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Simulating Spatial Patterns of Land-use and Land-cover Change — A Multi-agent Model and its Application to an Upland Watershed in Central Vietnam

QUANG BAO LE¹, SOOJIN PARK², PAUL L. G. VLEK¹

¹*University of Bonn, Department of Ecology and Natural Resource Management, Center for Development Research (ZEF), Germany*

²*Seoul National University, Department of Geography, Shilim-dong, Kwanak - Gu, The Republic of Korea*

Abstract

Land-use and land-cover (LUCC) is an essential environmental issue to be monitored and projected in order to suggest alternatives for better land management policy. However, scenario studies on LUCC processes are often challenged by the complexity nature and unexpected behaviour of these processes. The primary objective of this study is to formulate a spatial simulation framework of LUCC that can be used as decision-support tools in land management and planning.

This paper presents a multi-agent-based model for simulating the evolution of an entire rural landscape from local actor-based processes over an extended period of time, subject to different land-use policy options. Agents simulated in the model are households situating in defined typical household groups. A hybrid of spatial discrete choice function and rule-based computational method is employed to represent individual agent's behaviour about land and forest uses. Spatial entities in the model include land parcels (cells), micro-landscapes inferred by individual agents (agent's cellular grids), and the overall landscape (entire cellular grids). Cellular automata (CA), coupled with multi-nominal logistic computation of choice probability, are used to infer the knowledge needed by agents to make decisions about land use within their environment. The major innovation feature of this design is that performs human decision-making while utilise the strength of self-organisation concept in cellular automata simulation. Considered policy factors are land use zoning, forest use regulations and agricultural intensification level. As the model was designed using an object-oriented approach, it is extensible to other key policy factors.

The modelling framework is applied to a pilot model of a micro watershed of about 100 km² in A Luoi district, Central Vietnam. Spatially explicit data were obtained from Landsat ETM images, thematic maps, extensive forest inventory and intensive household survey. Field data were used for calibrating agent's parameters and develop an initial database for simulation runs. The relevance land use policy factors and related parameters were preliminarily checked with local key stakeholders. The model was built within NetLogo, an agent-based computer platform with user-friendly GIS interface and external controller.

Keywords: Agent decision-making, land use and land cover change, Multi nominal logistic model, Multi-agent system, NetLogo, Spatial simulation, Vietnam