STRATEGIC THINKING FOR IMPROVED REGIONAL PLANNING AND NATURAL RESOURCES MANAGEMENT

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This special theme issue of *Applied GIS* further widens the scope of our journal by edging it closer to the "policy support" pole of the *GIScience* continuum. It contains several creative articles showing how practicing planners of natural resources and the environmental have managed to exploit the power of GIS and remote sensing in order to improve strategic thinking.

More specifically, this issue showcases innovative GIS-related work being led by the *Department of Primary Industries* (DPI) in the State of Victoria, Australia. All authors either work for, or collaborate with this department's research division, which is known as *Primary Industries Research Victoria* (*PIRVic)*. Moreover, in the spirit of providing informed decision support for rural and regional policy makers, the selected articles describe and explain actual working projects that have usually generated tangible results already.

This editorial begins, therefore, by outlining the basic philosophy of *PIRVic*. It then describes a "systems framework for spatial decision making" in which each paper can be situated. Finally, we briefly describe the nature and context of each article.

UNDERLYING PHILOSOPHY

The substantial increases in human population and economic activities of the past decades have changed natural ecosystems and their services faster and more extensively than in any other era of human history. This transformation of Planet Earth has contributed to significant gains in human well being and economic growth. However, not all groups of people have benefited from the process and the pressures on the environment and natural resources have intensified (Reid et al. 2005; Steffen et al. 2004; Saul 2005). For decision-makers, planners and natural resource managers, sustainable resource allocation has become especially difficult.

In this turbulent environment of increased complexity, uncertainty and risks, there have been renewed calls for science to underpin decision-making and implementation (Diamond 2005; Reid et al. 2005).

In the 1950s and 1960s the quantitative revolution contributed to planning several urban and regional planning models which were developed and applied across America and Europe

(Hill, 1965; Schlager, 1965). In the 1970s there was a backlash against such quantitative models because they were seen to be providing prescriptive, top down, black box solutions that were inaccessible to planner practitioners and decision makers (Lee, 1973). The 1980s and 1990s then saw the resurgence of information, and of models in the form of expert systems (Wyatt, 1996). Moreover, within the last couple of decades, the proliferation of desktop GIS and Internet technologies has given rise to a number of spatial decision support tools for assisting planners and natural resource managers to model future scenarios (Sprague and Carlson, 1982; Densham, 1991 ; Jankowski and Richard, 1994; and Church et al.1998).

Finally, in the last few years there has been a development and application of specialised *Spatial Decision Support Systems* (SDSS) to assist planners. Such products are commonly referred to as planning support systems (PSS) (Brail and Klosterman, 2001; Geertman and Stillwell, 2003; and Klosterman and Pettit, 2005), so PSS constitute the newest generation of decision support instruments. They comprise tools that are related to geo-information technology and which were primarily developed to support the different aspects of the planning process (Geertman and Stillwell, 2003).

A SYSTEMS FRAMEWORK FOR SPATIAL DECISION MAKING

Developments in the general area of SDSS have focused on flexible, well-equipped and user-friendly systems that strategically and intelligently underpin different aspects of the decision-making process – *problem formulation, analysis, forecasting, generation of alternatives, evaluation, choice*. SDSS can be generally identified as dedicated sets of computer-based tools (methods, models and techniques) that support the decision-making process across different stages, scales and contexts via integrated multiple technologies. Therefore, the conceptual framework of SDSS can be defined as an interactive, integrative, flexible and user-friendly system composed of three main components: data management system, modelling system, and user interface system (**Figure 1**).

1. *Data Management System* - This is a data generation and management system that includes tools to support the generation and storage of spatial and non-spatial (attributes) data which is specific for the study/system of concern, the transformation between data models, the translation of a data structure for a given model, and the retrieval of data from storage. The system includes a database comprising socio-cultural, economic, environmental, physical and organisational data and supporting metadata.
2. *Modelling System* - This can be described as a spatial modelling toolbox that helps the user identify the most appropriate methods, models and tools for dealing with the particular study/system of concern. The modeling system includes analytical, forecasting, design and evaluation models and tools that draw from datasets stored within the data management system.
3. *User Interface System* – This supports the visualisation and distribution of the data sets from the data management system and the outputs from the modelling system. The user interface system can represent data and model outputs in the form of traditional flat two-dimensional (2D) maps. Recent advancements in the field of geographical visualisation are resulting in more SDSS tools comprising a three-dimensional (3D) interface such as the

CommunityViz tool (Kwartler and Bernard, 2001). A 3D interface is an integral part of this system to enable decision- and policy-makers to view the results of system modelling in an interactive 3D environment. The fourth dimension - - time (4D) is also an important feature of this system.

Underpinning both the modelling and data management systems is a data infrastructure built around the concept of *metadata* (data about data). As depicted in the figure, it is important to have both metadata for models and data. Metadata about models should include a number of attributes including lineage of where a particular model has been run, where it can be run, and what data is required to support the model. Metadata about the data should include attributes such as custodian/creator, currency, scale, resolution and accuracy. The data infrastructure underpinning a SDSS should be developed in accordance with AS/NZS ISO 19115 and other associated relevant ISO standards.

