Spatially Explicit Multi-Agent Modelling of Land Use Change in the Sierra Madre, Philippines

Introduction

Land use in tropical regions such as the Sierra Madre in the Philippines is influenced not only by proximate actors such as farmers or loggers but also by many others such as government agencies, NGOs, absentee landlords, banks and politicians, who exert many influences on the proximate actors and on each other. In order to "socialize the pixel", i.e. to make the connection between social science and the "GIS-based" land use models of geography, the ensemble of these actors can be represented in a multi-agent model. This project aims to do so in an empirically and theoretically valid manner, following the basic structure of the 'Action-in-Context' framework (De Groot 1992).

The goal of the PhD is the design and implementation of a computerized structure that catches the basic causality of land use change in the Sierra Madre in a spatially explicit manner, while yet remaining sufficiently connected to real-world phenomena and social science theory. This implies that the gap has to be bridged between, on the one hand, the great modeling power (but weak validity) of present-day computer science and, on the other hand, the theoretically sound, quantitative models from social sciences such as micro-economics and social psychology that are as yet not spatially explicit and do not contain the many types of actors interacting in actual land use changes.

Region

The region of focus will be the Sierra Madre in the Philippines, characterized by a high diversity in land use types and processes of change. The project will use an "available" multi-agent modeling platform, adapt this so that it comes closer to social-scientific theory of agency and inter-agent connectivity, and validate the model through field work. The modelled structure of the environment will be put to work in a number of small areas of 1 to 25 square kilometres.

Agents

The agents are the Farmers and loggers, the direct ('proximate') actors in tropical land use change. Focusing on these actors only, however, does not give insight in the crucial role of numerous other actors that co-determine what farmers and loggers do, such as government agencies, traders, landlords etc. that are causally linked to each other and to a next ('tertiary') layer of actors that may in fact be even more responsible for what in fact happens in the forest lands, such as the legislature, manufacturers or consumers of forest land products.

Based on previous research in the area (e.g. Van den Top 1998), candidates for primary and secondary actors are, for instance, maize traders, logging crews, Agta hunter-gatherers, furniture industrialists, the ministry of the environment and forest (DENR), the ministry of agriculture (DA), local and supra-local politicians. All in all, then, there will be a maximum of approximately 16 agents connected to each pixel, part of which will represent generalized actor categories.

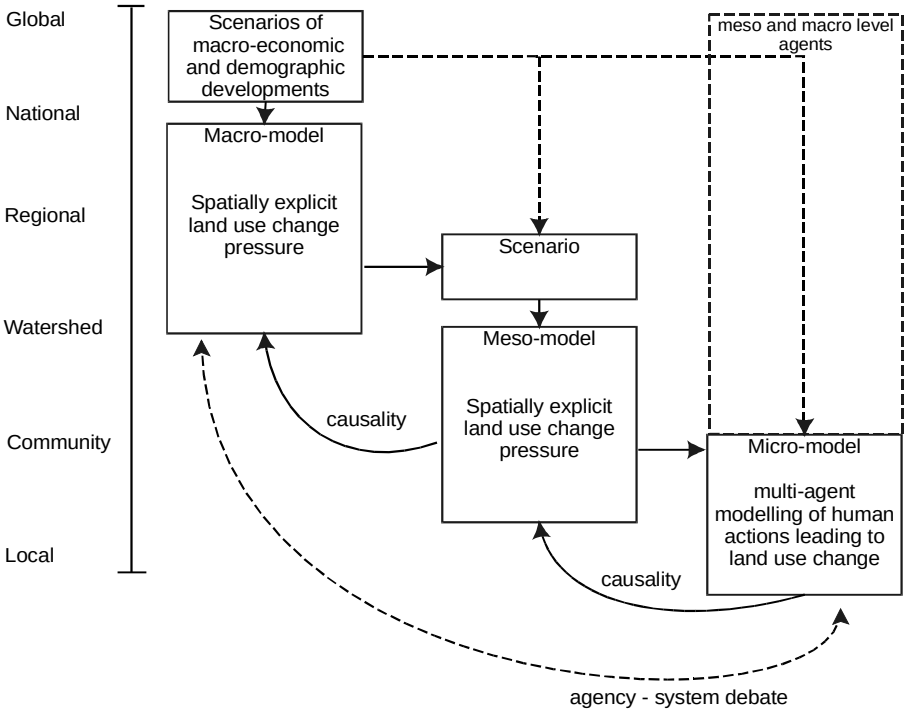
The most pertinent type of interaction between agents in the model will follow the principle of the 'actors field' in the Action-in-Context framework. This type of connection is that the options, outcome or weights on criteria (hence the choices) of the proximate agents (in this case, the farmers) are influenced by the choices of secondary agents, e.g. the DENR field officials who may choose to fine small-scale logging activities and confiscate their illegal logs, or traders who may decide to accept a promise to plant maize as a collateral for credit. Next are the tertiary agents such as the local politicians who influence the DENR field

officials and so on; such an actors field may include agents up to the national and international level. Thus, the land use actions of the farmers become actions-in-context. Besides these 'vertical' interconnections that express the lines of power surrounding local land use, there exists a class of 'horizontal' interconnections between agents of largely the same level (primary, secondary etc.). Farmer agents, for instance, may learn from each other, imitate each other or coordinate actions. This is the type of interconnections that gets most attention in the majority of current multi-agent models, that are usually interested in game theory or the emergence of collective action. The model of the present project will put the 'vertical' interconnections first, however, for reasons of scientific innovation but also of empirical relevance. It is felt that the power field surrounding the land use choices is more salient in the actual land use decisions. They are also more policy relevant, for obvious reasons.

The research program

Being embedded in the program (http://gissrv.iend.wau.nl/~clue/philippines/intro.htm) as a whole is of great value to this project, and in return the project adds to the program as a whole. One aspect of this concerns the upscaling steps of the model; The project will receive important information from the meso and macro-scale projects (CLUE) 'downward' in terms of the various driving factors that are important for the options and/or motivations (hence the choices) of actors in the multi-agent model. Examples of this are shifts in demand and prices, shifts in logging policies, the construction of rural roads, tenure policies that change the motivation of actors to invest in the land they work, etc.; the information may represent actual or predicted developments, or policy scenarios. From the project 'upward' into the meso and macro-scale projects, the causal structure of the model (both the way the agents are modelled and the way they are interconnected) will support the quality of the causal structures as that are modelled at the meso and macro scales, for instance in the regression analyses. The same bottom-up interaction concerns the possibility to assess the causal status of statistical relationships found at these scales.

Being actor-oriented throughout, the 'micro-project' is truly micro in that it conceptualizes the world as an assembly of actors, but not truly micro in terms of spatial scale, because some of its actors are 'macro-actors'. The programme thus yields a fairly unique opportunity to compare the 'system' and the 'actors' conceptualisations of the world at work on the same scale connected to the same problem. The figure below, representing the program and the multi-agent project embedded in it, shows the most important of these interactions.


Global
National
Regional
Watershed
Community
Local
Scenarios of macro-economic and demographic developments
meso and macro level agents
Macro-model
Spatially explicit land use change pressure
Scenario
Meso-model
Spatially explicit land use change pressure
causality
Micro-model
multi-agent modelling of human actions leading to land use change
causality
agency - system debate