Preface

The study of collaborative geographic information systems (GIS) is centered on the designs, processes, and methods that integrate people, spatial data, exploratory tools, and structured discussions for planning, problem solving, and decision-making. However, the transdisciplinary roots of collaborative GIS present two primary challenges. The first challenge is that the extent of the research field may result in researchers being unaware of theories and methods that can significantly improve collaborative GIS designs and processes. The second is that the research field has been application driven at the expense of stronger theoretical integration and synthesis.

Collaborative Geographic Information Systems is an edited book that integrates relevant theoretical frameworks, methods, and the latest research findings for group planning, problem solving, and decision making using GIS-based technologies. The chapters explore innovative practices and methods from transdisciplinary research areas, in order to consolidate current collaborative GIS efforts and to map future research directions. In the transdisciplinary paradigm, the goal is to engage research beyond the boundaries of specialized core areas to find solutions and strategies that can yield greater knowledge integration and synthesis.

The book was designed around selected and focused research questions. These questions include "What are the theories and methods that drive collaborative GIS designs and processes? What new theories and methods can improve collaborative GIS designs and processes? How can we integrate current and new theories and methods into collaborative GIS applications to make them more efficient and meaningful?” The chapters of the book are arranged to highlight the theories, designs, and functions of collaborative GIS, and to examine the Internet and wireless technologies as new frontiers for collaborative planning, problem solving, and decision making.

Organization of This Book

The book contains 17 chapters organized into 5 sections. The first section outlines the origin and boundaries of collaborative GIS, to provide a contextual background. The next three sections address the themes of *“system design, group spatial planning, and mapping,” “modeling, decision support, and visualization,”* and *“Internet and wireless applications.”* The final section summarizes some of the current conceptual and technical hurdles of collaborative GIS, and suggests how these may be addressed by emerging transdisciplinary areas of research.

Section I: Introduction

Chapter I, by *Shivanand Balram* and *Suzana Dragićević,* outlines the origins, boundaries, and structures of collaborative GIS. The key literatures on spatial planning, computer-supported cooperative work, and group decision making are used to trace a historical lineage. Using this lineage, a discussion of collaboration vs. cooperation is presented, and this forms the basis to propose a guiding definition for collaborative GIS. The conceptual linkages between collaborative GIS and related research efforts such as spatial decision support systems (SDSS), planning support systems (PSS), geocollaboration, and participatory GIS (PGIS) are presented. The conclusion is that collaborative GIS is centrally positioned on a participation spectrum that usually ranges from the technical expert to the general public, and that an important goal of collaborative GIS is to use spatial discussions and mapping to structure and reconcile planning and decision-making differences among representative interest groups. The implication is that collaborative GIS must deal with integrating experts and the public in decision making. The role of the Internet and wireless technologies to evolve a distributive turn to planning is discussed and further explored in Chapter XVII.

Section II: System Design, Group Spatial Planning, and Mapping

Chapter II, by *Muki Haklay,* discusses the importance of designing collaborative GIS implementations with end-user needs and requirements in mind. Designs that do not explicitly consider the end user can risk being ineffective, inefficient, and can frustrate the end user to the extent that technology becomes a barrier to the planning and decision-making process. In order to address this issue, the chapter draws on usability engineering and human-computer interaction (HCI) studies to show how these concepts are connected to collaborative GIS designs. Two case studies demonstrate the benefits of integrating usability considerations into collaborative GIS. In the first case, the process of digitizing an area on a Web-based GIS is improved to enhance the user's experience by allowing interaction over narrowband Internet connections. In the second case, server-side rendering of 3-D scenes allow users not equipped with powerful computers to request sophisticated visualization without needing to download complex software. The conclusion is that an understanding and consideration of end users' context and conditions are key factors for the effective implementation of any collaborative GIS project.

Chapter III, by *Timothy Hawthorne, Michael Dougherty, Gregory Elmes, Christopher Fletcher, Brent McCusker, Marta Pinto,* and *Daniel Weiner,* presents a land-use study that incorporates community-based qualitative information into a participatory geographic information system. The PGIS implementation is field based, and provides residents with an opportunity to discuss and map their priority land-use issues, and to identify land-use hotspots in ways not usually possible at general public meetings. The use of multimedia integration and representation of local knowledge with formal spatial information was the principal approach adopted. The work also promotes university-community-government partnerships. The conclusion is that these partnerships in PGIS land-use planning and decision making are beneficial for integrating knowledge from multiple stakeholders, prioritizing actions for effective resource allocations, and encouraging continuity in the collaborative land-use planning and decision-making process.

