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ENVIRONMENTAL RANKING OF LANDFILL SITES AMONG n-ALTERNATIVES

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Abstract- In almost all cities, the solid waste generation is increased dramatically and becomes a great challenge today to municipal authority for its collection and safe disposal. Continuous uncontrolled generation of solid wastes forces the existing landfills to become exhausted rapidly[2-3]. Other hand the chance of availability of open land for future provision of landfill in a city is now very less. At present no sanitary landfill technique is practiced for disposal of wastes rather wastes are dumping crudely in a open field without any environmental protection. This indiscriminate disposal of wastes leads to significant degradation of environment and spreads diseases nearby locality of landfill site[4]. Naturally every landfill has an independent grade of acceptability to local authority in respect of their 'Land Area'; 'Daily loading of wastes quantity'; 'Environmental adverse impact to nearby area' and 'Cost of land' etc. In this paper a methodology of Neutrosophic Fuzzy (NSF) model has been introduced to select the environmentally best acceptable landfill out of n-alternative and make a ranking among them. To validate the model, a case study on three landfills of Delhi(capital of India) is presented here.

***Keywords:** FAS, FD, SVN-set, neutrosophic logic, score function, AEIV, etc.*

I. INTRODUCTION

The rapid growth of population leads ultimately the increase of wastes generation in a society. Most of the solid waste management authorities are not able to collect 100% wastes from all sources of generation and dispose it safely due to their poor economical infrastructure. The disposal system is also not in sanitary manner rather drivers have usual habits to dump wastes in landfill where they felt comfortable with less time and efforts. Ultimately it creates a hillock of rubbish posing great environmental threats to nearby residential area. When moisture exceeds the field capacity of the waste matrix as a result of percolation of rain water it squeeze the waste itself and form leachate that contaminated the surrounding soil structure of landfill. It contains a wide variety of hazardous chemicals as well as conventional and non-conventional contaminants that degrades the quality of original soil and underground water sources [3-4]. The sanitary condition around the periphery of landfill becomes highly polluted due to frequent interferences of birds, dogs, pigs, rodents, cows etc as well as lack of proper drainage system and unhygienic latrine. As result the whole environment become a favourable condition for high breeding of fly and mosquito and make responsible for causing different diseases like gastroenteritis, asthma, bronchitis, skin diseases, etc among local people those are living nearby landfill sites[2]. This people are often found illiterate and economically backward thus there is an essential need of continuous awareness programs on sanitation and hygienic from local authority but such practice are found in field. Due to rapid urbanization, open big field for provision of future landfill is not available easily inside the city and if available then cost of land will be very high which will not permit the local authority to purchase for purpose of wastes dumping. In other hand, existing landfills are started overflow due to uncontrolled solid wastes generation and it's dumping in each daily. Naturally it is now necessary to an authority to assess the importance of existing all landfills and select the environmentally best acceptable landfill out of n-alternative with degree of certainty. But this type of assessment involves prediction where uncertainty has a great role for its evaluation. During assessment, data are generally found in linguistic form viz. 'good', 'very good, "less amount', 'too much polluted', 'not lees than 30%', 'poor drainage system', 'many scavengers', 'unusual number', 'good eco-friendly', 'huge quantity', 'bad water quality', 'bad approach road', 'acute rodents problems', 'huge debris', etc. to list a few only out of infinity. This type of data are called fuzzy data [8] and evaluation of such data are not always possible with numerical valued description. Because some part of the evaluation contributes to truthness, some part contributes to falseness and the rest part remains indeterministic. Every expert or decision-maker hesitates more or less, on every evaluation activity due to their certain limitation of knowledge or intellectual functionaries and thus outcome result of their perceptions becomes with full of uncertainty [3]. The 'Neutrosophic Fuzzy Logic' of Prof. Florentin Smarandache [5-7] that used in this paper can give a beam of light to management authority to mitigate the adverse environmental impacts of landfill and it's future longevity.

