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Neutrosophic Fuzzy Approach for Assessment of Health Hazard of Ragpickers

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Abstract: India's informal sector of solid waste management involving rag pickers, middlemen and wholesale dealers face relative apathy at the community level. Lack of sustainable commitment from the government and stringent implementation of regulatory framework to manage waste has resulted in negative impacts of this obstinate issue. Rag pickers from diverse age groups including women, do not have any social or occupational recognition in the country and also suffer from local injuries, infections and systemic illnesses. There is hardly any published evidence of the key determinants of health of ragpickers, gender or age specific health, awareness on handling wastes and hygiene practices. This paper presents a systematic analysis of the morbidity profile of ragpickers to assess their health more so, from non-governmental organisations. This research involved 306 ragpickers which were divided into seven age groups and surveyed to ascertain the most prominent disease for a particular age group. A Neutrosophic health rating model has been proposed employing Neutrosophic Fuzzy Set theory [5]. This model can be used to implement long term occupational health monitoring programs and health awareness campaigns.

Keywords: Dominating matrix, Neutrosophic logic, Ragpickers, SVN set.

I. Introduction

Due to rapid growth of population solid wastes generation has increased dramatically and is a great challenge to solid waste management authorities for its safe disposal [1]. The whole responsibility for collection and final disposal to landfill directly relies on the shoulders of rag pickers who are basically illiterate, unskilled, migrants and lowest in the caste hierarchy. The rag pickers of different age groups involved in handling, collection and disposal of wastes are more susceptible to occupational health hazards beyond their purview of knowledge. At present there are no published rules or regulations by the local Govt. and authorities on restriction of age of rag pickers who handle the wastes. Also, the numbers of rag pickers of different age groups plying in the field every day varies on daily basis [2]. There is no official restriction on sanitary and hygiene facilities for handling of wastes by the rag pickers or for their free roaming in the landfill area. As a result, almost all the rag pickers are more or less affected by multiple disease(s) due to their wide exposure to the wastes. Most of them are suffering from different diseases like 'gastroenteritis', 'asthma', 'bronchitis', 'skin diseases' etc. [3]. But for a particular disease, some rag pickers of a specific age group are more vulnerable. Considering all the diseases with respect to different age groups, a comparative analysis is made in this paper to assess the morbidity order.

Presently, there is no model available to assess the health hazard rating of ragpickers. This paper aims to identify the particular age group out of n options, most affected by a particular disease using Neutrosophic logic so that a suitable health program may be initiated. This sort of appraisal is difficult due to lack of data and one has to rely on prediction where uncertainty has an incredible part in each progression of assessment. Since, every expert is uncertain on their assessment because of specific impediment of learning or scholarly functionaries [4]. This study has addressed this issue all the more decisively utilizing 'Neutrosophic Fuzzy Logic' [5].

Usually, this kind of uncertainty is being tackled by the 'Intuitionistic' fuzzy logic [6] where the summation of membership value, non-membership value and hesitation always sum up to 1 within subset [0,1]. An intuitionistic fuzzy set is represented as $A = \{(x : t_A(x), f_A(x)) \mid x \in U\}$ where the functions , $t_A(x) : x \rightarrow [0,1]$ and $f_A(x) : x \rightarrow [0,1]$ define the degree of membership and the degree of non-membership of the element $x \in U$, respectively, and for every $x \in U$ there is a condition that $0 \leq t_A(U) + f_A(x) \leq 1$. The main novelty of Atanassov's approach is that $[\, t_A(x) + f_A(x) + i_A(x) \,] = 1$, where the value of hesitation or in deterministic part of an IFS can estimate by $i_A(x) = [1 - t_A(x) - f_A(x)]$. But in this study, Neutrosophic logic of Florentin Smarandache is used where it is not assumed that 'incompleteness' or 'indeterminacy degree' is always given by $[1 - t_A(x) - f_A(x)]$. Instead, it estimates the percentage of truth in a subset T where $t_A(x) : x \rightarrow [0, 1]$, percentage of indeterminacy in a subset I, where $i_A(x) : x \rightarrow [0, 1]$, percentage of falseness in a subset F, where $f_A(x) : x \rightarrow$

