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Fuzzy Decision for Assessment of Sanitary Condition of a House

Ms. Sonal Bhugra, Dr. Srijit Biswas, FIE

***Abstract* – In this paper we study a methodology to assess the overall sanitary condition of a house in some rural or urban area. Sanitary condition of a house depends upon its peripheral environmental condition as well as the quantum of developmental infrastructure exists for the benefit of local people of that house. But during assessment of this of job, the information or data so far available from the field can't be evaluated with numerical valued description because of the involvement of uncertainty with each data. Naturally to eliminate the uncertainty for the evaluation process of these type of data fuzzy logic of Prof. Latfi Zadeh is most important tool to all decision maker at present. In this paper we approach the methodology of fuzzy approach for such evaluation.**

***Keywords* – Fuzzy Set, Fuzzy Weight, MCO, NLT, Weighted Average.**

I. Introduction

We present a brief introduction of EIA first of all.

1.1 Environmental Impact Assessment

The assessment (EIA) [4-5] describes a technique by which information about the environmental effects of a proposed project is collected from different sources, and them analyzed to make a judgment on whether proposed development project should go ahead or not. In question of sustainability and viability of a project it is now mandatory to conduct an EIA before finalization for construction of project into a particular area. By EIA we do a systematic analysis using information usually in a from which focuses the public views and comments on the periphery of the project. The general public attitude in a major project is often expressed as concern about the existence of unknowns or unforeseen effect. The concerned authority will look after the appraisal of projects with regard to their environmental implications as identified by EIA. It is always desirable to conduct an EIA early enough during the planning stage of a project.

1.2 Managing uncertainty

EIA involves prediction and thus uncertainty is an integral part. There are two types of uncertainty associated with environmental impact assessments: that associated with the process and, that associated with predictions. With the former the uncertainty is whether the most important impacts have been identified or whether recommendations will be acted upon or ignored. For the latter the uncertainty is in the accuracy of the findings.

1.3 Mathematical modeling

Mathematical modeling is one of the most useful tools for prediction work. It is the natural tool to assess both flow quantities and qualities (i.e salt/water balances, pollution transport, changing flood patterns). However, it is essential to use methods with an accuracy which reflects the quality of the input data, which may be quite coarse. It should also be appreciated that model output is not necessarily an end in itself but may be an input for assessing the impact of changes in economic, social and ecological terms.

In the next section we justify the necessity of adopting Zadeh's fuzzy theory [9] in EIA.

II. Why Fuzzy Technique is to be Adopted?

In EIA, general public views and observation are collected as important information. To collect the data from the people of proposed project area, generally questionnaires methods are more suitable and easy for handling. A set of questions in the linguistic form are offered to local people and the people are also shared their views and perception in the form of linguistic form. Thus the output result of EIA study are not always found crisp or precise rather non-numeric. People expressed their views in the linguistic form like "good", "very good", less noisy, "too much polluted", etc. to list a few only out of infinity. The uncertainty is fully involved with such type of imprecise data and so thus called as fuzzy data. Evaluation of many objects here is not always possible with numerical valued description because some part of the evaluation contributes to truthness, and the other part to falseness. Consequently it is ideal to adopt a proper mathematical tool to do a proper judgment or evaluation. Certainly fuzzy mathematics is the most suitable for the purpose. Because of this obvious reason we adopt fuzzy logic [9] in the present work to make EIA.

III. Preliminaries

For better understanding the fuzzy methodology the following preliminaries which will be useful to our main work in the next section.

3.1 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

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

Thus in the classic theory of sets, very precise bounds separate the elements that belong to a certain set form the

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elements outside the set. In other words, it is quite easy to determine whether an element belongs to a set or not. For example, if we denote by **A** the set of signalized intersections in a city, we conclude that every intersection under observation belongs to set **A** if it has a signal.

Element *x*'s membership in set **A** is described in the classic theory of sets by the membership function $\mu_A(x)$, as follows :

$$m_A(x) = \begin{cases} 1, \text{ if and only } if \; x \text{ is member of } A \\ 0, \text{ if and only } if \; x \text{ is member of } A \end{cases}$$

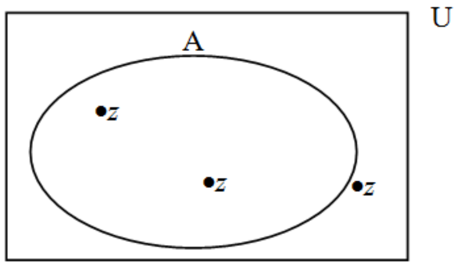

Fig.1. Set A and elements x, y and z

It is clear form Figure-1, that $\mu_A(x)$=1, $\mu_A(y)$=1, and $\mu_A(z)$=0.