The 'Fuzzy Logic' of Prof Lafti Zadeh[8] deals with truth membership function [$t_A(x)$] within subset [0,1] and then false membership function [$f_A(x)$] will be [$f_A(x) = 1 - t_A(x)$] within sub set [0,1]. Prof. K.T.Atanassov who introduced 'Intuitionistic Fuzzy Logic' [1] tackled the uncertainty more precisely by generalization of normal fuzzy logic of Prof Lafti Zadeh. To tackle the uncertainty he approached a strong logic that [$t_A(x) + f_A(x) + i_A(x) = 1$], where the value of hesitation [$i_A(x)$] or indeterministic part can estimate by [$i_A(x) = 1 - t_A(x) - f_A(x)$] within sub set [0,1].

Later on Prof. Florentin Smarandache introduced 'Neutrosophic Fuzzy Logic'[5-7] which does not permit the logic of [$t_A(x) + f_A(x) + i_A(x) = 1$] within single sub set [0,1] to tackle the uncertainty at the extreme point of perception. Instead of that we have to estimate 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 falsity in a subset F, where $f_A(x): x \rightarrow [0,1]$ individually and independently. According to his logic there will be no restriction on summation of $t_A(x)$, $i_A(x)$ and $f_A(x)$, and the condition will exist in such that [$0 \leq \sup t_A(x) \leq \sup i_A(x) \leq \sup f_A(x) \leq 3$]. Thus to tackle the uncertainty with more degree of satisfaction, 'Neutrosophic Fuzzy Logic' is now being used in large scale in all research fields. This paper deals with a 'Neutrosophic Fuzzy(NSF)' model to select the environmentally best acceptable landfill out of three landfills of Delhi (capital of India).

II. PRELIMINARIES

Different mathematical concepts has used in this methodology which are discussed below briefly.

A. Crisp Set

A set can be described either by list method or by the rule method. We know that the process by which individuals from the universal set X are determined to be either members or nonmembers of a set can be defined by a characteristic function or discrimination function.

For a given set A, this function assign a value $\mu_A(x)$ to every $x \in X$ such that

$$\mu_A(x) = 1 \quad \text{iff} \quad x \in A$$
$$= 0 \quad \text{iff} \quad x \notin A$$

Thus in the classic theory of sets, very precise bounds separate the elements that belong to a certain set form the elements outside the set. In other words, it is quite easy to determine whether an element belongs to a set or not.

B. Fuzzy Set [8]

Many sets encountered in reality do not have precisely defined bounds as in case of crisp sets that separate the elements in the set from those outside the set. That so the crisp characteristic function can now be generalized such that the values assigned to the elements of the universal set fall within a specified range and indicate the membership grade of these elements in the set in question. Such a function is called membership function and the set defined by it a fuzzy set. The membership function for fuzzy sets can take any value form the closed interval [0,1]. Fuzzy set A is defined as the set of ordered pairs A = { x, $\mu_A(x)$ }, where $\mu_A(x)$ is the grade of membership of element x in set A. The greater $\mu_A(x)$, the greater the truth of the statement that element x belongs to set A [2,7]. Let $X = \{x_1, x_2, \ldots, x_n\}$ be a finite discrete universe of elements xi, i = 1, 2, …. , n. A fuzzy set A defined over a set X is most often shown in the form

$$A = \{(x_1, \mu_A(x_1)), (x_2, \mu_A(x_2)), (x_3, \mu_A(x_3)), \ldots, (x_n, \mu_A(x_n))\} \text{ where } \mu_A(xi) \rightarrow [0,1].$$

C. Instuitionistic Fuzzy Set [1]

An intuitionistic fuzzy set (IFS) A in X is defined as an object of the following form.