[0, 1] individually and independently. In the Neutrosophic logic the T, I, F are defined as standard or non-standard subsets of the non-standard interval]-0, 1 + [instead of [0, 1]. Thus there is no restriction on the summation of $t_A(x)$, $i_A(x)$ and $f_A(x)$, but a condition exists as $[0 \leq \sup t_A(x) \leq \sup i_A(x) \leq \sup f_A(x) \leq 3]$. The study manages a philosophy of 'Neutrosophic Model (NS-model)' where comparison of age groups is done bitwise (i.e. independently for each disease) to rank them and assess the rating of overall health hazards of rag pickers with degree of certainty. The comparison for different diseases has been done considering only the age groups which may have either male or females. The gender specific comparison, however will involve the female specific diseases also and the disease which may pass on through generations. This is purely a mathematical modelling of the dominating disease with respect to age. Different diseases as may be predominant in a particular region may be considered in the same mathematical model. This model if implemented by the regional/local governments may prove to be very useful in initiating health related programs.

II. Preliminaries

This section gives a brief of a few preliminaries which will be useful in the area of Neutrosophic logic.

A. Fuzzy Sets (FS) and Fuzzy Logic

In everyday life, there are issues which can't be understood decisively because of association of uncertainty in progression of its assessment. To handle these vulnerabilities, Prof. Lotfi Zadeh established the framework of fuzzy set hypothesis in 1965 by speculation of conventional fresh set hypothesis and presented the theory of fuzzy logic which can handle the issue of uncertainty effectively. As per the idea of fuzzy logic, when a statement is totally true then the membership value is 1 and when a statement is totally false the membership value is 0 and when the statement is incompletely valid and somewhat false then the membership value can take any value from the interval: [0, 1]. A fuzzy set communicated as the arrangement of ordered pairs like $B = \{(x_1, m_B(x_1)), (x_2, m_B(x_2)), \ldots, (x_n, m_B(x_n))\}$, where $\mu_B(x_i)$, is the grade of membership of element x_i in set B. The greater value of $\mu_B(x_i)$, indicates greater the truthness of statement that 'the element xi belongs to set B'[4]. The part of decision maker is imperative to survey the degree of membership value of any assessment activity [7].

B. Intuitionistic Fuzzy Set (IFS) vs. Neutrosophic Fuzzy Set (NFS)

An intuitionistic fuzzy set (IFS) presented by Prof. K.T. Atanassov in 1986. He communicated IFS-set B in U, as $B = \{(x, \mu_B (x), \nu_B (x)) \mid x \in U\}$ where the functions, $\mu_B : x \rightarrow [0,1]$ and $\nu_B : x \rightarrow [0,1]$ define the degree of membership and the degree of non-membership of the element $x \in U$, respectively with a condition that $0 \leq \mu_B (x) + \nu_B (x) \leq 1$. When $\nu_B (x) = 0$, then there is no difference in between IFS and FS [5].

The Neutrosophic Fuzzy Set (NFS) presented by Prof. Florentin Smarandache is dealt with as super logical set out of every single logical set till date. The principle thought of NFS is to portray each logical proclamation in a 3D Neutrosophic space, where each assessment represents respectively the truth membership function $T_C(x)$, an indeterminacy function $I_C(x)$ and a falsity membership function $F_C(x)$ within sub sets of]-0,1+[, where $1+ = 1 + \varepsilon$ and $-0 = 0- \varepsilon$. Here '1' and '0' are the standard part and 'ε' its non-standard part. That is $T_C(x) : x \rightarrow]-0, 1+[$, $I_C(x) : x \rightarrow]-0, 1+[$ and $F_C(x) : x \rightarrow]-0, 1+[$. There is no restriction on the sum of $T_C(x)$, $I_C(x)$ and $F_C(x)$ to be 1 [8]. In general refined Neutrosophic logic, T can be split into subcomponents $T_1, T_2, T_3, \ldots T_p$ and I into $I_1, I_2, I_3, \ldots, I_r$ and F into $F_1, F_2, F_3, \ldots, F_s$ where $t_C(x) : x \rightarrow [0,1]$, $i_C(x) : x \rightarrow [0,1]$ and $f_C(x) : x \rightarrow [0,1]$ with $0 \leq t_C(x) + i_C(x) + f_C(x) \leq 3$ for all $x \in U$ [5].

