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Participatory agent-based modeling and simulation of rice production and labor migrations in Northeast Thailand

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ABSTRACT

Rainfed lowland rice production in lower Northeast Thailand is a complex and adaptive farming activity. Complexity arises from interconnections between multiple and intertwined processes, affected by harsh climatic and soil conditions, cropping practices and labor migrations. Having faced a spatially heterogeneous and dynamic environment for centuries, local rice farmers are very adaptive and are used to adjusting their behavior in unpredictable climatic and economic conditions. Better understanding is needed to manage the key interactions between labor, land and water use for rice production, especially when major investments in new water infrastructure are now being considered.

Based on the principles of the iterative and evolving Companion Modeling (ComMod) approach, indigenous and academic knowledge was integrated in an Agent-Based Model (ABM) co-designed with farmers engaged in different types of farming practices over a period of three years to create a shared representation of the complex and adaptive social–agroecological system in Ban Mak Mai village, in the south of Ubon Ratchathani province.

The ABM consists of three interacting modules: Water (hydro-climatic processes), Rice, and Household. "Household" is a rule-based agent; it makes daily decisions based on its available means of production, taking into account the stage of the rice crop, and water and labor availability. Key decisions made are related to: i) rice nursery establishment, ii) rice transplanting, iii) rice harvesting, and iv) migration of household members. The spatially explicit model interface represents a virtual rainfed lowland rice environment as an archetypical toposequence made of upper to lower paddies in a mini-catchment farmed by 4 different households, and also includes water bodies and human settlements. Thanks to intensive communication, the participating farmers, made sure that the ABM adequately represents their rice farming and labor migration management practices. They found the model useful to deepen their understanding of the interrelations between labor migrations and rice production, which helped to strengthen their adaptive management ability.

1. Introduction

85% of the 5.2 million ha of rice land in Northeast Thailand are under rainfed conditions with a single crop per year and low agricultural productivity (average paddy yield is 1.8 t ha^{-1}). This is mainly the result of the combined effects of low water-holding, infertile coarse-textured soils and erratic rainfall distribution (Jintrawet, 1995; Somrith, 1997). Notwithstanding, 25% of the households living in this most populated region of the kingdom are still engaged in the rainfed lowland rice (RLR) production (OAE, 2005). Cash incomes generated from RLR production are inadequate to meet their basic needs, leading to a relatively high rate of poverty in this region. Therefore, to improve their livelihoods, the resource-poor rice farmers have long been migrating to urban areas, which caused labor scarcity at the household and community levels during the peak labor demand periods of transplantation and harvest.

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More than a third of all interregional migrations in Thailand – involving more than 2 million rural people – still originates from this region (Santiphop, 2000). Two main types of labor migration can be distinguished: seasonal and 'more-permanent'. Seasonal migrants leave the farm after the completion of the RLR harvest to look for off-farm employment during the long December to May dry season. In general, seasonal migrants come back from urban areas to the village to participate in RLR transplanting (mainly in July–August) and harvest (in November–early December). In contrast, the permanent migrants no longer participate in RLR farming activities but send remittances to the household members in the village to be partly used for hiring farm labor as needed. These migrants are usually young male and female adults. This situation can lead to a relative scarcity of farm labor during the RLR crop cycle and is the source of other social problems.

Several state policies have been implemented to improve farmers' livelihoods by making more water available, but they have had limited success. Presently, ambitious new plans to provide more water for farming in this region are being drawn. In early 2008, the Thai government decided to spend US$ 22 million for the construction of hundreds of new small on-farm reservoirs, and US$ 59 million for other irrigation projects. One very ambitious scheme proposes a US$ 15 billion investment in the construction of a future "hydro-shield tunnel" to divert water from the Mekong River to supply 19 provinces in the Northeastern region (Bangkok Business News, 2008; Matichon, 2008). But, as in the past, the success of water improvement schemes could be limited if they are not based on an in-depth understanding of the interactions between water use, rice production practices, and migration. The co-design with stakeholders of a shared representation of these interactions is a pre-requisite. This was the objective of the collaborative modeling process reported in this article.