$$A = \{ (x, \mu_A(x), v_A(x)) \mid x \in X \}$$

where the functions,

$$\mu_A : x \rightarrow [0,1] \text{ and } v_A : x \rightarrow [0,1]$$

define the degree of membership and the degree of non-membership of the element $x \in X$, respectively, and for every $x \in X$ we have the relation $0 \leq \mu_A(x) + v_A(x) \leq 1$ which is called 'Atanassov condition'. Obviously, each ordinary fuzzy set may be written as

$$\{ (x, \mu_A(x), 1-\mu_A(x)) \mid x \in X \}$$

and thus every fuzzy set is an intuitionistic fuzzy set but not conversely. The amount $\pi_A(x) = [1 - (\mu_A(x) + v_A(x))]$ is also called the hesitation part (i.e. the degree of non-determinacy or uncertainty) of the element and this amount may cater to either membership value or to non-membership value or to both [1,5]. Clearly, in case of ordinary fuzzy sets (Zadeh's fuzzy sets) it is presumed that $\pi_A(x) = 0$ for every $x \in X$.

D. Neutrosophic Fuzzy Set (NFS) [5-7]

Neutrosophic Fuzzy Set (NFS) introduced by Prof. Florentin Smarandache is now treated as super generalized set of all existing logical sets. The logic stated that truth membership function $T_C(x)$, indeterminacy function $I_C(x)$ and falsity membership function $F_C(x)$ of a NFS is to be characterized each in a 3D neutrosophic space individually within sub sets of]-0,1+[, where only '1' and '0' are the standard part and 'ε' its non-standard part such that 1+ = 1 + ε and -0 = 0- ε. There is no restriction on the sum of $T_C(x)$, $I_C(x)$ and $F_C(x)$ thus the relation of there membership function will be $-0 \le t_A(x) + i_C(x) + f_C(x) \le 3+$. In neutrosophic logic, T can be split into subcomponents $T_1, T_2, T_3, \ldots Tp$ and I into $I_1, I_2, I_3, \ldots, Ir$ and F into $F_1, F_2, F_3, \ldots, Fs$, and their individual membership function will be within [0,1] and to be expressed as $t_C(x) : x \rightarrow [0,1]$, $i_C(x) : x \rightarrow [0,1]$ and $f_C(x) : x \rightarrow [0,1]$ with $0 \le tC(x) + iC(x) + fC(x) \le 3$ for all $x \in X$.

E. Single Valued Neutrosophic Set [7]

If $t_A(x)$, $i_A(x)$ and $f_A(x)$ denote the truth-membership degree, the indeterminacy-membership degree and the falsity membership degree of x of universal set X, then the single valued neutrosophic set(SVN-set) A is defined as

$$A = \{(x : t_A(x), i_A(x), f_A(x)) \mid x \in X\},$$

where $t_A(x) : x \rightarrow [0,1]$, $i_A(x) : x \rightarrow [0,1]$ and $f_A(x) : x \rightarrow [0,1]$ will evaluate individually so that the condition of $0 \le t_A(x) + i_A(x) + f_A(x) \le 3$ for all $x \in X$ exists.

III. METHODOLOGY

To understand the functional approach of NSF model, few working tools are discussed below before starting of case study.

A. Fuzzy Alternatives Statement (FAS)

During evaluation of job, the expert's views or local public's opinions are often found in non-numerical or linguistic statement like 'poor drainage system', 'many scavengers are working', 'unusual number of fly breeding', 'good eco-friendly', 'huge quantity of solid waste', 'bad water quality', 'bad approach road', 'acute rodents problems', 'huge debris', etc. All these data are considered as fuzzy alternatives statements (FAS) in the present model of NFS.

B. Score Function Fuzzy Sets

If A is a single valued neutrosophic set and $t_A(x)$, $i_A(x)$ and $f_A(x)$ are suppose degree of truthness, degree of indeterminacy and degree of falsity, then score function fuzzy set SF(x) is defined by the membership function (SF) as

$$S_A(x) = \frac{[t_A(x) + i_A(x)/2] + [1- \{f_A(x) + i_A(x)/2\}]}{2}$$

where, set-$S_A(x) \rightarrow [-1, 1]$ and $t_A(x) + i_A(x) + f_A(x) \le 3$ for all $x \in X$.