C. Single Valued Neutrosophic Set (SVN Set)

If B is the single valued Neutrosophic set of the universe U and $t_A(x)$, $i_A(x)$ and $f_A(x)$ denote the truth-membership degree, the indeterminacy-membership degree and the falseness membership degree of x to the universal set U [9], then

$B = \{(x : t_B (x) , i_B(x) , f_B (x))) \mid x \in E \}$, where $t_B(x) : x \rightarrow [0,1]$, $i_B(x) : x \rightarrow [0,1]$ and $f_B(x) : x \rightarrow [0,1]$

with $0 \leq t_B(x) + i_A(x) + f_B(x) \leq 3$ for all $x \in U$

D. Neutrosophic Fuzzy Relation

If $U, Y \subseteq R$ be universal sets to survey the quantum assessment of uncertainty related with occasions then fuzzy set R is to be called Neutrosophic fuzzy relation on U X Y where μ_R {x : t(x), i(x), f(x)} is a function of three individual variables or membership functions [10]. Let U be the domain of patients = $\{P_1, P_2, P_3\}$ and Y be the domain of sicknesses = $\{D_1, D_2, D_3\}$ be two universes then a conceivable Neutrosophic fuzzy relation R on U x Y would be in matrix notation as in Table I.

Table I: Neutrosophic Fuzzy Relation

R	*D_1*	*D_2*	*D_3*
P_1	(0.8, 0.1, 0.1)	(0.4, 0.2, 0.6)	(0.5, 0.4, 0.2)
P_2	(0.5, 0.2, 0.4)	(0.7, 0.3, 0.2)	(0.5, 0.6, 0.2)
P_3	(0.6, 0.2, 0.4)	(0.5, 0.5, 0.1)	(0.6, 0.4, 0.2)

III. Methodology

To comprehend the useful approach of NS-model, few aspects of this model are examined underneath before beginning of contextual investigation.

A. Fuzzy Alternatives Statement (FAS)

Amid assessment of occupation, the expert's perspectives or public's opinions, sentiments are regularly found in non-numerical or semantic proclamation like 'poor drainage system', many scavengers are working', 'unusual number of fly breeding', 'good eco-friendly', 'huge quantity of solid waste', 'highly affected', 'bad approach road', 'acute rodents problems', 'huge debris', etc., and so forth. Each information is clearly called fuzzy information yet in the present NS-model, these are called as fuzzy alternatives statements (FAS).

A. Score Fuction Fuzzy Sets

If $B = [\, t_B(x) , i_B(x) , f_B(x)]$ be a single valued neutrosophic set, then the membership function (S_B) of a score function fuzzy set $S_B(x)$ is defined by the crisp number as given in equation (1).

$$S_B(x) = \frac{\left\{t_B(x)+\frac{i_B(x)}{2}\right\}+\{1-\left(f_B(x)+\frac{i_B(x)}{2}\right)\}}{2} \qquad (1)$$

where, set-$S_B(x)$, → [-1, 1] and $t_B(x)+ i_B(x) + f_B(x) \leq 3$ for all x ϵ U.

B. Disease Affected Matrix

Suppose collection of all diseases D_1 , D_2 , D_3 ,……, D_m and the collection of all age groups of rag pickers are say, G_1 , G_2 , G_3 ,……., G_n , then the 'Disease Affected Matrix' is an n x m matrix (q_{ij}), where n is the number of different age groups of rag-pickers and m is the number of diseases affected by the rag-pickers and represented as in Table II.

