Use Participatory Modeling to Validate and Build Multi-Agent System Model regarding Rainfed Lowland Rice and Labour Management in Lower Northeast Thailand

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Abstract

The Lam Dome Yai watershed is a drought-prone area dominated by the rainfed lowland rice (RLR) ecosystem. It is also a homeland of the poor and the only recourse for better livelihood is to migrate to cities. Poverty and labour migration are a result of the interaction between agro-ecological constraints such as erratic rainfall distribution, lack of irrigation and poor soil quality, and socioeconomic dimensions such as economic disparity. In this research, decision-making process of stakeholders regarding farm and labour management is a key to better understand such interaction. A participatory modeling approach like Companion Modeling (ComMod) can be used to understand stakehoders' decision-making process and acquire the mutual recognition of different points of view on a given problem to build a comprehensive knowledge. It is very important to take this knowledge into account for successful investments when the sustainable livelihood of this local community is targeted. In this experiment, we aim at modeling the interaction between land/water use and labour management on different types of RLR farms. The results of three successive participatory modeling workshops using combined-tool, Role-Playing Game (RPG) and Multi-Agent Systems (MAS) model, are presented. The results indicate that the diversity of farms plays an important role to alleviate the labour scarcity. An improvement of water availability is likely to affect only small holders in terms of more farm intensification and fewer migrants. The perception of water availability in farmponds and the use of water are different based on rainfall situation and farmer's means of production. However, a similar rice-growing practice emerged as a collective agreement among players when a community pond was introduced into the RPG.

KEY WORDS: Participatory modeling, Companion Modeling (ComMod), farm and labour management

Introduction

The Lam Dome Yai watershed located south of Ubon Ratchathani Province is a typical drought-prone area dominated by the rainfed lowland rice (RLR) ecosystem. The adverse climate and poor soils lead to low rice yields, low incomes, and a high rate of poverty. The only recourse for a better livelihood is to migrate to cities and search for more profitable employment. The availability of labour and water determine the on-farm and off-farm management. Water availability depends on the erratic rainfall distribution and the accessibility to water infrastructure while the labour availability fluctuates depending on migrations. The Royal Thai Government has attempted to improve farm intensification through the construction of water storage facilities without prior understanding of household's labour management. Consequently, their impact remains limited. The comprehensive knowledge of the diverse stakeholders' decision-making processes is very important to take into account for successful investment in water infrastructures. In this experiment, we use a participatory approach, Companion

Modeling (ComMod), to build a family of models of the interaction between land/water use and labour management on different types of RLR farms. This paper presents the evolving process of three successive participatory modeling workshops with regard to

- The evolutionary Role-Playing Game (RPG) to fulfil new research questions and requests by concerned stakeholders,
- The importance of the diversity of farm types and their interactions to understand the land/water use and labour management interaction,
- The Multi-Agent Systems (MAS) model is enriched by applying the results of three successive participatory modeling workshops.

Materials and methods

The Companion Modeling (ComMod) approach emphasizes better understanding interactions between ecological and socioeconomic dynamics through the iterative process between field circumstances and computer-based model implementation. It aims to develop a series of models that integrates stakeholders' representations and knowledge by encouraging stakeholders' participation throughout the process (Bousquet *et al.*, 2005). The creation of an non-threaten environment is conducive to participatory approaches which seek to bridge the divide between local and scientific knowledge (Neef, 2005). This is a key action of ComMod that facilitates friendly communication and disclose decision-making processes of stakeholders.

A distinguish character of ComMod is its iterative and evolving process to develop a family of model with concerned stakeholders. The principal combined tools, RPG and MAS models are also evolved through this process. Figure 1 shows the logic evolutionary process of the Lam Dome Yai Model (LdyModel). At the initial stage, the LdyModel was transformed from a conceptual model in Unified Modeling Language (UML) diagrams (Naivinit, 2005). It has been being evolved by integrating diverse points of view of concerned stakeholders through the series of participatory modeling.