C. Average Environmental Impact Value (AEIV)

If the set-SL(x) is a score function fuzzy sets such that for each element $x \in X$, there is an associated weight $Wi \in R+$ (which could be prefixed by the common decision of all experts before commencement of case study), then the 'Average Environmental Impact Value (AEIV)' of the score function fuzzy sets is the non-negative number a(x) given by :

$$a(x) = \frac{\sum SL(xi).WXi}{\sum WXi}$$

D. Fuzzy Decision (FD)

In every evaluation activity our target is always to achieve the goal where many constraints are clubbed with all possible decisions. Due to lack of knowledge or limitation of intellectual functionaries a decision maker hesitates more or less for taking perfect decision facing all constraints that plays an integral part for achieving the targeted goal. The fuzzy decision (FD) is an appropriate tool to achieve the targeted goal minimizing the doubt and uncertainty that arises in the perception of the experts or decision makers for solution this type of problems. To understand the function of FD an algorithm is presented below.

Algorithm of FD :

Here we use the general concept of fuzzy logic of Prof. Lafti Zadeh where the membership value (μ) for the 'maximum favourable condition' of an option is considered as 1 and for 'not maximum favourable condition' it is 0.

Let us consider a group of options as O

Where, $O = \{ O_1, O_2, O_3, \ldots\ldots, O_L\} = \{ Oi \}$, for $i = 1, 2, 3, \ldots, L$

Let a fuzzy set G describing goals associated with each option (oi) such that

$G = \{ \mu(g1/o1), \mu(g2/o2), \mu(g3/o3), \ldots\ldots,$

$\mu(gL/oL)\} = \{\mu(gi/oi)\}$, for $i = 1, 2, 3, \ldots, L$

Now if the three fuzzy sets C_1, C_2 and C_3 describing three constraints associated with each option (oi) such that $C_1 = \{ \mu_1(c_1/o_1), \mu_1(c_2/o_2), \mu_1(c_3/o_3), \ldots\ldots, \mu1(cL/oL) \}$

$= \{ \mu1(ci/oi)\}$, for $i = 1, 2, 3, \ldots, L$

And $C_2 = \{ \mu_2(c_1/o_1), \mu_2(c_2/o_2), \mu_2(c_3/o_3), \ldots\ldots, \mu_2(c_L/o_L)$

$= \{ \mu2(ci/oi)\}$, for $i = 1, 2, 3, \ldots, L$

And $C_3 = \{ \mu_3(c_1/o_1), \mu_3(c_2/o_2), \mu_3(c_3/o_3), \ldots\ldots, \mu_3(c_L/o_L) \}$

$= \{ \mu3(ci/oi)\}$, for $i = 1, 2, 3, \ldots, L$

Then the Fuzzy Decision (FD) will be given by

$$FD = Max \{D(oi)\},$$

where $D(Oi) = [\text{ sub set-G} \cap \text{sub set-}C_1 \cap \text{subset-}C_2 \cap \text{subset-}C_3]$

$= Min \{\mu(gi/oi), \mu_1(ci/oi), \mu_2(ci/oi), \mu_3(ci/oi)\}$

Now to validate the fuzzy model, a case study is presented below.

IV. CASE-STUDY

To validate the NSF model we consider a project 'Environmental ranking of three landfill among 'Okhla at South Delhi; Bhalaswa at North Delhi and Ghazipur at East Delhi'. The land area of Okhla is 16.20 Ha started from 1992 and wastes received per day 1200 tons covering the area of Central Delhi, South Delhi, Najafgarh and Cantonment area. The land area of Bhalaswa is 21.06Ha started from 1993 and wastes received per day 2200 tons covering the area of Civil Line, Karol Bagh, Rohini, West Delhi and Najafgarh while the area of Ghazipur is 29.16 Ha started from 1984 and wastes received per day 2000 tons covering the area of Shahdara (North), Shahdara(South), Sadar Paharganj & NDMC area.