Table II: Disease Affected Matrix

	D_1	D_2	...	...	D_m
G_1	q_{11}	q_{12}	…	…	q_{1m}
G_2	q_{21}	q_{22}	…	…	q_{2m}
...	…	…	…	…	…
G_n	q_{n1}	q_{n2}	…	…	q_{nm}

Where, the element q_{ij} represents the number of rag-pickers affected by the disease D_j of age group G_i.

C. Single Valued Neutrosophic Set Matrix (SVN Set Matrix)

This is also an (n x m) matrix formulated from the 'Neutrosophic Fuzzy Relation' in between the age group (G_i) and the disease (D_j) of above disease affected matrix. As for example if the set of collection of all age groups say, B= {G_1, G_2, G_3,……., G_n} and the set of collection of all possible diseases say, D = {D_1, D_2, D_3,….., D_m}, then membership value matrix which comprises of element e_{ij} representing the degree of membership value of effect D_j on the age group of G_i will represent the set of 3-dimensional membership values of t(x), i(x) and f(x) of x to the universal set U and written as in Table III.

Table III: Membership Value Matrix

	D_1	D_2	...	...	D_m
G_1	e_{11}	e_{12}	…	…	e_{1m}
G_2	e_{21}	e_{22}	…	…	e_{2m}
...	…	…	…	…	
G_n	e_{n1}	e_{n2}	…	…	e_{nm}

D. Score Function Fuzzy Set Matrix

This is also an (n x m) matrix formulated from above SVN set matrix which comprises of element s_{ij} representing the degree of score function fuzzy membership value of effect D_j on the age group of Gi which can be evaluated from the individual score function fuzzy set of definition 3.2 and is written as in Table IV.

Table IV: Score Function Fuzzy Set Matrix

	D_1	D_2	...	...	D_m
G_1	s_{11}	s_{12}	…	…	s_{1m}
G_2	s_{21}	s_{22}	…	…	s_{2m}
...	…	…	…	…	
G_n	s_{n1}	s_{n2}	…	…	s_{nm}

E. Weighted Matrix

The weighted matrix is also like (n x m) matrix (p_{ij}) and it's each element denotes weighted value of each disease D_j for the age group G_i. The weighted value of $p_{ij} = (s_{ij} \text{ X } w_{ij})$ where w_{ij} is the weight of the disease to be prefixed by the expert before commencement of case study. So, the weighted matrix could be as in Table V.

Table V: Weighted Matrix

	D_1	D_2	...	...	D_m
G_1	p_{11}	p_{12}	…	…	p_{1n}
G_2	p_{21}	p_{22}	…	…	p_{2n}
...	….	…	…	…	…
G_n	p_{n1}	p_{n2}	…	…	p_{nn}

F. 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 G_j dominated by the age group G_i, on the basis of information available in the disease affected matrix. The dominance matrix will be as in Table VI.

Table VI: Dominance Matrix

	A_1	A_2	...	...	A_n	*Sum*
G_1	m_{11}	m_{12}	…	…	m_{1n}	r_1
G_2	m_{21}	m_{22}	…	…	m_{2n}	r_2
…	…	…	…	…	…	…
G_n	m_{n1}	m_{n2}	…	…	m_{nn}	r_n
sum	c_1	c_2	…	…	C_n	

G. Overall Weighted Average [a (U)]

If the set-$S_A(x)$ is a score function fuzzy sets such that for each element $x \in U$, there is an associated weight $W_i \in R+$ (which could be prefixed by the common decision of all experts before commencement of case study), then the individual 'weighted average' of the NFS is the non-negative number and given by Equation (2).

$$a(x)_{individual} = \sum S_A(xi).W_{xi} \Big/ \sum W_{xi} \quad (2)$$

If the no. of cases is consider for the assessment as N, then the overall weighted average is given by Equation (3).