The 1st participatory modeling was organized on 9-10 July 2005. The purpose was to have stakeholders validate the knowledge of researcher that was synthesized from the theoretical review and field surveys. A principle tool, Role-Playing Game (RPG), was designed based on an initial conceptual model in Unified Modeling Language (UML) diagrams. During the plenary session among players and research team in this workshop, the players purposed to have another workshop with new type of players who are migrants returning home during the Thai New Year in 2006. A new question was raised regarding water infrastructure, and its impact on labour migration because the government plans to invest about 31 billion Baht to develop Moon river basins (Phanayanggoor, 2005). We assumed that the water infrastructure would promote farmers to intensify their farm production and at the same time decrease a number of migrants. To prove our hypotheses and fulfil the request of stakeholders, the 2nd participatory modeling workshop was carried out on 20-21 April 2006.

The main tool for the 2nd participatory workshop was still the RPG with new objectives based on participants' request and hypotheses conceived from the 1st participatory workshop. The objectives were i) to validate the existing knowledge with new players (returned migrants) ii) to introduce water improvement feature (irrigated canal) to the players and observe their reactions and iii) to enable the players to relate the rules and features experiencing in RPG to MAS simulation. During the individual interviews at the end of this workshop, players asked to change the irrigated canal to farmponds and artesian wells.

A hydro-dynamic module was first developed and integrated into an agent-based model to simulate the availability of water in paddy fields and ponds related to daily rainfall patterns (Lacombe *et al.*, 2005). To face the challenge of introducing this scientific-based module and to be able to discuss the outputs of computer simulation runs directly with the farmers, we felt that building with the farmers a shared understanding of water levels dynamics was a needed intermediate stage. Therefore, 3rd participatory modeling workshop was organized to specifically address the issue of farmers' perceptions of water availability on 10-11 October 2006. Using RPG to investigate such perceptions would be useful i) to validate the water level in the LdyModel, ii) to investigate the impact

of dynamic of water availability in farmponds and artesian wells on players' decisions with relation to agricultural practices and migratory patterns, iii) to provide more insightful regarding the limitation of farmpond caused by the constraints of erratic rainfall distribution, and labour shortage caused by economic disparity.

Logic evolving process of Lam Dome Yai Model (LdyModel)