(Fig1-Different Scenario of Okhla landfill)

(Fig2-Different Scenario of Bhalaswa landfill)

(Fig3-Different Scenario of Ghazipur landfill)

For simplicity in presenting the methodology we selected ten locations around the periphery of each landfill and thirty experts who would finalize twenty five fuzzy alternative statements (FASs) and their individual weight (WXi). Then we grouped ten experts for obtaining their views in favour of truth-membership value [t(x)], ten experts for obtaining their views in favour of indeterminacy-membership value [i(x)] and rest ten experts for obtaining their views in favour of falsity membership value [f(x)] during evaluation of all FASs. Suppose the twenty five FASs that considered by the thirty experts for in case study are:-

x_1 = many vehicles are plying daily for disposal of wastes

x_2 = poor drainage system around the landfill site

x_3 = many scavengers are working in the landfill site

x_4 = unusual number of mosquito breeding in landfill site

x_5 = unusual number of fly breeding in landfill site

x_6 = unhygienic latrine in and around the landfill site

x_7 = acute birds problems in landfill site

x_8 = acute rodents problems in landfill site

x_9 = poor mechanical condition of carrying vehicles

x_{10} = inadequate water facilities in landfill site

x_{11} = heavy rainfall intensity in landfill site area

x_{12} = poor management for disposal of waste timely

x_{13} = bad habit of neighbors roaming around the disposal site

x_{14} = poor awareness of sanitation among the neighbors

x_{15} = poor awareness of sanitation among the scavengers

x_{16} = easy accessibility of dogs, pigs, cows, etc. in the landfill site

x_{17} = very crude dumping system of solid waste

x_{18} = heavy production of vegetables & fishes around the landfill area

x_{19} = poor barricade in between dumping area and neighbor

x_{20} = bad habit to use the recyclable materials by the neighbors

x_{21} = high mixing habit of scavengers and neighbors

x_{22} = bad approach road around the landfill site

x_{23} = huge quantity of solid waste dumping daily

x_{24} = bad water quality

x_{25} = huge amount of leachate coming openly from landfill periphery

These data leads to a neutrosophic fuzzy set of universe X, where

X = $\{x_1, x_2, x_3, x_4, x_5, \ldots\ldots\ldots\ldots, x_{23}, x_{24}, x_{25}\}$.

Suppose the individual weight (out of 10) of each FAS prefixed by the joint decision of thirty experts are:

$W_Xi = \{ x_1 = 2, x_2 = 8, x_3 = 2, x_4 = 7, x_5 = 7, x_6 = 9, x_7 = 4, x_8 = 6, x_9 = 3, x_{10} = 8, x_{11} = 10, x_{12} = 7, x_{13} = 5, x_{14} = 4, x_{15} = 3, x_{16} = 7, x_{17} = 6, x_{18} = 2, x_{19} = 10, x_{20} = 7, x_{21} = 5, x_{22} = 7, x_{23} = 10, x_{24} = 9, x_{25} = 10\}$.

Now the job is to assign values of these FASs by the three individual groups of experts independently for ten locations of each landfill for assessment of their individual AEIV.

