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Multi-Criteria Spatial Decision Support System *DECERNS*: Application to Land Use Planning

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ABSTRACT

Land-use planning and environmental management often requires an implementation of both geoyspatial information analysis and value-driven criteria within the decision-making process. DECERNS (Decision Evaluation in Complex Risk Network Systems) is a web-based distributed decision support system for multi-criteria analysis of a wide range of spatially-explicit land management alternatives. It integrates mainly basic and some advanced GIS functions and implements several Multi-Criteria Decision Analysis (MCDA) methods and tools. DECERNS can also be integrated with a model server containing generic and site specific models for in-depth analysis of project and environmental risks as well as other decision criteria under consideration. This paper provides an overview of the modeling approaches as well as methods and tools used in DECERNS. Application of the DECERNS WebSDSS (Web-based Spatial Decision Support System) for a housing site selection case study is presented.

Keywords: *DECERNS, GIS, Housing Development, Land-Use Planning, MCDA, Multi-Criteria Decision Analysis, Spatial Decision Support System, WebSDSS*

INTRODUCTION

There exists a need for an integrated land-use management approach supporting economic development and parallel goals. The goals of this approach include the conservation of natural resources, the restoration of habitats in surrounding ecosystems, maintaining and improving biodiversity, all while reducing present and future pollution. These seemingly

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complicated problems can be effectively addressed by implementing a Geographic Information System (GIS) along with decision analysis tools.

Currently GISs are an indispensable tool for investigating the problems associated with spatial/geographic data, including input of source data, storage and retrieval, manipulation, analysis, and output. The aim of GIS analysis is to help a user or a group of users answer questions related to spatial data, objects and processes. Typically, GIS specialists emphasize using GISs for data analysis and presentation, as well as for decision-making support while solving practical problems.

Decision support can be defined as the assistance for, and substantiation and corroboration of, an act or result of deciding; typically this decision will be a determination of an "*optimal*" or "*trade off*" approach which leads naturally to the use of [multicriteria] decision analysis tools. Decision support integrates specific objective and subjective information about a site and general information such as legislation, guidelines and technical know-how, to produce decision-making knowledge in a way that is transparent, consistent and reproducible.

Land-use planning, searching for the "best" location or a *compromise* location for facilities, and environmental management in a comprehensive manner, which requires implementation of not only (standard) GIS technologies and functions for spatial data representation and processing, but also decision analysis methods and tools to assist the decision-making process for comparison of spatial options/alternatives.

According to Simon (1960), any decision-making process can be structured into three major phases:

- **Intelligence:** Recognition of the decision problem; searching/scanning the decision environment; raw data collection and examination;
- **Design:** Inventing, developing, and analyzing a set of possible solutions;
- **Choice:** Evaluation of alternatives on the basis of a specified decision rule; ranking, sorting alternatives; uncertainty/sensitivity analysis; choice of the "best"/trade-off alternative(s); development of action plans.

A computerized Decision Support System (DSS) is a tool designed specifically for supporting the users in addressing semi-structured problems (Simon, 1960). An extended approach to defining DSS, according to Sprague (1980), suggests that DSSs should meet the following requirements:

- Designed to solve semi-structured problems that upper level managers often face;
- Capable of combining analytical models with traditional data storage and retrieval functions;
- User-friendly and accessible by decision makers with minimal computer experience; and
- Flexible and adaptable to different decision-making approaches.

Spatial DSSs (SDSSs) are essentially DSSs intended to solve semi-structured *spatial* problems. In addition to DSS characteristics, SDSSs provides functions and tools for spatial data processing and representation (Armstrong, 1986; Densham & Goodchild, 1989). Taking into account that most semi-structured spatial problems are multi-criteria by nature, SDSS, in general, may be regarded as some integration of GIS, at least in terms of basic functions, and MCDA tools. Thus, SDSS supports the decision-making process in terms of the analysis of spatial alternatives through providing access to GIS functions and decision analysis tools for the stakeholders (*i.e.*, decision makers, experts, and interested parties) (Armstrong, 1994; Carver, 1991; Jankowski, 1995; Laaribi, 1996).

The general approach to creating an SDSS based on integrating GIS and MCDA functions