

# Preface

A growing number of scientists and practitioners are merging theories, methods, and technologies from different disciplines to extract new meaning from data and to solve complex problems using new methods. The research on integrating Geographic Information Systems (GIS) and Multicriteria Decision Analysis (MCDA) is an example of how linking concepts and methods from two distinct fields can yield new ways of tackling decision problems. At the most fundamental level, GIS-MCDA can be thought of as a collection of methods and tools for transforming and combining geographic data and preferences (value judgments) to obtain information for decision making. The main aim of this book is to contribute to GIScience by providing a comprehensive account of the theories, methods, and technologies for integrating MCDA into GIS. The book also demonstrates how the GIS-MCDA approaches can be used in a wide range of real-world planning and management situations. Indeed, we provide practitioners and students with the knowledge required for them to gain a fuller understanding of MCDA using geographic information technologies.

In recent years, there has been a considerable growth of theoretical and applied research on GIS-MCDA. The field of GIS-MCDA has strongly been adopted within the GIScience community. The efforts to integrate MCDA into GIS have also been recognized as a significant achievement in expanding MCDA into new application areas. Although the primary motivation behind the research efforts on integrating MCDA into GIS comes from the need to expand the decision support capabilities of GIS and related technologies, equally important significance is that the two distinctive areas of research can benefit from each other. On the one hand, GIS techniques and procedures have an important role to play in analyzing multicriteria decision problems. They offer unique capabilities for storing, managing, analyzing, and visualizing geospatial data for decision making. GIS allows analysts and decision makers to think about the spatial relationships in a more sophisticated and meaningful manner than is otherwise possible. This, in turn, allows for developing new ways to think about decision alternatives and considering new solutions for decision problems. On the other hand, MCDA can improve the GIS ability to tackle spatial decision problems appropriately. It provides a theoretical foundation for

decision analysis and offers a wide range of methods for supporting complex decision-making processes. Although many aspects of spatial decision problems can be usefully tackled by the conventional, aspatial, MCDA methods, we believe there is a need for MCDA approaches specifically designed for dealing with spatial problems if the decision-making process is to provide meaningful results and avoid misguided recommendations.

The book is divided into three parts: Preliminaries (Part I), Spatial MCDA: Methods (Part II), and Spatial MCDA: Technologies (Part III). Parts I and II were written by Jacek Malczewski, while Part III was contributed by Claus Rinner.

Part I consists of three chapters. Chapter 1 examines the linkages between GIScience, spatial analysis, and decision support. We highlight an important distinction between conventional MCDA methods and spatially explicit multicriteria/multiobjective approaches. Chapter 2 provides an overview of generic elements of MCDA. It also examines the basic concepts of GIS-MCDA including: value scaling, criterion weighting, and combination rules. The final chapter of Part I reviews the development of GIS-MCDA research and applications in the last 20 years or so.

Part II is subdivided into five chapters dealing with spatial MCDA methods for tackling decision problems. Chapter 4 focuses on the most frequently applied GIS-based multiattribute decision analysis methods including: weighted linear combination, analytic hierarchy process/analytic network process, ideal point approaches, and outranking methods. The classic multiobjective decision methods are discussed in Chap. 5. The focus is on the most often used GIS-based multiobjective decision techniques such as: the methods for generating non-inferior solutions, the distance metric-based methods, and the interactive approaches. The complexity of many spatial multiobjective optimization problems makes it very difficult or even impossible to search every candidate solution using the classic methods. Consequently, Chap. 6 presents the heuristic algorithms. These algorithms are classified into two groups: basic heuristics (such as site suitability/location heuristics and greedy algorithms) and meta-heuristics (including evolutionary algorithms and swarm intelligence meta-heuristics). Chapter 7 explores the concept of uncertainties in GIS-MCDA. It also provides an overview of approaches for handling uncertainties in GIS-MCDA including fuzzy and probabilistic methods as well as sensitivity analysis. Chapter 8 focuses on the GIS-MCDA approaches for group decision making. It presents a selection of conventional GIS-MCDA methods that have been used for tackling group decision-making problems, and a discussion of geosimulation approaches from the perspective of GIS-MCDA for group decision making. The last chapter in Part II extends the traditional GIS-MCDA approaches to spatial/temporal multiscale analyses.

Part III addresses technologies for tackling spatial multicriteria problems. The three chapters contained therein follow the development of information technology from desktop computing to Web-based and mobile technologies. Chapter 10 explains desktop GIS-MCDA implementations and their applications. The chapter distinguishes desktop GIS-MCDA by the vector and raster data models used to represent geospatial features. Chapter 10 also includes an overview of MCDA and

related modules in major commercial and open-source software packages. The chapter concludes with a case study illustrating the role of GIS-MCDA as a component in spatial decision support processes. Chapter 11 examines the combination of geovisualization and GIS-MCDA. Geovisualization is an approach to data analysis that entails multiple, linked, interactive maps that support geospatial data exploration and hypothesis development. Following an overview of geovisualization concepts, Chap. 11 distinguishes between the geovisualization of MCDA input and MCDA results. This chapter concludes with a case study, which illustrates the value of combining geovisualization and GIS-MCDA techniques to improve decision outcomes. Chapter 12 mirrors the trend of general information technology, and GIScience research and GIS development in particular, to move from desktop solutions to networked and mobile systems. The chapter outlines recent concepts and applications of Web-based and mobile GIS-MCDA technologies. This summary of ongoing research and development concludes Part III of the book.

This text is designed for researchers and practitioners in GIScience and operational research/management science, especially those conducting applied decision analysis. It is of interest to academics, students, and practitioners in both private and public sector organizations, who are interested in decision situations involving geographic datasets. In terms of pedagogical use, the book is suitable for upper level undergraduate and postgraduate teaching not only in GIScience and geography programs, but also in areas like urban and regional planning, environmental science, civil engineering, landscape architecture, and design. It can also be a valuable teaching resource for applied decision analysis and decision support systems courses offered in operational research/management science programs.

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