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Environmental Management of Natural Resources in Town Planning- Example Applications from Projects in Greece

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ABSTRACT

Natural resources are the basis of human welfare in developing as well as in developed societies. Their study in town planning has to satisfy an ever increasing demand, driven by population growth and changes in lifestyle, and at the same time meet an increasing set of constraints and concerns of environmental impacts and resource depletion and degradation. All these driving forces of development, acting in concert and often reinforcing each other, make better and more efficient tools for decision support in town planning increasingly important. Better, but not necessarily more information directly useful to a larger number of participants in more open and participatory decision making processes is urgently needed.

The management of natural resources requires the integration of often very large volumes of disparate information from numerous sources; the coupling of this information with efficient tools for assessment and evaluation that allow broad, interactive participation in the planning, assessment, and decision making process; and effective methods of communicating results and findings to a broad audience.

Information technology, and in particular, multi-criteria optimization models provide some of the tools for effective decision.

An example from different domains of natural resources and environmental management in Attica Greece. A Town Planning Project is presented, which illustrate a few of the important concepts of effective environmental management. It supports their interactive analysis and helps to display and interpret results in a format directly understandable and useful for decision making processes. Conclusively, Environmental Management systems can support a more interactive, exploratory, and participatory, and thus useful and effective approach to Natural resources.

INTRODUCTION

Fuzzy set theory is a useful tool for dealing with knowledge about territory, taking into account uncertainty in the interpretation of quantitative information on land use, particularly when this is automated in Geographic Information Systems (GIS). These and other problems of integration of fuzzy set methods to a GIS environment for land use are

discussed in Chen (1997), McBratney et al (1997), Lark (1997) and Lagacherie et al (1997). The applications of knowledge management for land use, which may be generated from, or adapted to, fuzzy sets theory and fuzzy logic, are wide-ranging: numerical classification of soil and mapping, land evaluation, modelling and simulation of soil physical processes, soil quality indices and fuzzy measures of imprecisely defined soil phenomena.

This paper shows a methodological framework using GIS for knowledge management for land, based on the fuzzy set theory.

The rest of this paper is organized as follows. The next section introduces the definitions of the fuzzy sets theory which are used in this framework. Section 3 gives a brief overview of how to consider knowledge management within a GIS framework for the land use application domain..

Section 4 and shows an application example of the use of the framework for real data, in Athens Greece. Finally, section 5 presents conclusions and directions of ongoing work.

SYSTEM FRAMEWORK

The fuzzy sets theory originated in the work of Zadeh (1965). According to Zimmermann (1985) "The theory of fuzzy sets is, in effect, a step toward a rapprochement between the precision of classical mathematics and the pervasive imprecision of the real world - a rapprochement born of the incessant human quest for a better understanding of mental processes and cognition".

Fuzzy sets theory is a mathematical method used to characterize and propagate uncertainty and imprecision in data and functional relationships. Fuzzy sets are especially useful when insufficient data exist to characterize uncertainty using standard statistical measures (e.g., mean, standard deviation, and distribution type) Abbott (1999).

An underlying philosophy of the fuzzy sets theory is to provide a strict mathematical framework, where the imprecise conceptual phenomena in decision making maybe precisely and rigorously studied, in particular for knowledge management (Bogardi , 1997). The fuzzy sets theory includes fuzzy mathematics, fuzzy measures, fuzzy integrals, etc .Fuzzy logic is a minor aspect of the whole field of fuzzy mathematics. In classical sets theory, the membership of a set is defined as true or false, 1 or 0. Membership of a fuzzy set, however, is expressed on a continuous scale from 1 (full membership) to 0 (full non membership)

It is well known that many elements of land plot properties (soil,, microclimate, etc) have uncertainties. Uncertainty is inherent in decision-making processes, which involve data and model uncertainty. These range from measurement errors, to inherent variability, to instability, to conceptual ambiguity, to overabstraction, or to simple ignorance of important factors.

METHODOLOGY

In this case, the GIS knowledge management fuzzy model is based on a multicriteria theory of multiple assessment of landscape parcels and choice of alternatives Kaufmann and Gupta (1988)

The methodological framework concerns assessment of land uses, having soil conservation as a goal. In the process of monitoring natural resources it is a need to estimate an effect of soil conservation actions taking into account economical, ecological, agricultural, and social factors. In this case, the GIS knowledge management fuzzy model is based on a multicriteria theory of multiple **assessment** of landscape parcels. The corresponding **multiple assessment** can be carried out by criteria such as:

Technological criteria (TC),

Economical criteria (EC),

Ecological Criteria (EC)

Social Criteria (SC) etc.