Chapter IV, by *Sarah Elwood,* examines the current status and emerging trends in public participation GIS (PPGIS) research and application. The chapter uses the community planning application domain to draw attention to the important issues of access and participation, and how these have shaped PPGIS in the past decade. Discussions about the influences of institutional frameworks and sociopolitical impacts on PPGIS implementation provide a context for examining PPGIS technologies and processes. The impacts of new developments in technologies such as distributed GIS, coupled with mixed forms of participatory planning processes such as multiple partnerships are used to outline expansion areas and challenges for PPGIS research. Practical strategies to address some of the challenges are presented. The conclusion is that as PPGIS continues to expand, researchers and practitioners must be proactive in adapting new systems and science to address the inherent ambiguities that may exist in using a PPGIS approach to planning, decision making, and problem solving.

Chapter V, by *Claus Rinner,* presents the concept of argumentation maps to support geographically referenced discussions, and to provide visual access to planning debates. In many planning applications, the spatial domain and the argumentation domain are only loosely coupled. Argumentation maps provide an explicit link between the geographic objects being debated about and the arguments related to those objects. This explicit linkage or geoargumentative relations provide new opportunities for the quantitative analysis and synthesis of planning debates. Spatial queries, visualization of arguments, and cartographic displays are some of the capabilities provided by argumentation maps. The chapter also discusses the argumentation model, and some research and application development. The connections between argumentation maps and the related concepts of geographic visualization, spatial decision support systems, and public participation GIS are presented. The conclusion is that argumentation maps provide a useful mapping and analytical framework to integrate expert planners and local communities in collaborative GIS planning and decision making activities.

Chapter VI, by *Edward Mac Gillavry,* outlines an alternative geographic information infrastructure using existing collaborative mapping initiatives and established Web technologies. National mapping agencies provide much of the spatial data collection and dissemination goods and services that the geospatial community uses. The availability and access of location-aware mobile devices could potentially turn everyone into a mapmaker. In collaborative mapping, the goal is to collectively produce models of real-world locations online so that other users can access and enhance these models virtually by using annotations. The chapter discusses the technical and social developments that characterize this form of map making. The conclusion is that by storing geographic information in machine-readable formats and exchanging geographic information through Web services, collaborative mapping may enable the "napsterisation" of geographic information. This may lead to complementary and alternative geographic information developed from the products created by national mapping agencies. (*Editors note:* This chapter was submitted before the 2005 Katrina and Rita hurricane events in the USA. These events displaced many lives, and also highlighted the importance of collaborative mapping for disaster planning and information dissemination. The Scipionus Web site (http://www.scipionus.com) provides some collaborative mapping examples. The relevance of the framework presented in this chapter is further endorsed by these recent real-world collaborative mapping initiatives.

Section III: Modeling, Decision Support, and Visualization

Chapter VII, by *Shivanand Balram* and *Suzana Dragićević,* presents a collaborative modeling framework that uses the agent UML (AUML) profile to develop and document spatial agent-based solutions. The complex interactions between natural and human systems have led to an increasing interest within geographic information science to adopt the agent paradigm to model complexity. Consequently, the agent paradigm has sparked a growing need for integrated tools to support the design, analysis, and documentation of agent-based solutions. Also, because these solutions are dependent on the input from many types of system users and modelers, an emerging challenge is how to develop and document a consistent agent-based design. The chapter argues that objects and agents share many common features and hence, adapting object-oriented approaches to serve the needs of agent designs is a more effective route to model agents. Further, a framework is presented where the AUML profile can be used in a collaborative group process to support consensus model building, documentation of designs, and knowledge sharing.

Chapter VIII, by *Raja Sengupta,* integrates cause-effect models and software agents as a way to reduce the computer processing and cognitive complexity associated with using simulation models. The research challenge can be traced to the fact that solutions for spatial environmental problems often require the integration of dynamic simulation models within GIS to create spatial decision support systems that can generate responses to theoretical "what-if?" scenarios. The extension of this embedded GIS modeling approach to collaborative SDSS presents a challenge for real-time display and end-user interaction with simulation models. The chapter uses artificial neural networks and software agents to address the challenge associated with real-time collaborative modeling. The neural network rules link the inputs to outputs for a limited number of viable scenarios, and software agents assist novice users to determine the most suitable input parameters for the developed model. Applications of this approach are provided. The conclusion is that the use of cause-effect models and software agents can improve end user interaction and processing of spatial models in collaborative GIS settings.