$$a(X) = \sum a(x)_{individual}/N \quad (3)$$

I. Health Hazards Rating System

If the overall weighted average is assessed as a (U), then health hazardous rating of output results of fuzzy-analysis could be proposed as below:

grade A = Extremely severe Impact, if .8 < a (U) < 1

grade B = Very Severe Impact, if .6 < a (U) < .8

grade C = Severe Impact, if .4 < a (U) < .6

grade D = Moderately mild Impact, if .2 < a (U) ≤ .4

grade E = Mild Impact, if 0 ≤ a (U) ≤ .2

IV. Case Study

The case-study is completed into two phases. In first phase we collected the data from 306 rag pickers for the information of diseases which they are actually suffering due to handling of wastes daily. Then all rag-pickers are divided into seven age groups as given in Table VII and study of their health conditions for the five common diseases i.e. 'D_1 = gastroenteritis', 'D_2 = asthma', 'D_3 = bronchitis', 'D_4 = skin diseases', and 'D_5 = others diseases' etc. The seven age groups of 306 rag-pickers are considered as

Table VII: Number of Ragpickers in a Particular Age Group

Group	*Age in Years*	*No.*
G_1	Below 10	12
G_2	11-20	37
G_3	21-30	68
G_4	31-40	71
G_5	41-50	66
G_6	51-60	35
G_7	above 60	17

The survey data is given in Table VIII in the form of disease affected matrix for evaluation of SVN Set Matrix.

Table VIII: Disease Affected Matrix

	D_1	D_2	D_3	D_4	D_5
G_1	2	4	3	2	1
G_2	7	8	11	6	5
G_3	15	13	20	11	9
G_4	22	12	18	8	11
G_5	13	18	12	14	9
G_6	4	7	6	13	5
G_7	4	2	2	3	6

In second phase NS-model for assessment of their health hazardous condition has been used. Before doing the job of SVN Set Matrix, ten experts (Group-I) were selected for collection of their opinion in favour of truth-membership value [t(x)], another ten experts (Group-II) for collection of their opinion in favour of indeterminacy-membership value [i(x)] and another ten experts (Group-III) for collection of their opinion in favour of falseness membership value [f(x)]. Then, Neutrosophic fuzzy relation R on B x D for the FAS 'x = age group highly affected by the disease' and the SVN set for each relation is given in Table IX.

Table IX: Single Valued Neutrosophic Set

R	*D1*	*D2*	*D3*	*D4*	*D5*
G_1	(0.8, 0.2, 0.1)	(0.7, 0.3, 0.4)	(0.6, 0.3, 0.2)	(0.7, 0.2, 0.3)	(0.1, 0.5, 0.7)
G_2	(0.4, 0.4, 0.6)	(0.6, 0.2, 0.7)	(0.4, 0.3, 0.8)	(0.5, 0.4, 0.6)	(0.8, 0.2, 0.3)
G_3	(0.2, 0.3, 0.5)	0.5, 0.3, 0.2)	(0.5, 0.6, 0.2)	0.8, 0.1, 0.2)	0.7, 0.1, 0.2)
G_4	0.6, 0.2, 0.4)	(0.5, 0.5, 0.1)	(0.6, 0.4, 0.2)	(0.7, 0.6, 0.1)	(0.8, 0.2, 0.1)
G_5	(0.5, 0.6, 0.2)	(0.2, 0.7, 0.4)	(0.2, 0.6, 0.2)	(0.5, 0.3, 0.4)	(0.4, 0.6, 0.2)
G_6	(0.8, 0.1, 0.1)	(0.4, 0.2, 0.6)	(0.5, 0.4, 0.2)	(0.7, 0.3, 0.3)	(0.7, 0.6, 0.1)
G_7	(0.5, 0.2, 0.4)	(0.7, 0.3, 0.2)	(0.5, 0.6, 0.2)	(0.5, 0.5, 0.3)	(0.5, 0.2, 0.3)

Table X: Score Function Fuzzy Set Matrix

R	*D1*	*D2*	*D3*	*D4*	*D5*
G_1	0.55	0.35	0.50	0.40	0.05
G_2	0.25	0.40	0.20	0.50	0.65
G_3	0.35	0.65	0.65	0.80	0.75
G_4	0.60	0.70	0.70	0.80	0.85
G_5	0.65	0.40	0.50	0.55	0.60
G_6	0.85	0.40	0.65	0.70	0.80
G_7	0.55	0.75	0.65	0.60	0.60

So the Score Function Fuzzy Set Matrix of the above SVN Set Matrix is calculated as in Table X.