The mathematical operation of intersection of fuzzy sets is in agreement with operation of the search for minimum of the membership functions of these fuzzy sets. In this specific problem, preference is given to land plots that are characterized by the greatest value of the membership function.

In this case, the GIS knowledge management fuzzy model is based on a multicriteria theory of multiple assessment of landscape parcels and choice of alternatives In particular, consider there is a set of *m* landscape plots:

$A=\{a1, a2, ... am\}$ (3)

and a fuzzy set of criteria described in:

$C=\{mc(a1)/a1, mc(a2)/a2, ..., mc(am)/am\}$, (4)

where the membership function $mc(ai)$ expresses the experts knowledge about grade of landscape plots satisfaction to criteria *C*.

The coefficients of relative significance are found by comparison of pairs of criteria.

To start this assessment, these criteria are initially entered into matrix *B.*

Elements *bij* of matrix *B* are defined and must satisfy the conditions: $bij = 1$, $bij = 1/bji$ For example,

if a user is estimated relative importance of criteria *Ci* and *Cj as* equilibrium so element $bij = 1;$

if user is estimated relative importance of criteria *Ci* and *Cj as* great importance so element $bij = 7$ (Kurtener1999).

Next, the self-vector of the matrix *B* is determined from the solution of equation:

$Bw = lmax\ w$ (5)

where $lmax$ is maximum of self-number of the matrix.

The solution sought is given by $ai = n\ wi$, where *n* is a predefined number of criteria.

The mathematical operation of intersection of fuzzy sets is in agreement with operation of the search for minimum of the membership functions of these fuzzy sets (Kurtener and Bundego 1998).

- With the TC we try to evaluate soil conservation actions and the feasibility of re-making the area. TC =1, if the action is fully suitable; TC = 0, if it is not.
- With the EC we evaluate the economical efficiency of soil conservation actions. EC =1, if the action is economically efficient; EC = 0, if it is not.
- With the ECC we evaluate the environmental additional negative effect of the soil conservation actions. ECC =1, if the environmental additional negative effect is absent, ECC = 0, if it is not.
- SC provides an estimate of the social factors. SC =1, if the human response is positive; SC = 0, if the human response is negative.

Application

Let us consider an example of multiple assessment of soil conservation actions by this approach. We

will proceed to analyze the territory located in Athens Greece The plots submitted for analysis differ

in types of soil type, soil hydrology, microclimate, processes of soil degradation, processes of soil

contamination, crop rotation, etc. and the scores in terms o the above mentioned criteria are

tabulated in Table1. The relative importance of criteria is presented in Table 2.

Table 1. *Criteria scores of characteristic plots*

Plot number	TC	EC	ECC	SC
1	1	0.95	1	0.9
2	0.50	0.40	1	0.70
3	0.80	0.80	1	0.70
4	0.70	0.60	1	0.60

Table 2. *Coefficients of relative significance*

	TC	**EC**	**ECC**	**SC**
TC	**1**	5	6	7
EC	1/5	1	4	6
EC-	1/6	¼	1	4
SC	**1/7**	**1/6**	¼	**1**

Components of self-vector of the matrix with B*max* = 4,390 are: *w1* = 0,619;

w2 = 0,235; *w3* = 0,101; *w4* =0,045.

Coefficients of relative significance of criteria are:

w*1* = 2.48; w*2* = 0,94; w*3* = 0,4; w*4* = 0,18.

On the basis of the fuzzy model, a software oriented for use with MapInfo Professional GIS software,version 4,0 has been designed. By this, software values of integral index of multiple assessment ofsoil conservation action for selected land plots are calculated and mapped automatically (Figure 1).

Conclusions

In this paper, a conceptual framework of modeling decision-making processes with insufficient knowledge in project site selection is used. Compared with existing methodologies, the proposed framework claims to be more realistic, since it takes into account the available information, without enforcing an artificial accuracy. In

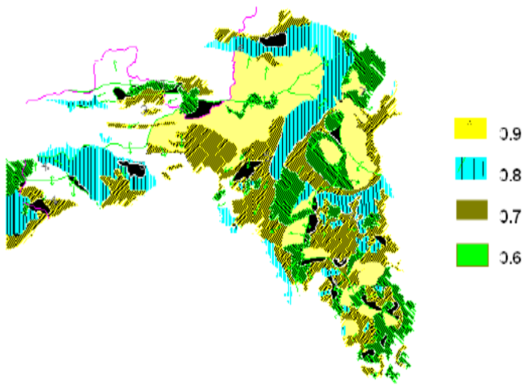

Figure1. *Study area and characteristic plots*

addition, this methodology is easily portable to many project management decision-making activities, regardless of the knowledge representation formalisms (e.g. frames, rules.).

The further development of this approach could create a methodological framework for GIS oriented for social, economical and environmental support of decision- making processes.

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