<u>Assessment of AEIV of Okhla Landfill :</u>

Suppose for location-1, the SVN set-L1 is assigned as below:-

SVN set-L_1 = $\{(x_1,0.7,0.6,0.1), (x_2,0.5,0.6,0.2), (x_3,0.4,0.2,0.6), (x_4,0.8,0.1,0.2), (x_5,0.5,0.2,0.3), (x_6,0.5,0.5,0.1), (x_7,0.7,0.3,0.3), (x_8,0.7,0.6,0.1), (x_9,0.5,0.6,0.2),(x_{10},0.6,0.2,0.4), (x_{11},0.5,0.2,0.4), (x_{12},0.2,0.7,0.4),(x_{13},0.2,0.3,0.5), (x_{14},0.2,0.6,0.2), (x_{15},0.5,0.6,0.2),(x_{16},0.8,0.1,0.1), (x_{17},0.6,0.4,0.2), (x_{18},0.5,0.4,0.2),(x_{19},0.5,0.3,0.2), (x_{20},0.4,0.6,0.2) (x_{21},0.7,0.3,0.2),(x_{22},0.8,0.2,0.1), (x_{23},0.5,0.5,0.3), (x_{24},0.5,0.3,0.4), (x_{25},0.7,0.1,0.2)\}$.

The Score Function fuzzy set SL(x) of above SVN set-L1 is thus calculated as

$S_{L1}(x) = \{(x_1,0.80), (x_2,0.65), (x_3,0.40), (x_4,0.80), (x_5,0.60), (x_6,0.70), (x_7,0.70), (x_8,0.80), (x_9,0.65), (x_{10},0.60), (x_{11},0.55), (x_{12},0.40), (x_{13},0.35), (x_{14},0.50), (x_{15},0.65), (x_{16},0.85), (x_{17},0.70), (x_{18},0.65), (x_{19},0.65), (x_{20},0.60), (x_{21},0.75), (x_{22},0.85), (x_{23},0.60), (x_{24},0.55), (x_{25},0.75)\}$.

Similarly for the rest nine locations of Okhla landfill periphery, the assigned score function fuzzy sets are suppose as follows:

$S_{L2}(x) = \{(x_1,0.05), (x_2,0.45), (x_3,0.25), (x4,0.30), (x_5,0.40), (x_6,0.20), (x_7,0.60), (x_8,0.30), (x_9,0.20), (x_{10},0.45), (x_{11},0.15), (x_{12},0.60), (x_{13},0.30), (x_{14},0.25), (x_{15},0.25), (x_{16},0.55), (x_{17},0.25), (x_{18},0.25), (x_{19},0.50), (x_{20},0.30), (x_{21},0.45), (x_{22},0.75,), (x_{23},0.35), (x_{24},0.55), (x_{25},0.65)\}$

$S_{L3}(x) = \{(x_1,0.35), (x_2,0.15), (x_3,0.35), (x_4,0.50), (x_5,0.25), (x_6,0.40), (x_7,0.20), (x_8,0.30), (x_9,0.20), (x_{10},0.65), (x_{11},0.05), (x_{12},0.30), (x_{13},0.10), (x_{14},0.25), (x_{15},0.25), (x_{16},0.55), (x_{17},0.50), (x_{18},0.55), (x_{19},0.40), (x_{20},0.10), (x_{21},0.45), (x_{22},0.25), (x_{23},0.65), (x_{24},0.40), (x_{25},0.20)\}$

$S_{L4}(x) = \{(x_1,0.35), (x_2,0.55), (x_3,0.50), (x_4,0.40), (x_5,0.25), (x_6,0.45), (x_7,0.60), (x_8,0.60), (x_9,0.30), (x_{10},0.25), (x_{11},0.25), (x_{12},0.10), (x_{13},0.50), (x_{14},0.55), (x_{15},40), (x_{16},0.55), (x_{17},0.50), (x_{18},0.20), (x_{19},0.20), (x_{20},0.25), (x_{21},0.65), (x_{22},0.25,), (x_{23},0.35), (x_{24},0.15), (x_{25},0.45)\}$