Chapter IX, by *Piotr Jankowski* and *Milosz Stasik,* describes an experimental investigation to determine the extent to which spatial decision support tools support participatory planning. The chapter uses a participatory geographic information systems framework and a land-use planning example to develop the experiment. The potential of PGIS has been based on the assumption that maps are rich in information content, and can therefore communicate shared understanding and analytical thinking. The rapid development of multimedia cartography has added to this assumption. The question about whether maps alone are a suitable medium to support shared understanding and analytical thinking in participatory decisions is an open one. This chapter tests the applicability of maps, decision models, and Internet-based communication tools for PGIS using a developed spatial understanding and decision support system (SUDSS) software tool. SUDSS was built for an asynchronous spatio-temporal environment, and tested in a real setting involving a public land-use planning debate. The conclusion is that experimental investigations of PGIS can identify critical components of the processes that can then be used to more effectively engage participants in collaborative spatial decision making.

Chapter X, by *Jacek Malczewski,* provides a critical overview of GIS-based multicriteria decision analysis (GIS-MCDA) for supporting group (collaborative and participatory) decision making. Multicriteria decision analysis has been used widely as an analytical tool to integrate decision variables towards a common solution. Combining MCDA with geographic information systems allows for powerful spatial and decision-making analysis. The chapter is based on a survey of peer-reviewed papers published over the last 15 years. A classification of the GIS-MCDA approaches used for group decision making is presented. First, the articles are classified according to the generic elements of the MCDA methods. Second, the GIS-MCDA methods are classified according to the various perspectives about collaborative decision support. These taxonomies of the GIS-MCDA approaches provide a background for an evaluation of the contribution of MCDA to GIS-based collaborative decision making. The conclusion is that MCDA in GIS can provide a flexible problem-solving environment, facilitate structuring of the group decision problem, and promote consensus-based decision making.

Chapter XI, by *Jianhua Gong* and *Hui Lin,* describes a collaborative virtual geographic environment (CVGE) in a 3 dimensional, distributed, and graphical world. This environment is used to represent and simulate geographic phenomena and processes to enable spatially distributed users to explore geoproblems and theories, and to generate hypotheses. Further, the environment supports model building, validation, and collaborative planning. The chapter also reports on an approach to establish a CVGE across the Internet, and its application to the collaborative planning of silt dam systems in watersheds through the integration of distributed virtual environments, geographical information systems, planning models of dam systems, and geocollaboration. A conceptual and system framework of the distributed CVGE, and the 3 dimensional modeling of virtual geographic environments and virtual collaborative studios is presented. A case study and prototype system is designed and developed with Java, Java3D, and VRML to explore the methodologies of collaborative spatial planning of silt dam systems. Using the prototype system, participants can communicate with each other via media tools, mainly in the virtual collaborative studio, and 3 dimensional editing of shared dams, calculation of topographic properties, and ideal spatial distribution of dam systems in a virtual geographic environment.

The conclusion is that integrated collaborative mediating tools can enhance the end-user experience by providing a consistent environment to facilitate scenario planning and decision making.

Section IV: Internet and Wireless Applications

Chapter XII, by *Timothy Nyerges*, *Kevin Ramsey* and *Matthew Wilson,* explores system design considerations to support structured and flexible analytic-deliberative processes in transportation improvement decisions. Research about "analytic-deliberative" decision processes shows that meaningful public participation is possible, and decision outcomes are improved. The analytic component provides technical information that ensures broad-based and competent perspectives are treated. The deliberative component provides an opportunity to interactively give voice to diverse values, alternatives, and recommendations. Unfortunately, such public participation has been expensive and time consuming, and thus involved small groups. An Internet system that combines geographic information system technology, decision modeling technology, and communications technology into a geospatial portal to support analytic-deliberative processes might be one way to facilitate meaningful participation in large groups, as a way for agencies to more effectively engage a public who wish to participate. The conclusion is that an analytic-deliberative approach in participatory decision processes can improve participant's understanding of information and their level of engagement with the decision problem.