The next job is to frame the weighted matrix for functioning of dominating matrix. Considering the severity of impact to the individual age group, the weight of each disease is prefixed by the thirty experts jointly and assigned as suppose, for D_1 = 80, for D_2 = 60, for D_3 = 70, for D_4 = 40 and for D_5 = 30 respectively. So the weighted matrix is calculated as in Table XI.

Table XI: Weight Matrix

R	*D1*	*D2*	*D3*	*D4*	*D5*
G_1	44	21	35	16	1.5
G_2	20	24	14	20	19.5
G_3	28	39	45.5	32	22.5
G_4	48	42	49	32	25.2
G_5	52	24	35	22	18
G_6	68	24	45.5	28	24
G_7	44	45	45.5	24	18

We now compute the dominating matrix from the above weighted matrix as mentioned in Table XII.

Table XII: Dominance Matrix

	G1	*G2*	*G3*	*G4*	*G5*	*G6*	*G7*	*Sum*
G_1	5	2	1	0	1	0	1	$r_1 = 10$
G_2	3	5	0	0	2	1	1	$r_2 = 12$
G_3	4	5	5	1	4	3	3	$r_3 = 25$
G_4	5	5	5	5	4	3	4	$r_4 = 31$
G_5	5	4	1	1	5	1	2	$r_5 = 19$
G_6	5	5	3	1	5	5	4	$r_6 = 28$
G_7	5	4	3	1	3	2	5	$r_7 = 12$
Sum	c_1 = 32	c_2 = 30	c_3 =18	c_4= 9	c_5 = 24	c_6 = 15	c_7 = 20	

The gross comparison values (GCV) of the age groups were found as G_1 = -22 , G_2 = -18 , G_3 = 7 , G_4 = 22, G_5 = -5, G_6 = 13 and G_7 = -8.

Clearly, $G_1 < G_2 < G_7 < G_5 < G_3 < G_6 < G_4$. Thus study reveals that G_4 is the most affected age group out of all whereas G_1 is the least. Now we calculate the overall weighted averages [a (U)] of the assessment with degree of certainty as given in Table XIII.

Table XIII: Overall Weighted Averages

R	*D1*	*D2*	*D3*	*D4*	*D5*	*Individual Weighted Average*	*Overall Weighted Average a (U)*
G1	44	21	35	16	1.5	0.419	0.558
G2	20	24	14	20	19.5	0.348	
G3	28	39	45.5	32	22.5	0.596	
G4	48	42	49	32	25.2	0.700	
G5	52	24	35	22	18	0.539	
G6	68	24	45.5	28	24	0.676	
G7	44	45	45.5	24	18	0.630	

Result: Degree of overall assessment = 0.558 and thus rating is 'Severe Impact'.

V. Conclusion

At present there is no tool or model available to solid waste management authorities to assess the degree of health hazard conditions of the rag pickers. The present study on the use of NS-model can serve important information to the solid waste management authority for protection of the health of rag-pickers within law and act of local Govt. This study also present an optimisation method which will not only finds the most affected age group out of n-alternatives but do a ranking too among them. Out of seven age groups of the 306 ragpickers surveyed, G4 group of rag-pickers is the most affected age group whereas G1 group is the least. But all rag-pickers are suffering from different diseases more or less with certain degree of health hazard. Hence, the overall weighted average of this study is found to be 0.558 which could be scored as grade 'C i.e 'Severe Impact' according to the scale adopted in this study. This study was generic based on age groups but gender specific studies can also be undertaken. The gravity of health assessment is manifolds in case of women as the diseases are reproductively transmitted to future generations to which the governments need to take a serious insight.

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