$S_{L5}(x) = \{(x_1,0.25), (x_2,0.35), (x_3,0.55), (x_4,0.65), (x_5,0.45), (x_6,0.80), (x_7,0.20), (x_8,0.20), (x_9,0.60), (x_{10},0.65), (x_{11},0.75), (x_{12},0.50), (x_{13},0.30), (x_{14},0.95), (x_{15},0.45), (x_{16},0.45), (x_{17},0.80), (x_{18},0.65), (x_{19},0.40), (x_{20},0.60), (x_{21},0.30), (x_{22},0.50,), (x_{23},0.65), (x_{24},0.70), (x_{25},0.85)\}$

$S_{L6}(x) = \{(x_1,0.65), (x_2,0.65), (x_3,0.25), (x_4,0.50), (x_5,0.85), (x_6,0.90), (x_7,0.20), (x_8,0.10), (x_9,0.60),$

$(x_{10},0.65)$, $(x_{11},0.25)$, $(x_{12},0.40)$, $(x_{13},0.10)$, $(x_{14},0.15)$, $(x_{15},0.45)$, $(x_{16},0.95)$, $(x_{17},0.60)$, $(x_{18},0.20)$, $(x_{19},0.45)$, $(x_{20},0.35)$, $(x_{21},0.65)$, $(x_{22},0.35,)$, $(x_{23},0.25)$, $(x_{24},0.20)$, $(x_{25},0.40)\}$

$S_{L7}(x) = \{(x_1,0.75), (x_2,0.35), (x_3,0.25), (x_4,0.30), (x_5,0.25), (x_6,0.60), (x_7,0.20), (x_8,0.80), (x_9,0.10), (x_{10},0.65), (x_{11},0.75), (x_{12},0.30), (x_{13},0.10), (x_{14},0.25), (x_{15},0.60), (x_{16},0.75), (x_{17},0.20), (x_{18},0.35), (x_{19},0.20), (x_{20},0.20), (x_{21},0.15), (x_{22},0.55,), (x_{23},0.45), (x_{24},0.05), (x_{25},0.20)\}$

$S_{L8}(x) = \{(x_1,0.85), (x_2,0.35), (x_3,0.65), (x_4,0.70), (x_5,0.55), (x_6,0.80), (x_7,0.40), (x_8,0.40), (x_9,0.20), (x_{10},0.25), (x_{11},0.15), (x_{12},0.10), (x_{13},0.40), (x_{14},0.25), (x_{15},0.40), (x_{16},0.70), (x_{17},0.50), (x_{18},0.20), (x_{19},0.70), (x_{20},0.20), (x_{21},0.65), (x_{22},0.45,), (x_{23},0.05), (x_{24},0.45), (x_{25},0.20)\}$

$S_{L9}(x) = \{(x_1,0.25), (x_2,0.35), (x_3,0.05), (x_4,0.70), (x_5,0.65), (x_6,0.40), (x_7,0.20), (x_8,0.30), (x_9,0.20), (x_{10},0.65), (x_{11},0.05), (x_{12},0.30), (x_{13},0.10), (x_{14},0.25), (x_{15},0.45), (x_{16},0.75), (x_{17},0.20), (x_{18},0.25), (x_{19},0.40), (x_{20},0.20), (x_{21},0.35), (x_{22},0.45,), (x_{23},0.05), (x_{24},0.10), (x_{25},0.40)\}$

$S_{L10}(x)= \{(x_1,0.05), (x_2,0.35), (x_3,0.05), (x_4,0.70), (x_5,0.65), (x_6,0.40), (x_7,0.20), (x_8,0.30), (x_9,0.20), (x_{10},0.65), (x_{11},0.05), (x_{12},0.30), (x_{13},0.10), (x_{14},0.25), (x_{15},0.65), (x_{16},0.75), (x_{17},0.20), (x_{18},0.25), (x_{19},0.40), (x_{20},0.20), (x_{21},0.35), (x_{22},0.45,), (x_{23},0.05), (x_{24},0.10), (x_{25},0.40)]$.