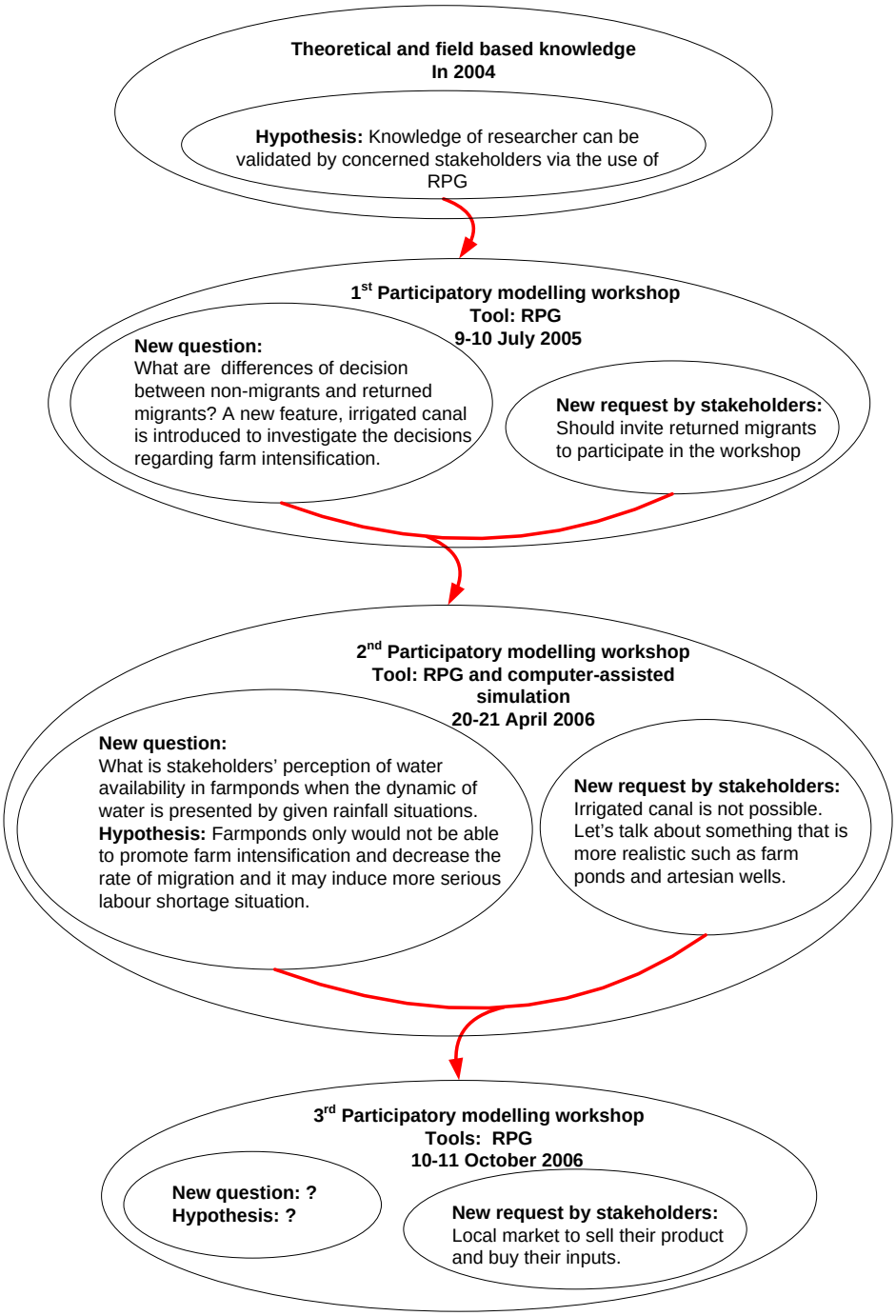

Figure 1: Evolutionary process of Lam Dome Yai Model

Results

The importance of the diversity of farm types and their interactions

The farm types were typified based on different means of productions and objectives of living. Different farm types cope with different cropping calendars in the village play a major role in alleviating labour shortage at high labour demand period when rice is harvested. Since wage is considered a major source of revenue for the farm type A (small holders), it plays a role of labour supplier while other farm types are employers (see appendix for definition of farm types). The result shows that the decision regarding labour migration was a collective agreement among family members. The new players, returned migrants, did not participate in the 1st RPG but their decisions to manage their household labour regarding on-farm and off-farm employment was not different from the participants of the 1st RPG. For irrigation scenario, an irrigated canal was introduced and we presumed that the water was always available for the players. The result shows that the farm type A (small holders) was more adaptive in terms of taking advantage of this water accessibility while it had little impact on other farm types. Farmer type A grew more cash crops in dry season and there were fewer migrants. In last scenario of the 3rd participatory modeling workshop, when severe drought and a community pond were simulated, the planted area in dry season of farm type A was almost 9 percent of the total area of farm type A while there was about 4 percent for the farm type B (medium holders) and the farm type C (large holder) was zero (Figure 2). This is because the farm type B and C who normally relied on hired labour cloud not plant dry-season crops because small holders who were the main source of labour supply were not available. This indicates that the improvement of water infrastructure only would not help all farmers to intensify their farm production because it can induce the labour scarcity which is also important to determine the capability of agricultural production of these farmers.