The overall process of planning and decision-making is informed by the policy context, which includes the concept of sustainable development (World Commission on Environment and Development, 1987; Daly, 1992; State of the Environment Advisory Council, 1996). Moreover, the SDSS has to be responsive to the purpose of the study, taking into consideration both the local and expert knowledge inherent within a defined geographical space.

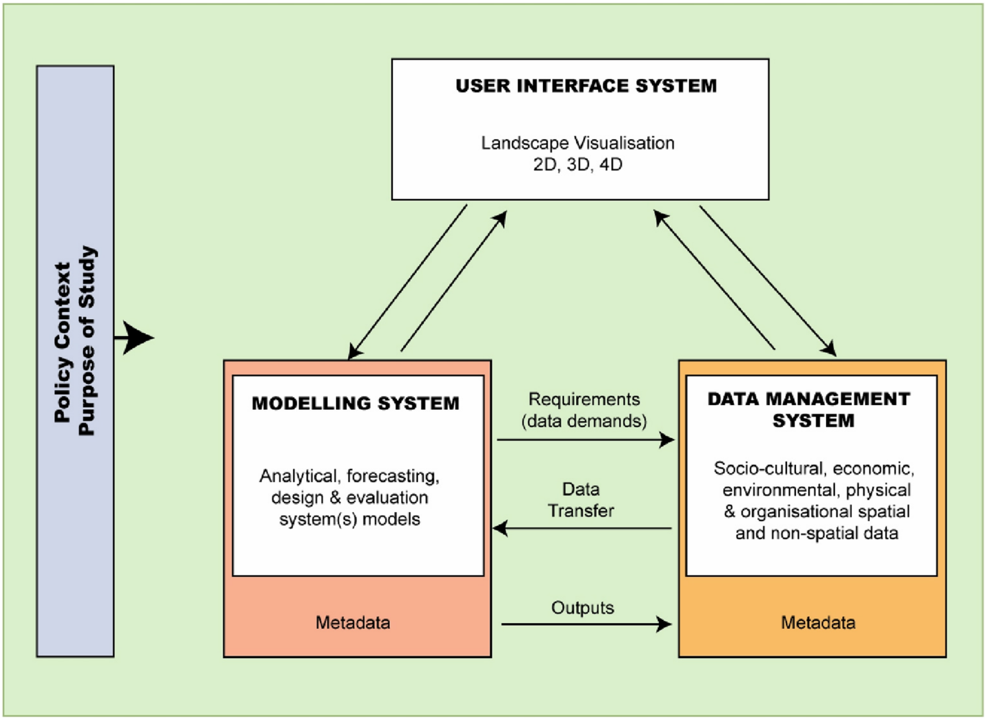

Figure 1 Generic Spatial Decision Support System

Since frameworks can restrict the users' thinking, care has been taken to conceptualise the generic framework shown in Figure 1, so users can decide which model is most relevant to providing insight into their particular problem. The framework is flexible enough to accommodate newly created models, customised models, integrated models or off the shelf models.

As we will see in the papers in this special issue, the models which support regional planning and natural resources management are derived from ecology, economics, geography, climate science, hydrology, soil science, planning, engineering, and organisational development. A common requirement for all models is their dependency on data. Thus, to properly support modelling a robust data management system is necessary and should include the following functionality: (i) collection, (ii) storage and (iii) retrieval.

Many of the issues that ought to be addressed in meeting the requirements of the conceptual SDSS are now receiving scientific attention and dedication. Substantial research originates, however, in allied areas such as knowledge management (data infrastructure and system design), geomatics (spatial analysis and remote sensing) and user-interface tools (2D, 3D, and 4D visualisation). Therefore, advances in SDSS are partly dependent on the advances in a combination of technologies. At the same time, the reality of planning practice makes it often necessary to create a SDSS as one-off application in response to the special characteristics of the specific issue(s) and/or the situation it should address.

Despite their significant role regarding system functionality, the required technological components should not drive system structure but serve to support the other key components. Saarloos (2006) believes that components of a SDSS which assimilate the complexity of planning and decision-making are the most central and directive within the model framework. This reinforces the notion that a SDSS can serve both as a pedagogical tool and predictive tool. Furthermore, the outputs from a complex systems modelling approach are only as useful as the quality of data and metrics that serve as inputs.

THE CONTENTS OF THIS SPECIAL ISSUE

Consistent with the above, this special issue of *Applied GIS* primarily focuses on the main models developed, or being developed, by PIRVic and its associates.

The first article by Hossain, Sposito and Evans describes the integration of a Multiple-Criteria Evaluation (MCE) method, the *Analytic Hierarchy Process* (AHP), with a GIS environment to assess agricultural and urban land suitability. These land suitability analysis (LSA) models were formulated as a response to the strategic planning needs of government organisations and industries operating at regional and local geographic scales. The integration of AHP with GIS generates a robust approach, which benefits from the strength of both the AHP as a multi-criteria assessment method and GIS's spatial analytical capabilities. It is thus used extensively as a structuring platform for a number of other models developed and applied by PIRVic.

