Chapter 80
A Review of Methodological Integration in Land-Use Change Models

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ABSTRACT

Global change research communities are paying increasing attention to answering critical questions related to land-use change, questions which are at the root of many pressing socio-economic and environmental issues. In this regard, a huge number of models have been developed to support future land-use planning and environmental impact assessments of land-use change activities. Within land-use change models, methodological integration is recognized as an essential feature for a complete model, which can help to combine the strength of single modelling methods/techniques without inherent weaknesses. Despite the potential and remarkable growth of methodological integration in land-use change models, limited attention has been paid to this aspect of integration. In response to this, the authors' paper summarizes the current major land-use modelling methods/techniques, and explains the co-integration of these methods/techniques. In addition, they summarize the achievements, limitations and future trends in the use of the methodological integration approach in land-use change models.

1. INTRODUCTION

The Millennium Ecosystem Assessment (MEA) (2005) revealed that the modification and conversion of land by humans is among the most important and major global changes of the last three centuries. During this time, half of the Earth's ice-free land surface has been transformed by man. Most of the remainder is managed for human purposes unpredictably in terms of pace, magnitude and spatial scale (Global Land Project, 2005a). The MEA found hardly any uses of land that did not have negative effects on ecosystem patterns and processes across the terrestrial biosphere, including on the water cycle (Ster-

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ling et al., 2012; Swartz et al., 2003), soil environment (da C Jesus et al., 2009) and biodiversity (Hof et al., 2011; Seto et al., 2012; Zorrilla-Miras et al., 2014). Changes of the land surface have also disturbed the balance of greenhouse gases and resulted in the Aledo effect, which ultimately has contributed to regional and global climate change (Cai et al., 2004; Chhabra et al., 2006; Pielke, 2005; Rindfuss et al., 2004; Steffen et al., 2005; Wu et al., 2014).

Given continuous population growth, sustainable land-use management has become ever more essential to human life (Global Land Project, 2005b). The need for sustainable land-use management has resulted in the development of models that describe and explain the process of land-use change, predict future scenarios, and measure the impact of land-use activities (Turner et al., 1999; Veldkamp et al., 2001; Verburg et al., 2004). Currently, the principal aim of land-use science is to project changes to land-use, an aim which helps natural resource managers and decision-makers make long-term, comprehensive and sustainable plans (Ghaffarzadegan et al., 2011; Helming et al., 2011; Müller, 2003; Parker et al., 2003; Pontius Jr et al., 2001; Reidsma et al., 2011).

With the progress in computing power, the integrated approach has emerged as an important means by which to improve comprehensive understanding of land-use dynamics (Rotmans et al., 2001; Verburg et al., 2006). The integrated approach varies with the model purpose, for example spatial integration; sectoral integration; land use type integration; economy-society-environment integration and methodological integration etc (Briassoulis, 2000). In this review, we concentrate on methodological integration, which is one of six essential features for a complete land-use change model as stated by Verburg et al (2004). Despite of its importance, there is very limited attention has been given to methodological integration within land-use change models. Methodological integration in land-use change models can be defined as the combination of more than one technique/method to better develop simulation algorithms in land-use change models. This approach gives detailed coverage of several essential aspects of the land-use change process, something that single methods fail to do. Methodological integration was analysed in the reviews of Briassoulis (2000); Heistermann et al. (2006), Koomen et al. (2011), and Michetti (2012). Nevertheless, these reviews focused only on the integration within operational models, which was established as a model package. Indeed, a large number of researchers have developed their own models rather than use operational models, given restricted scope and scale in the application of operational models (data and knowledge requirements, for instance). Reviews that focus only on the operational model do not cover the diversity of the methodological integration in land-use change models.

To fill this gap in knowledge, we reviewed methodological integration in both operational non-operational land-use change models. We summarized and synthesized knowledge and information from previous studies in the field to explore four key areas: (1) major modelling methods/techniques and their strength and weakness; (2) methodological integration in land-use models; and (3) the achievements and limitations of the methodological integration and future trends in this regard. A search of Scopus and Web of Science revealed that research in the field of land-use change began in the 1960s, and has continued since then. We consulted 30 of the most-cited articles and books written in the research field during this period. The references in these sources suggested further sources to examine. Our review paper is aimed at researchers or modellers who intend to improve their models or are looking for new research approaches but do not have much time to review a wide range of land-use change model research. Just by referring to our paper, readers will have a general picture and can find the appropriate methodological integration for their current and future works.

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