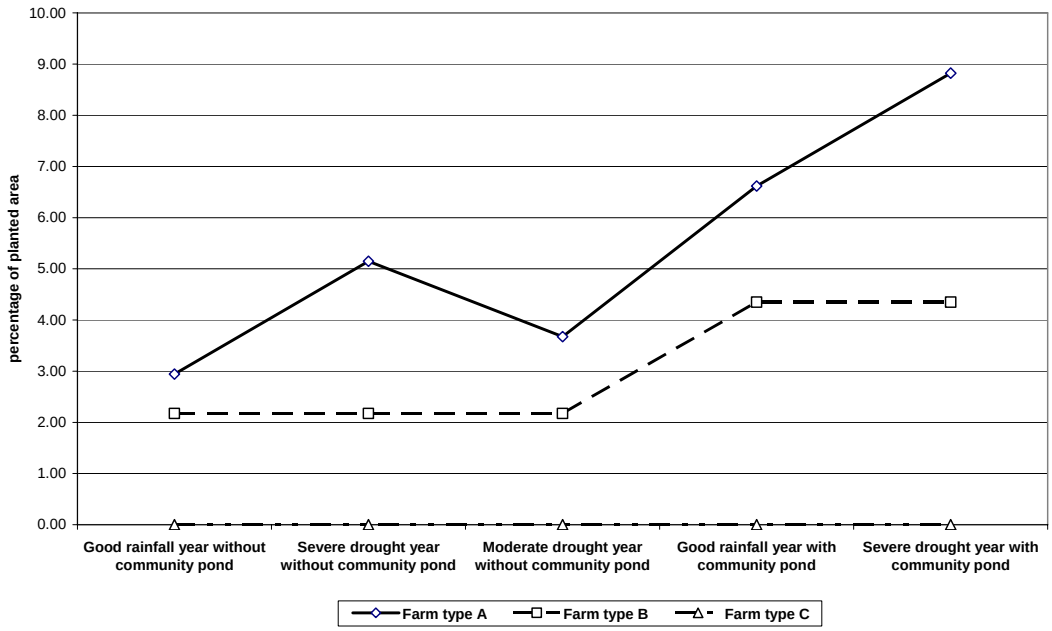

Figure 2: The impact of water availability on farm intensification indicated by percentage of planted area in dry season compared to the total area of each farm types.

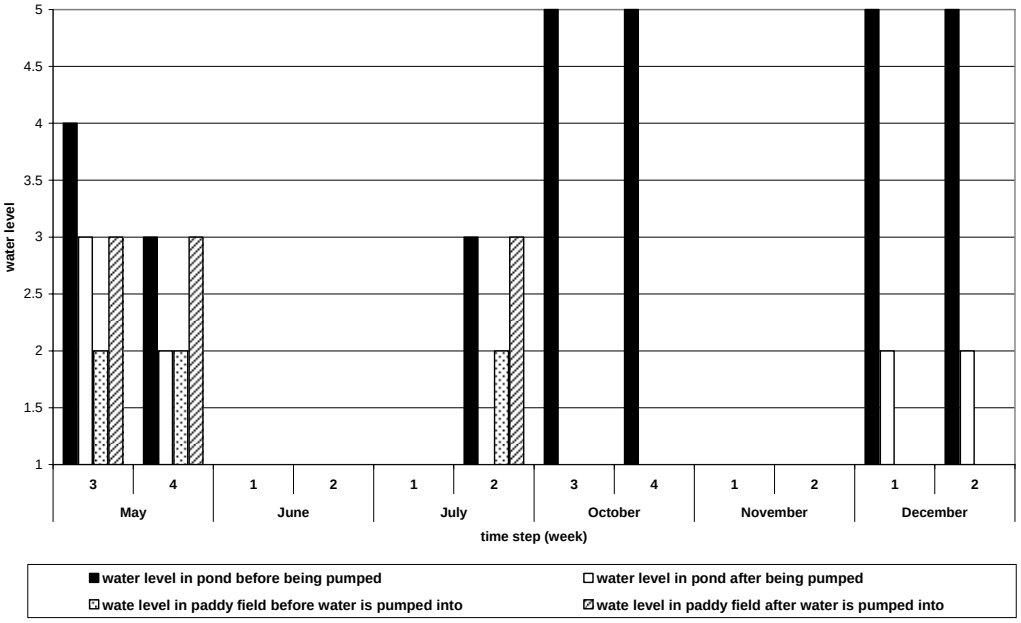

Figure 3: Perception of water level in the community pond and paddy field during a severe drought year.

For the perception of water availability (in this experiment, we called water level), the qualitative definition of water level was used to make it easy for the players to understand (see appendix for definition of water level given in the RPG session). There were several patterns based on players' experience when the individual farmpond scenario was played. It is difficult to use these patterns to validate the hydrological processes with regard to water availability in our MAS simulation. However, when a community pond scenario was played, the water level of the community pond was collectively discussed. The collective perception of water availability in both the community pond and in paddy field of this scenario was defined as a unique pattern (Figure 3). It can be later interpreted to quantitative values e.g. centimeters of water level to validate hydrological processes regarding water availability of the MAS model.