3.2 Fuzzy Set [9]

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. Thus, it might be said that waiting time of a vehicle at a certain signal is "long". If we denote by A the set of "long waiting time at a signal," the question logically arises as to the bounds of such a defined set. In other words, we must establish which elements belong to this set. Does a waiting time of 25 seconds belong to this set? What about 15 seconds or 90 seconds ?

Now the crisp characteristic function can 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, μA(x)}, where μA(x) is the grade of membership of element x in set A. The greater μA(x), the greater the truth of the statement that element x belongs to set A.

3.3 Concept of fuzzy numbers

Subjective estimation that deals with the imprecise object like

(i) waiting time of a car or vehicle at a traffic signal, or

(ii) manufacturing cost of a flight etc.

can be expressed by a fuzzy sets. Based on experiences or institution , an expert or decision maker is able to state that waiting time of vehicle at a traffic signal is "around 20seconds","not more than 20 seconds " etc. such type of subjective estimations are characterized by certainly values. Intuitively it is clear that a flight cost that is "approximately $5,000" is certainly less than a flight cost of approximately $6,000". In another terminology, the fuzzy numbers is fuzzy set that is convex and normalized. The figure shows the graph of fuzzy number "approximately20":-

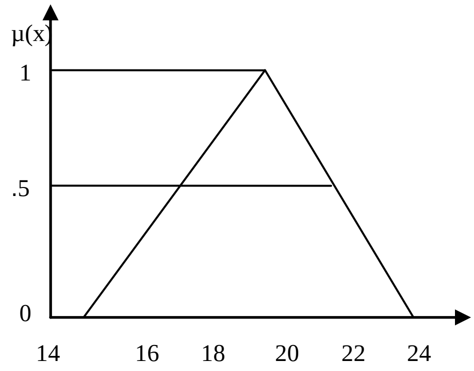

Fig.2.The fuzzy number "approximately 20")

3.3.1 The fuzzy numbers nlt(x) and MCO(x)

Let x € R, the set of real numbers. The fuzzy number "*not less than x*", as defined above is called nlt(x). It is to be noted that the membership value μnlt(x) may or may not be equal to unity. In nlt(8:25), in the above graph, we see that $\mu nlt_{(x)}(8:25) \neq 1$, but $\mu nlt_{(8:25)}(8:27)=1$.A real number x'€R is said to be most certain object in nlt(x)" denoted by MCO(x) if μnlt(x)=1.

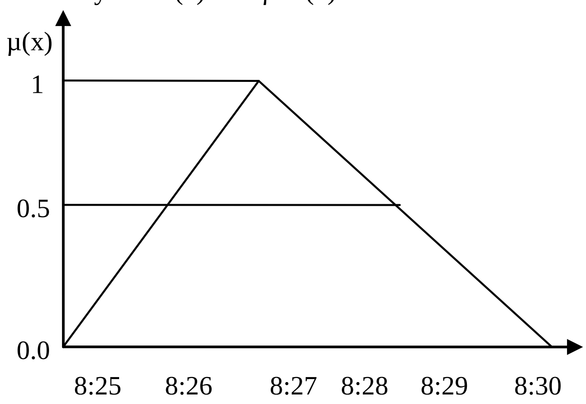

Fig3.. The fuzzy number 'not less than 8:25 or nlt 8:25'

IC. Methodology for Our Proposed "Fuzzy EIA"

Now we will propose a methodology of fuzzy assessment for environmental impact. First of all we present some definitions.

4.1 Attribute of the Assessment

The assessment is done by collecting information or values for certain attributes which are called the attributes of the assessment. For example, consider a project of "SANITARY ASSESSMENT OF A HOUSE", for which some relevant attributes could be "bad approachable road", "poor drainage system", etc.

4.2 Universe of the Assessment

Collection of all attributes of the assessment is called the Universe of the Assessment.

4.3 Weighted Average of a Fuzzy Set

Let μ be a fuzzy ser of a finite set X. 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 μ is the non-negative number a(μ) given by :

$$a(\mu) = \frac{\sum \mu(x).W_x}{\sum W_x}$$

4.4 Grading of Fuzzy Assessment Output

In Fuzzy-EIA modeling, evaluation of all attributes are done either based on their negative aspects (draw backs) or positive aspects. If negative aspects of all attributes are consider then grading of output results of Fuzzy-EIA could be proposed as below:

grade = Extremely degraded, if $.8 < a(X) \le 1$
grade = Very degraded, if $.6 < a(X) \le .8$
grade = Degraded, if $.4 < a(X) \le .6$
grade = Marginally degraded, if $.2 < a(X) \le .4$
grade = Not degraded, if $0 \le a(X) \le .2$.