RLR farming in lower northeast Thailand is a complex and adaptive system (CAS). Complexity arises from the interconnections between multiple and intertwined processes, modified by unpredictable climatic conditions, rice production practices and labor migration. Having faced a heterogeneous and very variable environment for centuries, local rice farmers have become very adaptive in their farming behavior. Agent-Based Modeling and simulation is becoming more widely used to represent, simulate, and analyze the dynamics of such CASs. Agent-Based Models (ABMs) explicitly represent human decision-making processes by means of agents presented as autonomous computer entities interacting directly among themselves and with their common environment, in order to achieve their goals (Ferber, 1999; Valbuena et al., 2008). An agent has certain knowledge about the system in which it is situated and operates (but it is not omniscient). By nature, an ABM provides a real system representation that is less abstract than a mathematical model. Therefore, it is a tool that can promote discussion and further exploration among researchers and model developers, as well as with subject matter specialists, policy-makers and local stakeholders (O'Sullivan, 2008). The Companion Modeling (ComMod) approach has been designed as an iterative, continuous, evolving method to facilitate dialogue, shared learning and collective decision making through interdisciplinary and action research processes, and to strengthen the adaptive management capacity of stakeholders facing a common resource management problem (Bousquet and Trébuil, 2005).

Local stakeholders are usually involved in ComMod through role-playing games (RPG) that support the whole process. When an ABM is combined with a RPG, most of the time the computer model is simply a computerized version of the RPG, with the same high degree of simplification. The similarity between the two tools enables the local stakeholders to feel comfortable with the computer model and to easily follow the simulations (Barreteau, 2003). In this study, RPG sessions were used to support the co-designing process with local farmers of an elaborated ABM which, by the end of the process, reifies a shared representation of their socio-ecosystem.

Past studies have examined labor migration as a result of economic drivers, often at the macro level, such as push and pull factors in the neoclassical economic theory (Chamratrithirong et al., 1995; Chantavanich and Risser, 2000; Matsumura et al., 2003; Paris, 2003). Some studies (Fuller et al., 1985; De Jong, 1997) have focused on the migration decision-making process as a result of the interaction between individual or micro-factors (often referred to demographic and social characteristics) or macro factors ranging from household to community levels (often referred to economic-related factors). But few studies have examined the relationship between renewable natural resource use and labor migration (Santiphop, 2000; Rattanawarang and Punpuing, 2003). Even fewer have used an ABM to assess changes in technologies and land use in relation to labor migration (Loibl et al., 2002; Laine and Busemeyer, 2004). Recent studies of RLR systems and RLR crop modeling carried out in this region took rainfall variability and the risk of drought into account. But none of them integrated the key interaction between rainfall distribution and farmers' decisions regarding RLR crop management, particularly in cases where the areas under study heavily depend on manpower (Boonjung, 2000; Boling et al., 2008). Furthermore, there has been no effective methodological process to facilitate local RLR farmers in developing a shared representation of their resource management as influenced by interactions between land/water use and migration. Therefore, the purpose of this research is to build a shared representation of the interactions between RLR farming, water availability, and labor migration by integrating indigenous and academic knowledge through a collaborative construction of an ABM with local RLR farmers. In this experiment, such a shared representation is presented by a family of models that was used to facilitate knowledge-exchange and knowledge discovery through the participatory simulation exercises. We also aim to stimulate the participants' thinking and co-learning through the collective exploration of scenarios of varying water and labor availability, with the ultimate goal of further strengthening their adaptive management ability throughout this very interactive participatory modeling and simulation process.

First, the collaborative modeling process of ABM co-construction is presented to illustrate its evolutionary path and degree of stakeholder involvement. The resultant structure and behavior of the ABM is described. The field-based scenarios and their participatory analysis are then introduced, and the salient points of the simulation results, as discussed with the stakeholders, are presented. The analytical elements derived from the laboratory-based simulation and analysis are also presented.

2. A collaborative modeling process

The study area is located in the Lam Dome Yai watershed, south of Ubon Ratchathani province. It covers 1680 km^2 in the district of Det Udom and Na Chaluay's northern region, with 80% of the land used for RLR (Naivinit, 2005). Within that area, the Ban Mak Mai village was selected, as a typical regional RLR-based farming system with a diversity of farming households. Within the village, 11 farming households ranging from small farms (average size of 3.2 ha), to larger holdings (average size of 7.2 ha), were carefully recruited to take into account the diversity of farming conditions among the households, which have different amounts of productive assets, and socio-economic RLR production and labor employment strategies (Naivinit et al., 2008). The husbands and wives from each selected household were invited to participate in modeling field workshops held in the village. Farmers of the same