Furthermore, a new rice-growing calendar was emerged as a collective agreement based on when water in the community pond was used. It shows that all players practiced similar rice-growing calendar. During plenary discussion, some players realized that the labour shortage would be a negative consequence of this new emergent rice-growing practice because all farmers would need to hire labour almost the same time. However, some player said that it would be possible to recover the mutual help schema among relatives if the labour shortage is critical. They also mentioned the water availability of the community pond would not be sufficient if successive drought occurred.

Playing real life with Role-Playing Game (RPG)

The RPG mainly helps the stakeholders to understand the rules and sequence of MAS simulation while the MAS model "playing the game" helps the stakeholders to better understand self-situation and examined causes of actions of other players. Without the RPG, it is not possible for stakeholders to understand the MAS simulations. Furthermore, all players agreed that the game represented their current situation regarding land/water use and labour migration. For 3rd participatory modeling workshop, by the end of the RPG session, farmers acknowledged that it was easy for them to relate to the reality, mainly because of the delivery of weekly rainfall information. We observed some players who refused to be hired because when discussing with other players, the proposed wage was too low (120 baths/day during harvesting period, whereas they wanted 150 baths/day). This happened although there was no use of fake money, which tends to demonstrate that they really referred to their real live when playing the game. The follow-up step of the study will be the development of computer simulations based on the results from RPGs. Since local farmers have experienced as participants of "players-based simulations" in the RPG sessions, they are then expected to be comfortable in

following and discussing computer simulations as they will be able to relate the "agent-based simulations" with the their experiences.

Conclusions

Diversity of farm types is important to mitigate labour shortage problem when rice is transplanted and harvested because of the difference of rice-growing calendar. The water improvement such as a community pond can be well managed by these farmers, helps to alleviate climatic risk, and provides more flexible to rice-growing practices. However, since an aim of local farmers is to sell rice as soon as possible for higher price at early rice-market, better water accessibility could also induce similar rice-cropping calendar to all farmers and raise more competitive labour demand. Moreover, only small holders trend to use this kind of water improvement for crop production in dry season. The result also indicates that RPG can be used to acquire new knowledge to enrich the initial conceptual model and have real resource users validate it. This conceptual model is a fundamental synthetic knowledge to build the MAS model. Furthermore, RPG can be used, at intermediate stage, to prepare stakeholders for discussing computer simulations in the next participatory simulation workshop.

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Appendix

Definition of farm types

- Farm type A is poor (average annual household income is 1,300 US dollars) and has small land with average at 3.2 ha. It is a rice-based, self-subsistence oriented farm whose objective is to satisfy family needs (family food security) and receive regular income through selling surplus rice and full employment of family labourers.
- Farm type B is a medium-sized holder with average size of land at 6.4 ha, rice-based with more diversified farms whose objective is to increase land productivity through the farm diversification. Labour shortage is a key constraint for farm production. The average annual household income is 2,500 US dollars.

- Farm type C is characterized as a medium to large holder with average size of land at 7.2 ha. The diversification of farm production and/or repeated labour migration is an important strategic use of means of production. The objective is to increase labour productivity through diversification out of rice e.g. fish and livestock production and/or receive remittance from migrants.

Definitions of water level

- Water level of pond
  - Level 1: There is no water
  - Level 2: Water availability is adequate for livestock rearing
  - Level 3: Water availability is sufficient to be pumped for establishing rice-seedling nursery beds.
  - Level 4: Water availability is sufficient to be pumped for establishing rice-seedling nursery beds and some parts of transplanting area.
  - Level 5: Water availability is good for all above including vegetables.
- Water level of paddy field
  - Level 1: There is no water
  - Level 2: The soil is wet.
  - Level 3: Water availability is sufficient to establish rice-seedling nursery beds.
  - Level 4: Water availability is too high for establishing rice-seedling nursery beds.
  - Level 5: There is flooding.