Chapter 6
GI-Technology: Adaptive Generator of Spatio-Temporal Decision Support Systems for Land Use Planning

Anja Wijffels
Katholieke Universiteit Leuven, Belgium Universidad de Cuenca, Ecuador

Jos Van Orshoven
Katholieke Universiteit Leuven, Belgium

Bart Muys
Katholieke Universiteit Leuven, Belgium

Dirk Cattrysse
Katholieke Universiteit Leuven, Belgium

ABSTRACT

To deal with the complexity of land use allocation in a spatio-temporally variable context, a generic framework for automated support to multi-objective land use planning is proposed. The framework is rooted in the discipline of land evaluation which is considered a go-between between land resources survey and land use planning. It draws on own experiences and on lessons learnt from literature. It consists of five integrated and interoperable components. The core three ones, the spatio-temporal database, the engine for data query, transformation and analysis and the user interface are adopted from geographical information systems (GIS). A 'knowledge and model base' component adds capability for assessing land performance over time. Finally, a multicriteria decision analysis component allows for identifying optimal land units and optimal land use options. The framework's applicability and the limitations of geographical information technology (GI-Technology) to generate spatio-temporal decision support systems (stDSS) are illustrated with two cases: one in data rich and one in data poor conditions.

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INTRODUCTION

Decisions are commitments to action with a view to achieve set objectives. In the process of land use planning for sustainable natural resources management, core decisions typically have to do with a choice among alternative land use types (LUT). The standard approach is that multiple land evaluation is done, assessing land suitability based on the matching of the relevant land characteristics with the requirements of each land use type (FAO, 1976). Making such decisions, based on prior land evaluation, is complex since they have to satisfy diverse objectives at a time, like yielding a threshold economic return, maximizing social benefits and minimizing environmental impacts. The spatial and temporal variability of land characteristics and land qualities in the planning area add to this complexity. In order to accomplish the set objectives, the land use planner not only has to make a choice between alternative land use types, defining how to use the land within the study area, but must also address questions related to where, when and during how much time to implement a given land use type.

Most current land use policies inadequately take into consideration multiple objectives and spatio-temporal variability, as effective tools are lacking to address the decision questions involved (Matthews et al., 1999; Jakeman & Letcher, 2003; Roetter et al., 2005). Over the last decades a lot of efforts have been done around the world to develop such tools to address the multiple challenges that present the spatial planning of land use changes or land allocation, given the non homogeneity in space and time of land characteristics and land performance aspects, the diversity in user preferences and decision uncertainty as well as the existence of multiple, interdependent decision objectives (Chakroun & Bernie, 2005).

In this chapter we demonstrate how Geographic Information Systems (GIS) can be expanded into a spatio-temporal Decision Support Systems (stDSS) for land use planning by incorporating (i) a knowledge and model base (KMB) for assessing the temporal evolution of land attributes under actual and potential conditions and (ii) a module for dealing with multi-criteria optimization questions. This is different from the more traditional view in which spatial decision support systems (sDSS) and spatiotemporal decision support systems (stDSS) are sub-types of decision support systems (DSS) incorporating GIS-functionality.

The proposed concept is compared with other approaches reported in literature and illustrated with two stDSS developed to support afforestation planning in two contrasting geographical contexts: north-western Europe and the southern Andes of Ecuador. In north-western Europe (Sweden, Denmark, the Netherlands and Belgium), the AFFOREST-stDSS was developed with the aim of strengthening the knowledge regarding environmental effects of afforestation of former agricultural land (Heil et al., 2007). The FORANDEST-stDSS is meant to support decisions aiming at the enhancement, through afforestation, of the physical and socio-economical land performance in the Southern Andes of Ecuador. Alike the AFFOREST-stDSS, the FORANDEST-stDSS addresses questions related to the environmental performance of future afforestation of agricultural land. In addition it also encompasses non-agricultural land en socio-economic performance.

BACKGROUND

Land Use Planning

Whereas land use changes on small areas are the result of sequential decisions made by individual land users, land use planning is policy-based, concerns larger areas and is part of a broader, multi-stakeholder process requiring specific concepts and tools. As various actors are involved in the decision-making process, multiple goals and interests may appear (Witlox, 2005). According to FAO (2007), land use planning should guide