Similarly for positive aspects, grading of output result of Fuzzy-EIA could be proposed as:

grade = Not degraded, if $.8 < a(X) \le 1$
grade = Marginally degraded, if $.6 < a(X) \le .8$
grade = Degraded, if $.4 < a(X) \le .6$
grade = Very degraded, if $.2 < a(X) \le .4$
grade = Extremely degraded if $0 \le a(X) \le .2$

In the next part we present the methodology of assessment by a hypothetical case study for the sake of better understanding.

V. Case Study

Consider a project of SANITARY ASSESSMENT (DRAWBACK) of a house in a village area. To do the assessment let us consider the following attributes (for the sake of simplicity in presenting the method we consider here only ten attributes):-

x_1 = bad approachable road.
x_2 = high noisy surroundings
x_3 = poor living standard
x_4 = unusual number of mosquito breeding
x_5 = unusual number of fly breeding
x_6 = poor drainage system
x_7 = very dirty premises
x_8 = inadequate water facilities
x_9 = unhygienic latrine & toilet
x_{10} = highly congested area

Now the job is to assign values to these attributes. This can be done either by direct observation or by collecting views from a good number of nearby inhabitants in addition to the residents of the house, in general. Let us suppose that the data collected from 100 people for an attribute x_i reveals that more or less 70 people are in support of the truthness of the attribute and the rest 30 are in support of falseness. We set for our fuzzy analysis that $\mu_A(x_i) = .7$.

Suppose that the data (hypothetical) made available are as below in a tabular form :

Attribute name	in support of truthness μ(x)	in support of falseness	Fuzzy weight f_x	weight of the attribute $w_x = MCO_{(x)}$
x_1	.75	.25	approx. 6	5
x_2	.85	.15	nlt(48)	50
x_3	.5	.5	approx. 10	10
x_4	.6	.4	approx. 11	10
x_5	.85	.15	approx. 18	20
x_6	.8	.2	nlt(19)	20
x_7	.9	.1	approx. 10	10
x_8	.45	.55	approx. 9	10
x_9	.9	.1	approx. 42	40
x_{10}	.75	.25	nlt(19)	20

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

E = $\{x_1, x_2, x_3, x_4, x_5, x_6, x_7, x_8, x_9, x_{10}\}$,

and the fuzzy set X is given by

$$X = \frac{x_1}{.75}, \frac{x_2}{.85}, \frac{x_3}{.5}, \frac{x_4}{.6}, \frac{x_5}{.85}, \frac{x_6}{.8}, \frac{x_7}{.9}, \frac{x_8}{.45}, \frac{x_9}{.9}, \frac{x_{10}}{.75}$$

We can easily calculate that the weighted average a(X) of this fuzzy set which is **.753,** and consequently the grade to be awarded is "**B**".

Result of Fuzzy Assessment

(i) Grade = **"B"**

(ii) And thus the assessment reveals that the house is not in a good book as far as the sanitary condition is concerned.

VI. Conclusion

Fuzzy decision technique can suitably be applied in the evaluation of data required for environmental impact analysis. As the data or information available from the project area are not always crisp or precise, naturally any fuzzy tool can claim its tremendous power to tackle the uncertainty involved with all the data under consideration for evaluation. The fuzzy tool used in the present case study for assessment of sanitary condition of a house is also appealing the same because they provide assistance in trying to grasp the overall effect of the project in the sense of assessing the collective impart of the "good" and the "bad" of the project. However, the overall assessment or summarization of the environmental impact is not fully support the methodology because there could be other hidden issues such as local politics, local constraints, etc which will influence the decision maker's proper perception .

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AUTHOR'S PROFILE

Dr. Srijit Biswas

he has obtained his Ph.D from Jadavpur University and M.E from Calcutta University, India. He is 'Fellow' of Institute of Engineers (India) and working as a Professor, Department of Civil Engineering, Manav Rachna International University, Faridabad. Besides this he has more than 18 years research experiences out of 28 year in total. He is the member of editorial board of few reputed international journals and reviewers of many international and national journals. He authored a book on the area of "Fuzzy EIA' published from Germany.

Ms. Sonal Bhugra

She has obtained M.Tech from Maharishi Dayanand University in Transportation Engineering and A.M.I.E in Civil Engg. from Institute of Engineers (India). Currently she is working as an Assistant Professor, Department of Civil Engineering, Manav Rachna International University, Faridabad. She has 6 years of teaching experience.