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FUZZY LOGIC FOR ENVIRONMENTAL ASSESSMENT

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Abstract: *In the recent years, the scope of environmental studies has expanded dramatically all over the world. This paper aims to build a system based on fuzzy models that can be implemented in the assessment of ecological systems, to determine appropriate methods of action for reducing adverse effects on environmental and implicit the population. It is noted that this subject of research represent a high interest current in the world. In situations difficult to approach methods with modeling conventional, are proposed as a reliable alternative pathways to fuzzy logic-based modeling. Information systems may determine, based on data supplied by the beneficiary (government agencies, local authorities, economic agents), appropriate methods of action for reducing adverse effects on industry, agriculture, forestry, water management and human settlements. Fuzzy algorithms in this field is new, and presume definition, clear delimitation and the analysis of the system which performing the tasks specified.*
Key words: *environmental assessment, fuzzy model, sustainability*

1. INTRODUCTION

The present era of fast development and growth is aimed at raising the quality of human life by providing greater opportunities for employment, better provisions of basic amenities and comforts, healthy environment ensuring physical and mental well-being of humans.

Issues like global warming, depletion of ozone layer, dwindling forests and energy resources, loss of global biodiversity etc. which are going to affect the mankind as a whole are global in nature and for that we have to think and plan globally (Kaushik&Kaushik 2010).

In this paper, a fuzzy model was developed, which uses data sampled from different environmental indicators that were then processed via fuzzy logic algorithms to derive measures for ecological sustainability of the region. Fuzzy logic is able of representing uncertain data, and handling vague situations where traditional mathematics is ineffective. Based on this approach we have developed a fuzzy model which uses basic indicators of environmental integrity, as inputs and employs fuzzy logic reasoning to provide sustainability measures on the local levels. A sensitivity analysis identifies the factors affecting sustainability. In this study, trials were made to identify those factors that influence the environment.

2. MODEL OVERVIEW

Environmental performance assessment related to a town region or a district is becoming a major issue worldwide and particularly in Europe. To assess the performance of an environmental system is necessary to make an integrated analysis of a variety of factors and the existing relationships between these factors often form a complicated problem. Indicators are often used with other types of information. In order to cope with performance assessment of an environmental system specific tools are needed and creative approaches. This is why in this paper we proposed a model based on fuzzy logic to establish ecological sustainability of a specified region. Accordingly, to our methodology the ecological sustainability of the environmental system is composed from three modules: water quality (WATER) soil integrity (SOIL) and air quality (AIR). Fig. 1 illustrates the dependencies of sustainability components.The paper data which must be fullfiled in the paper data table at the top of this page are:

The configuration of the model is shown in Fig.2. The model is composed from different sets of knowledge levels. The inputs of each knowledge level represent the parameters which can be provided by the user or composite indicators collected from other knowledge levels. By using fuzzy logic and IF-THEN rules, these inputs are combined to yield a composite indicator as output which represents an input for the subsequent knowledge level. For instance, the third order knowledge level that computes indicator AIR combines indicators TYPE 1, TYPE 2, and TYPE 3 indicators of air quality, which are outputs of fourth order knowledge level. Then, AIR is used in combination with SOIL and WATER as input for the first order knowledge level and so assesses ENVIRONMENT SUSTAINABILITY. The indicators from the third knowledge level were divided into three types of parameters because this way the analyze we believe would be is more accurate (Phillis& Kouikoglou 2009).

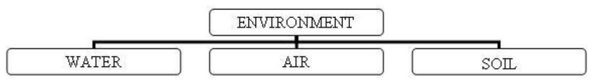

Fig. 1. Dependencies of sustainability components

3. ENVIRONMENT ASSESMENT METHODOLOGY

According to Fig. 2, the hierarchical structure of the evaluation problem consists of 4 levels. The first level represents the ultimate aim of the problem (environmental assessment), the second level represents decision criteria, the third level represents the evaluation criteria and the fourth level represents evaluation sub criteria (Andriantiatsaholiniaina& Phillis 2004). The hierarchical structure is very useful for decomposing complex sustainability problems. The problem of environmental assessment is depending of many parameters such as air quality impact, water quality or soil integrity. Of course there are many factors that can influence the environment as biodiversity but this fact represent the object of another study more complex and more elaborate, and for the moment we consider that these three factors have the predominant role. These parameters are represented by the decision criteria; in the present paper the decision criteria are classified into three main categories namely AIR (air quality), WATER (water quality) and SOIL (soil integrity). In order to create the decision criteria several other parameters that affect the criteria are considered. These parameters are represented by evaluation criteria and so on.

