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ENVIRONMENTAL IMPACT ASSESSMENT: AN INTUITIONISTIC FUZZY APPROACH

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Abstract. In this paper we study a methodology to find out the overall environmental impact on a future project to be undertaken in some rural or urban area. We use the intuitionistic fuzzy approach for such evaluation.

Keywords: Environmental impact, fuzzy set, intuitionistic fuzzy set, mean fuzzy set.

Introduction

Environmental Impact Assessment(EIA)[4,5] describes a technique by which information about the environmental effects of a proposed project is collected from different sources, and then analysed to make a judgement on whether the proposed development should go ahead. By EIA we do a systematic analysis using information usually in a form which focusses the public viewes 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 unknown 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. The objective of EIA are mainly the following:

(i) to identify beneficial and adverse environmental impacts,

(ii) to suggest mitigation actions which might reduce adverse impacts.

(iii) to suggest measures which might enhance beneficial impacts,

(iv) to identify and describe the residual adverse impacts which can not be mitigated

(v) to provide an early warning system

(vi) to incorporate environmental information into the decision-making process relating to the projects,

(vii) to help in selection of the optimum suitability out of several alternatives.

Scoping(process of deciding on the impacts to be investigated) is an important and essential initial activity in any EIA. Involvement of public in scoping, in many situations, is helpful because EIA is a predictive exercise. Project data and the data on the existing

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environmental conditions are known as baseline data. In the next section we justify the necessity of intuitionistic fuzzy set theory in EIA.

1. Why Intuitionistic Fuzzy Technique Is To Be Adopted?

In EIA, the general public viewes and observations are collected as an important information . But the data so obtained are not always crisp or precise. Most of the data are not numeric rather linguistic viz. "good", "very good", less noisy", "too much polluted", etc. to list a few only out of infinity. Such type of imprecise data are intuitionistic fuzzy data[1] or fuzzy data[9]. Evaluation of many objects here is not always possible with numerical valued description. Besides, such type of evaluation is often associated with unavoidable hesitation. Some part of the evaluation contribute to truthness, some part to falseness and the rest part remains indeterministic. Consequently it is ideal to adopt a proper mathematical tool to do a proper judgement or evaluation. Certainly intuitionistic fuzzy mathematics is a suitable one for the purpose. There are several non-classical and higher order fuzzy sets. One of the interesting generalisation of the theory of fuzzy sets is the theory of intuitionistic fuzzy sets(IFS) introduced by Atanassov [1]. Intuitionistic fuzzy sets(IFS) are fuzzy sets described by two functions : a membership function and a non-membership function that are loosely related. Some basic preliminaries are presented in our next section.

2. Preliminaries

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

Definition 2.1

Let E be a non null set called the universe. A fuzzy set of E is characterized by the mapping $\mu : E \rightarrow [0,1]$. For an object x in E the degree of belongingness of x in the fuzzy set μ is defined by the amount $\mu(x)$.

Definition 2.2[1]

Let E be a fixed universe. An intuitionistic fuzzy set or IFS A in E is an object having the form

$$A^{*}3D \{ < x, \mu_A (x), \nu_A (x) > | \quad x \in E \}$$

where the functions $\mu_A : E \rightarrow [0, 1]$ and $\nu_A : E \rightarrow [0, 1]$ define respectively the membership function and the non-membership function. The value $\mu(x)$ indicates the degree of membership and the value $\nu(x)$ indicates the degree of nonmembership of the element x $\in$ E to the set A, and $\forall$ x $\in$ E,

$0 \leq \mu_A (x) + \nu_A (x) \leq 1$.

It has been proved with an example that fuzzy sets can be viewed as intuitionistic fuzzy sets but not conversely [1].

3. Methodology For Assessment

First of all we present some definitions.

Definition 3.1 Attribute of the assessment
Th 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 "noisy surroundings", "dusty place", etc.