Chapter XIII, by *G. Brent Hall* and *Michael Leahy,* situates PPGIS in the context of using the Web and Internet to improve participation and representation of planning issues in collaborative planning and decision-making processes. The chapter also considers the role that open source software tools can play in crafting accessible and highly customizable solutions using a primary-level education example. A central and general objective of PPGIS is to encourage the use of GIS technology by broad based and geographically dispersed nonexpert users. In the context of planning decision support, this involves creating software with map-based functionality that is responsive to the needs of user groups that have limited experience with computers, and only a rudimentary knowledge of even simple spatial analysis concepts. This functionality should be designed to enable these individuals to communicate and interact with higher-level users and agencies on an equal footing so that all participants can be both better informed of each others perspectives, and more involved in decision-making processes that involve land- and resource-use planning and management. The conclusion is that the Internet and open source technologies can be used to enhance dialogue between participants, and this represents a shift from the traditional approach that has focused on participants' interactions with the decision-making technology.

Chapter XIV, by *Brad Mason* and *Suzana Dragićević,* examines the integration of Web GIS technologies with knowledge management systems to support community planning. The integration of multiple knowledge types is required to effectively deal with the complexity of spatial environmental problems. However, past research and applications of Web geographic information systems (Web GIS) have mostly focused on using spatial tools to manage explicit or codified knowledge. This has reduced the complementary contribution that tacit or experiential knowledge can provide to environmental problem solving. A customized end-user interface for data entries and simplified georeferencing tools enabled asynchronous collection of local knowledge about the location of species, ecological habitats and environmentally sensitive areas, among others. The conclusion is that the integration of Web GIS and knowledge management systems can facilitate greater access to environmental data, encourage community participation, and provide a foundation for coordinated data exchange across geographic borders.

Chapter XV, by *Songnian Li,* discusses the Web technologies that are important to the development of collaborative spatial decision support systems, and identifies their technology impediments and strengths. The rapidly expanding range of Web technologies has made it possible to collaboratively make decisions over the Web. The outcomes provide a basis to discuss how the existing collaborative spatial decision support systems may be redesigned to take advantage of new Web technologies, and how new collaborative spatial decision support systems may be designed and developed in this Web-based paradigm. The chapter discusses selected design and development issues such as system design, user's impact, and performance, which are important to the development of collaborative spatial decision support systems. The conclusion is that the integration of Web mapping/GIS and groupware technology can be used to redesign early CSDSS, and develop future systems for collaborative planning and decision making.

Chapter XVI, by *Ming-Hsiang Tsou,* introduces a collaborative GIS prototype that demonstrates an interoperable framework for combining Web-based GIS technologies and wireless mobile GIS applications. Internet GIS provides a collaborative communication environment for sharing data, information, and knowledge. Mobile GIS can add both geospatial information and global positional systems (GPS) coordinates from remotely located field-based personnel to spatial decision support systems. By adopting broadband wireless telecommunication technology for connecting Internet GIS and mobile GIS devices, decision makers can collect real-time information from field workers and quickly distribute updated information back to the field. The integrated framework provides real-time or near real-time GIS data updating functions (such as adding new spatially located map features or GPS tracking locations) between mobile GIS devices and Internet GIS servers. The conclusion is that although these real-time GIS functions can be important during emergencies, they can be equally beneficial and highly cost-effective during routine field activities.

Section V: Conclusion

Chapter XVII, by *Suzana Dragićević* and *Shivanand Balram,* focuses on the existing published knowledge in the research area together with the chapters in this book to summarize some of the important conceptual and technical hurdles of collaborative GIS design and implementation. The conclusion is that the increasing complexity of environmental and societal problems requires the use of a transdisciplinary problem-solving approach. This approach will allow the development of integrated solutions that use the best available knowledge and tools to narrow the conceptual gaps that exist between technical experts and the general public towards more effective planning and decision making. Some emerging research areas from the transdisciplinary literature that hold promise for improving collaborative GIS theory and applications are also presented.

Intended Audience

Collaborative Geographic Information Systems will be of immense value to academic researchers, planners and policy makers, graduate students, and individuals working in GIScience, geography, environmental science, urban planning, computer-supported cooperative work, and information technology. The chapters are written by leading researchers and communicate the latest findings in the area. The chapters were subjected to at least two double-blind peer reviews to improve their accuracy and completeness. We hope the book will inspire readers to contribute in further developing the science and methods of collaborative GIS, and to use the developed systems to improve spatial planning, problem solving, and decision making.

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November 2005