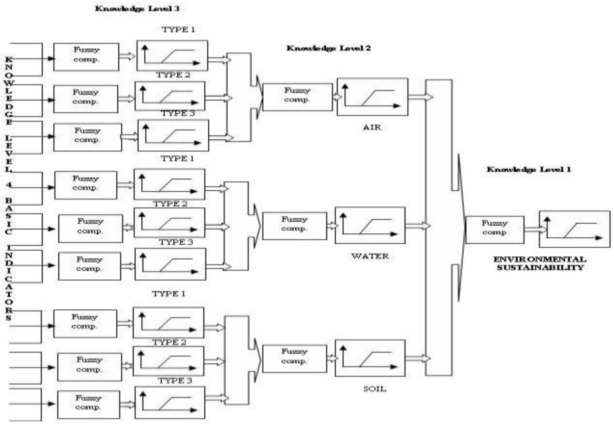

Fig. 2. Configuration of environmental sustainability model

The model uses a number of relevant knowledge levels to represent the interrelations and principles governing the various indicators and components and their contribution to the final decision of the expert system. The rules and inputs/outputs of each knowledge level are expressed symbolically in the form of words or phrases of a natural language and mathematically as linguistic variables and fuzzy sets.

By using fuzzy logic and IF-THEN rules, these inputs are combined to yield a composite indicator as output, which is then passed on to subsequent knowledge levels [2].

Computations are done with words, and the knowledge is represented by IF-THEN linguistic rules. A system based on fuzzy logic can be considered an expert system which emulates the decision-making ability of human expert. The user supplies facts or other information to the expert system and receives expert advice for his queries. The internal organization of an expert system consists of a knowledge-base and an inference engine. The knowledge –base contains the knowledge with which the inference engine draws conclusions. The inference engine is a control structure which helps in generating various hypotheses leading to conclusions that from the basis of answers to user queries (Prescot 1996).

4. CASE STUDIES

To test the environmental assessment methodology the model has been applied to the town of Iasi in Romania. Iasi is located in the northeast part of Romania, having an area of 3770 ha and a population of 340.000. Until the middle of '90 the town was an important industrial center in Romania. Since then, the economy is unfortunately decreasing, but pollution with solid and liquid waste, toxic waste has reached high values. About twenty indicators were tested and classified according to sensitivity as promoting, impeding, or having no effect on sustainability.

The primary components of environmental sustainability (AIR; WATER, and SOIL) and their sensitivities to various input indicators were computed (Table 1). If the derivative with respect to a basic indicator is positive, then the indicator is classified as promoting indicator because an increase of his value will lead to a higher sustainability. On the other hand, if the derivative is negative, then the indicator is classified as impeding indicator, because an increase of his value will reduce the degree of sustainability. If the derivative is zero, then it is accepted the idea that the respective parameter has no substantial effect upon de sustainability. According to the sensitivity analysis projects can be proposed to improve promoting indicators, and taking measures to correct impeding factors. A sensitivity analysis of the model permits to determine the evolution of sustainability variables subject to perturbations in the value of basic indicators.

Component	Type 1	Type2	Type 3
AIR	SO_2 emissions, CO_2 emissions (3) CH_4 emissions	Atmospheric concentration of greenhouse and ozone depleting gases: CO_2 , NO_2 SO_2 CH_4 CFC-12	Fossil fuel use, Primary electricity production Public transportation
WATER	Water pollution Urban per capia water use Freshwater withdrawals	Annual internal renewable water sources	Percent of urban wastewater treated
SOIL	Solid and liquid waste generation Population density Growth rate Commercial energy use	Net energy imports Domesticated land Forest and wood-land area	Primary enery production Nationally protected area Urban households with garbage collection

Tab 1. Parameters used in the sustainability model

5. CONCLUSION

In this paper we developed a model, an attempt to provide an explicit and comprehensive description of the concept of environmental sustainability. Using linguistic variables and linguistic rules, the model gives quantitative measures of ecological sustainability. Then, the problem of sustainable decision-making becomes one of specifying priorities among basic indicators and designing appropriate policies that will guarantee sustainable progress.

The model proposed provides new insights of sustainable development, and it may serve as a practical tool for decision – making and policy design at the local or regional levels.

In the future we will try to extend this system by incorporating more representative environmental parameters after discussions with specialists. Thus the system will be able to provide a more concrete analysis of a studied ecosystem.

6. ACKNOWLEDGEMENTS

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