Definition 3.2 Universe of The Assessment
Collection of all attributes of the assessment is called the universe of the assessment.

Definition 3.3 Mean Fuzzy Set of an IFS
Let E be an universe and X be an IFS of E. The mean fuzzy set of the IFS X is a fuzzy set m of E given by the membership function
m(x)3D $\frac{\mu(x)+1-\nu(x)}{2}$.

Definition 3.4 Weighted Average of a Fuzzy Set
Let μ be a fuzzy set 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(μ)3D $\frac{\sum \mu(x)\cdot w_x}{\sum w_x}$.

Definition 3.5 Grading of Assessment Output
Depending upon the value of a(μ), the grading of overall output could be proposed as below:

grade3D A , if .8 $<$ a(μ) $\leq$ 1
grade3D B , if .6 $<$ a(μ) $\leq$ .8
grade3D C , if .4 $<$ a(μ) $\leq$ .6
grade3D D , if .2 $<$ a(μ) $\leq$ .4
grade3D E , if 0 $\leq$ a(μ) $\leq$ .2

In the next part we present the methodology of assessment by a hypothetical case study.

3.1. 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 metod we consider here only ten attributes):

$x_1$3D bad approachable road.
$x_2$3D noisy surroundings

$x_3$3D dusty surroundings
$x_4$3D unusual number of mosquito breeding
$x_5$3D unusual number of fly breeding
$x_6$3D drainage system not good
$x_7$3D dirty premises
$x_8$3D inadequate water facility (from all sources)
$x_9$3D unhygienic latrine
x_{10}3D sufficiently clean surrounding.

Now the job is to assign values to this attributes. This can be done either by direct observation or by collecting viewes 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 , 20 are in support of falseness and the rest 10 people are without any comment due to hesitation. We set the following :

$$\mu(x_i)3\text{D } .7, \quad \nu(x_i)3\text{D } .2.$$

The data(hypothetical) is presented below in a tabular form:

attribute name	in support of truthness μ(x)	in support of falseness ν(x)	indeterministic part	weight of the attribute w_x
x_1	.6	.1	.3	20
x_2	.8	.1	.1	10
x_3	.5	.5	0	10
x_4	.4	.2	.4	40
x_5	.8	.1	.1	20
x_6	.7	.1	.2	5
x_7	.8	0	.2	50
x_8	.3	.4	.3	10
x_9	.9	.1	0	10
x_10	.7	.2	.1	20

These data leads to an IFS X of the universe E where

$$\text{E3D} \left\{ x_1, x_2, x_3, x_4, x_5, x_6, x_7, x_8, x_9, x_{10} \right\}.$$

Now calculate the mean fuzzy set m of the IFS X. We find that

$$\text{m3D} \left\{ \frac{x_1}{.75}, \frac{x_2}{.85}, \frac{x_3}{.5}, \frac{x_4}{.6}, \frac{x_5}{.85}, \frac{x_6}{.8}, \frac{x_7}{.9}, \frac{x_8}{.45}, \frac{x_9}{.9}, \frac{x_{10}}{.75} \right\}.$$

We next calculate that the weighted average of this fuzzy set m is .753, and consequently the grade to be awarded is **B**. Thus the assessment reveals that the house is not in a good book as far as the sanitary condition is concerned.

4. Conclusion

EIA has a potential to play an important role at early stages of a project. In the present paper we see that for any type of such assessment and analysis therafter intuitionistic fuzzy set can be suitably applied, because the data or information available are not always crisp rather intuitionistic fuzzy. Such an analysis is appealing because they provide assistance

in trying to grasp the overall effect of the project in the sense of assessing the collective impact of the "good" and the "bad" of the project. However, this overall assessment or summerization of the environmental impact should only serve as one of the parameters or criteria just to the decision makers. There could be other parameters such as local politics, local constraints, etc which will influence the decision makers of the project. To understand the methodology for evaluation of environmental impact, an hypothetical case-study is presented here.

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