Now, mean of above ten score function fuzzy sets is also a new score function fuzzy set SL(X), which could be as below.

$S_L(X) = \{(x_1,0.39), (x_2,0.42), (x_3,0.355), (x_4,0.555), (x_5,0.505), (x_6,0.555), (x_7,0.35), (x_8,0.40), (x_9,0.34), (x_{10},0.57), (x_{11},0.31), (x_{12},0.33), (x_{13},0.25), (x_{14},0.37), (x_{15},0.45), (x_{16},0.685), (x_{17},0.415), (x_{18},0.355), (x_{19},0.435), (x_{20},0.32), (x_{21},0.455), (x_{22},0.475), (x_{23},0.35), (x_{24},0.33), (x_{25},0.435)\}$

Therefore AEIV of Okhla landfill

$$a(x) = \frac{\sum SL(xi).W_X}{\sum W_X i} = \frac{67.14}{158} = 0.425$$

Similarly the AEIV for the landfill of Balawasr and Gazipur are calculated as 0.439 and 0.255.

Now the job is to take decision which landfill out of three is more environmentally favourable to solid waste management authority using Fuzzy Decision (FD) tool. Here FD tool is applied considering final crisp data about 'land area', 'daily loading of wastes quantity', 'AEIV' and 'cost of land' and then finally come into conclusion which one is actually most environmentally best out of three landfills. In this case study cost of land is considered as per local market rate which has no influence in expert's perception directly.

Landfill (LF)	Land Area (In Ha)	Daily loading of wastes quantity (In tons)	AEIV	Cost of Land (Rs.in lakhs)
Okhla Landfill (LF1)	16.20	1200	425	230
Balawasr Landfill (LF2)	21.06	2200	439	120
Gazipur Landfill (LF3)	29.16	2000	255	150

A landfill (LF) will be more acceptable when more land area is available to management for disposal of wastes for long period. Thus in the present NSF-model 'Maximum land area' is considered as our goal, i.e. G and other three options: 'Maximum daily loading of wastes' ; 'Maximum AEIV' and 'Maximum cost of land' are considered as three constraints, i.e. C1, C2 and C3 respectively.

Now according the tool of FD, the fuzzy sets for each option are assessed as:

$G = \mu(gi/LFi) = [\ 0.6/LF_1, 0.90/LF_2, 1.0/LF_3]$

$C_1 = \mu(C_1/LFi) = [\ 1.0/LF_1, 0.70/LF_2, 0.50/LF_3]$

$C_2 = \mu(C_2/LFi) = [\ 0.70/LF_1, 0.65/LF_2, 1.0/LF_3]$

$C_3 = \mu(C_3/LFi) = [\ 0.40/LF_1, 1.0/LF_2, 0.70/LF_3]$

Therefore, $D(LFi) = \mu(g/LFi) \cap \mu(C_1/LFi) \cap \mu(C_2/LFi) \cap \mu(C_3/LFi)$

$= [0.40/LF_1, 0.65/LF_2, 0.50/LF_3]$

Then the fuzzy decision is given by

$FD = 0.65/LF_2 > 0.50/LF_3 > 0.40/LF_1$

Thus result reveals that the landfill 'Balawasr Landfill' is the best environmental suitable landfill out of three landfills of Delhi NCR. The next is Gazipur Landfill and worst is Okhla Landfill.

CONCLUSION

At present there is no tool available to a solid waste management authority which can solve the problem of uncertainties that faced by a decision maker for selection of best landfill out of n-alternatives options. In each landfill there are multiple environmental problems as well as importance too in respect of availability of land area for its future extension and grade of unhygienic loading of wastes in it. This NSF model will give a light of beam to authority to take decision more precisely which landfill is actually so much acceptable environmentally out of many under his control or supervision. This type of fuzzy model will also help the authority to make ranking all landfill and can take precaution and alertness for it's future growth and life keeping safety in all respect of environmental issues.

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