4 = 40$ and for $D_5 = 30$ respectively. Thus the membership value matrix is evaluated from expert's views & perceptions and presented below.

R	D_1	D_2	D_3	D_4	D_5
A_1	0.85	0.80	0.70	0.80	0.25
A_2	0.75	0.35	0.40	0.55	0.40
A_3	0.45	0.65	0.70	0.40	0.70
A_4	0.75	0.80	0.65	0.55	0.70
A_5	0.65	0.45	0.55	0.45	0.40
A_6	0.55	0.45	0.50	0.55	0.60
A_7	0.35	0.80	0.25	0.35	0.30

(Membership Value Matrix)

The next job is to frame the weighted matrix for the functioning of dominating matrix which is given by

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R	D_1	D_2	D_3	D_4	D_5
A_1	68	48	49	32	8
A_2	60	21	28	22	12
A_3	36	39	49	16	21
A_4	60	48	46	22	21
A_5	52	27	39	18	12
A_6	44	27	35	22	18
A_7	28	48	18	14	9

(Weighted Matrix)

We now compute the dominating matrix from the above weighted matrix. Clearly the dominating matrix will be

	A_1	A_2	A_3	A_4	A_5	A_6	A_7	Sum
A_1	5	4	4	4	4	4	4	$r_1 = 29$
A_2	1	5	2	2	3	3	4	$r_2 = 19$
A_3	2	3	5	2	3	3	4	$r_3 = 22$
A_4	2	5	4	5	5	5	5	$r_4 = 31$
A_5	1	3	2	0	5	3	4	$r_5 = 18$
A_6	1	4	2	1	3	5	4	$r_6 = 20$
A_7	2	1	1	1	1	1	5	$r_7 = 12$
Sum	$c_1 = 14$	$c_2 = 25$	$c_3 = 20$	$c_4 = 15$	$c_5 = 24$	$c_6 = 23$	$c_7 = 30$	

Thus the gross comparison values (gcv) of the age groups of

$A_1 = 15$, $A_2 = -6$, $A_3 = 2$, $A_4 = 16$, $A_5 = -6$, $A_6 = -3$ and $A_7 = -18$.

Clearly, $A_7 < A_5$ & $A_2 < A_6 < A_3 < A_1 < A_4$. Thus study reveals that $\mathbf{A_4}$ is the most sufferer age group out of all whereas $\mathbf{A_7}$ is the least. Now we calculate the weighted averages [a(X)] of the weighted matrix to determine the overall health impact with degree of certainty.

R	D_1	D_2	D_3	D_4	D_5	**a (X) =**
A_1	68	48	49	32	8	**0.732**
A_2	60	21	28	22	12	0.510
A_3	36	39	49	16	21	0.575
A_4	60	48	46	22	21	0.703
A_5	52	27	39	18	12	0.528
A_6	44	27	35	22	18	0.521
A_7	28	48	18	14	9	**0.418**

So the grade is awarded corresponding to the value of weighted averages[a(X)] of each group as

A_1 = grade B = Very Severe ,
A_2 = grade C = Severe ,
A_3 = grade C = Severe ,
A_4 = grade B = Very Severe ,
A_5 = grade C = Severe ,
A_6 = grade C = Severe ,

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A_7 = grade C = Severe ,

Result: Out of seven age groups, the scavengers of $\mathbf{A_4}$ is the most sufferer age group out of all whereas $\mathbf{A_7}$ is the least. But in question of the health severity the age group of $\mathbf{A_1}$ worst and $\mathbf{A_7}$ is the least.

V. CONCLUSION

Study reveals that all scavengers working daily in Dhappa landfill are suffering from different diseases and their health are in risk of danger with some degree of certainty. The scavengers in the age group of 31-40 years are the most sufferer scavengers while the scavengers in the age group of 'above 60 years' are least. Similarly from the analysis of health severity, scavengers in the age group of 'below 10 years' claims very risk of health condition where as scavengers of the age group of 'above 60 years' are very little with respect to rest. This type of fuzzy analysis can serve as important information to the "Department of Pollution Control Board" of different Government. This study also present an optimization method which will not only finds the most effected age group out of n alternatives but do a ranking too among them, on the basis of number of diseases effected by them as comparing bitwise.

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