The second article by Sposito, describes a strategic approach to examining potential climate change impacts on agricultural and regional/rural resources. It outlines a practical framework that links impacts with adaptation strategies. The framework is consistent with new thoughts on preparing society for climate change. The assessment of the potential impacts is a logical extension of the models described in the previous paper since it links LSA with climate change impacts models developed by Australia's *Commonwealth Scientific and Industrial Research Organ-*

isation (CSIRO). In fact, the project described in this article is part of a major joint national and state effort in Australia to improve the knowledge of, and tools to adapt to climate change and climate variability.

The article by Sietchiping discusses the development of a generic approach to determining the spatial variation of communities' and industries' adaptive capacity to climate change, and its application in the North-west of the State of Victoria (also known as Victorian *wheatbelt*), Australia. This paper also describes the process of identifying key driving forces and indicators for adaptive communities and industries as well as highlighting the importance of combining government policies, expert advice and empirical evidence to develop adaptive capacity. Adaptive capacity is formulated for three major fields (themes): socio-cultural, economic, and institutional and infrastructural. Each theme has associated sub-themes, which in turn are underpinned by a suite of indicators, albeit all contributing to overall adaptive capacity. GIS is used to collect and analyse the data, apply the AHP and spatially represent the indicators and indices.

Wyatt and Hossain's article describes a prototype computer program that uses a *"genetic algorithm"* to optimise the distribution of agricultural production across a region. Such optimisation is based on different crops' local yields along with their global market prices and levels of market demand. The program finds the pattern which achieves the highest economic return, or the least environmental damage, or the best fit with present and post-climatic-change soil suitability levels or the lowest transport costs. It can be applied within any region for which there exists the necessary underlying data, and it exhibits improved performance due to its forsaking of traditional optimizing methods in favour of the "evolutionary computing" approach. A number of features embedded within the package make it transparent, flexible and ultimately a more powerful optimisation tool – not to mention a more comprehensive simulation and decision-support system in its own right. This is an innovative approach for attacking what has hitherto been the impossibly complex problem of spatial crops' allocation.

The article by Sposito and Morse-McNabb explains an innovative approach to appraise the extent and quality of native vegetation and to identify significant habitats at strategic regional and local levels. The cornerstone of the approach is the formulation of a *'Regional Habitat Significance Model'*, which is built through the integration of the AHP and GIS. The GIS platform permits the ongoing improvement and input of relevant information and the preparation of a new assessment in a cyclical planning process. The paper also discusses the integration of remote sensing and GIS technologies to investigate natural resources, especially in the preparation of land use maps.

Pettit, Cartwright and Berry's article focuses on the geographical visualisation of urban and regional landscapes. It reports on work undertaken by PIRVic in collaboration with the *Royal Melbourne Institute of Technology (RMIT) University*'s Community Spatial Scenario Simulation Group (C-S3). These groups have jointly developed and applied a range of 3D geographical visualisation products to enhance both planning and scientific communication processes. In this paper some developments and applications of 3D geographical visualisation tools are reported, as is work that is being undertaken to evaluate their effectiveness for solving spatial planning problems. Lessons learnt in undertaking a cross-disciplinary approach to landscape visualisation tools, as well as and their usefulness in participatory planning approaches, are discussed.

The article by McNeill and MacEwan describes an alternative to the costly ground mapping of soil erosion's extent and severity, which is required for developing regional Soil Erosion

Management Plans. This new approach uses a GIS asset-based risk assessment model - the *Land Use Impact Model* (LUIM). LUIM deploys a Bayesian belief network and an ArcGIS interface to combine biophysical data and expert knowledge to produce maps that identify areas in the landscape which are at risk of degradation. The paper describes its application in West Gippsland, Victoria, Australia. The risk of soil erosion, under current land management regimes in that region, was mapped using the LUIM and the information was used to inform the prioritisation of actions for the West Gippsland Soil Erosion Management Plan.

The LUIM also has an aspatial component that incorporates knowledge of relationships between landscape characteristics and land management practices and a spatial component that uses a GIS to map where these relationships exist or are likely to exist. The use of a Bayesian belief network function within the LUIM, to combine the different types of information ('hard' and 'soft'), enables the final risk output to be expressed as a rating and as a probability distribution that can be used to map the uncertainty in the risk results.

The article by Wu, Bishop and Hossain describes a new methodology that combines an expert/design approach with a perception-based approach to assess Landscape Visual Quality (LVQ). With the help of GIS, it is now possible to handle a large amount of spatial information, which is at the base of the methodology. Possible predictors/indicators of visual quality are identified for the study area and, through spatial interpolation, LVQ is mapped across the area.

The final article by Pelizaro and McDonald presents the conceptual design of a SDSS for the Westernport Region within metropolitan Melbourne, Victoria. The system will underpin the region's integrated (whole-of-catchment) sustainable management of natural resources. The Westernport SDSS will integrate GIS technology, scenario management tools, state-of-the art terrestrial and marine ecosystem modelling and multi-criteria evaluation to capture and communicate the complex interactions within a dynamic landscape.

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