16 DECISION SUPPORT AND GEOGRAPHICAL INFORMATION SYSTEMS

Kurt Fedra and Rene F. Reitsma

16.1 Introduction

Geographical Information Systems (GIS) are gaining increasing importance and widespread acceptance as tools for decision support in land, infrastructure, resources, environmental management and spatial analysis, and in urban and regional development planning. GIS assist in the preparation, analysis, display, and management of geographical data. It is in the analysis and display functions that GIS meet Decision Support Systems (DSS). DSS analyse and support decisions through the formal analysis of alternative options, their attributes vis-a-vis evaluation criteria, goals or objectives, and constraints. DSS functions range from information retrieval and display, filtering and pattern recognition, extrapolation, inference and logical comparison, to complex modelling. The use of model-based information and DSS, and in particular of interactive simulation and optimization models that combine traditional modelling approaches with new expert systems techniques of Artificial Intelligence (AI), dynamic computer graphics and geographical information systems, is demonstrated in this chapter with application examples from technological risk assessment, environmental impact analysis, and regional development planning. With the emphasis on an easy-to-understand visual problem representation, using largely symbolic interaction and dynamic images that support understanding and insight, these systems are designed to provide a rich and directly accessible information basis for decision support and planning.

16.2 Decision support

Underlying the concept of DSS in general is the recognition that there is a class of decision problems that is neither well structured nor unambiguous. Such problems cannot be properly solved by a single systems analysis effort or a highly structured computerized decision aid (Fick and Sprague 1980). They are not unique so a one-shot effort would be justified given that the problem is big enough. Neither do they recur frequently enough with sufficient similarity to subject them to rigid mathematical treatment. They are somewhere in between. Due to the mixture of uncertainty in the scientific aspects of the problem, and the subjective and judgmental elements in its socio-political aspects, there is no wholly objective way to find a best solution.

There is no universally accepted definition of DSS. Almost any computer-based system, from database management or information systems via simulation models to mathematical programming or optimization, could conceivably support decisions. The literature on information systems and DSS is overwhelming; approaches range from a rigidly mathematical treatment to applied computer sciences, management sciences, or psychology. Decision support paradigms include predictive models, which give unique answers but with limited accuracy or validity. Scenario analysis relaxes the initial assumptions by making them more conditional, but at the same time more dubious. Normative models prescribe how things should happen, based on some theory, and generally involve optimization or game theory. Alternatively, descriptive or behavioural models supposedly describe things as they are, often with the exploitation of statistical techniques. Most recent assessments of the field, and in particular those concentrating

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on more complex, ill-defined, policy-oriented and strategic problem areas, tend to agree on the importance of interactiveness and the direct involvement of the end user. Direct involvement of the user results in new layers of feedback structures (Figure 16.1). The information system model is based on a sequential structure of analysis and decision support i.e. the relationships shown in the upper part of Figure 16.1. In comparison, the decision support model implies feedbacks from the applications, e.g. communication, negotiation, and bargaining to the information system, scenario generation, and strategic analysis. The realism of formal models is increased, for example, by the introduction of multiattribute utility theory (Keeney and Raiffa 1976, Bell et al. 1977), extensions including uncertainty and stochastic dominance concepts (e.g. Sage and White 1984), by multiobjective, multicriteria optimization methods, and finally by replacing strict optimization, requiring a complete formulation of the problem at the outset, by the concept of satisficing (Wierzbicki 1983).

Figure 16.1: Strategic decision problems: information systems versus DSS approach (partly after Radford 1978)