# Gaming and simulation to mitigate land use conflict between herders and foresters in northern Thailand highlands[1]

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**Abstract**

In the remote highland forest-farmland ecosystem of Doi Tiew, a Hmong village in Tha Wang Pha District of Nan province, Northern Thailand a land use conflict is taking place between the local herders and two government agencies (Nanthaburi National Park and the Nam Khang headwater research and development unit) having different interests, objectives and perceptions on land use and land management. In this research we are using the integrative companion modeling approach (http://www.commod.org) to co-construct a simulation tool representing the dynamic interactions between vegetation dynamics, reforestation efforts, and livestock grazing at the study site. This paper focus on the participatory modeling process implemented with concerned stakeholders. Three main investigation tools were used to gather knowledge on the relevant ecological and human decision making processes: field surveys (history of land use and analysis of vegetation dynamics at landscape level), farmers' interviews (analysis of decision making and determining factors across different types of farms), institutional analysis (changes in land use policy and related state interventions). This knowledge was first assembled in simple gaming exercises used with local herders and foresters to validate the researchers' understanding of key interactions regulating vegetation and land use dynamics. The outputs of these collaborative modeling activities were used to design the suitable features and rules of a role-playing game representing the complex human and ecological interactions at the landscape level. This game allowed stakeholders to criticize and improve this comprehensive formalization of the landscape dynamics. It was also used to introduce gaming and simulation exercises and to stimulate stakeholders to identify possible future land management scenarios mitigating the current conflict. The results from two gaming and simulation field workshops allowed local stakeholders to set up of co-management action plan collectively. Moreover, it proved that the gaming and simulation could facilitate the communication and shared learning among conflicting parties. Regarding the next steps, an agent-based model under the CORMAS simulation platform to facilitate the exploration of future scenarios in a time efficient way.

**Key words:** Forest conservation, Cattle raising, Land use change, Companion modelling, Agent-based model, Role-playing game, North Thailand.

## 1. Introduction

During the past four decades, the expansion of farm land in forest areas of montane Southeast Asia accompanied the commercialisation of upland and highland agriculture (Trébuil *et al*. 2006). For political and economic reasons, this agrarian transformation started earlier in Thailand but is also occurring in neighbouring countries. Deforestation occurred at a rapid pace in the 70s and continued at a more moderate rhythm during the following two decades. The interdependent major driving factors and related causes of this sharp decrease of forest cover were the promotion of logging concessions, counter insurgency measures like the construction of feeding roads bringing new settlers, especially from the lowlands, and facilitating the expansion of farm land and market integration of farms leading to a jump in the production of rainfed field cash crops such as maize,

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soybean, cassava and sugarcane (Delang 2002, Trébuil *et al*. 2000). The country farm land area jumped from 17.9 to 21.3 million hectares between 1975 and 1991 (OAE, 2000) and remained relatively stable afterwards, while the forest cover decreased from 20.9 to 13.6 million ha (Royal Forest Department, 2009) during the same period. In the words of Sato (2000), this peasant colonization process, in which many lowlanders took part, led millions of rural households to make a living on 'ambiguous lands' which are lands 'legally owned by the state but... used and cultivated by local people' especially along the forest - farm land interface.

The social context changed in the late 80s and early 90s with the rise of strong environmentalist protests supported by a booming middleclass, partly triggered by a major deadly landslide in the southern region, claimed to be a result of deforestation that ushered a nationwide government logging ban in 1989 (Delang 2002, 2005). During the previous decades, the Royal Thai Government (RTG) policies regarding forest management have been enforced through top-down policies implemented by the Royal Forest Department (RFD) created more than a century ago. Following decades of management of forest exploitation and logging activities, a new focus on forest conservation was declared during the last two decades in an attempt to reverse the trend of deforestation and forest degradation and to cope with new international conventions and global environmental concerns linked to biodiversity, climate change and carbon sequestration, etc. During this period, the transformation of various types of swiddening systems practiced by diverse ethnic highlanders toward more permanent and market-oriented agricultural production systems continued, with annual and low input cash crops being partly replaced by a range of perennial crops such as fruit orchards, tea gardens, rubber plantations, etc. (Kaosa-ard, 2000; Lakanavichian, 2001, Trébuil *et al.* 2006). Nevertheless, more intensive state control of forests led to a sharp increase in the number of "reserved forest areas" established by the RFD. The total area covered by national parks, forest parks and wildlife sanctuaries increased from 5.9 to 8.9 million ha during 1990-2004 and more have still to be officially declared (Royal Forest Department, 2009). But a large proportion of these "forest reserves" were already under cultivation and the way these conservation areas were created led to land use conflicts between the local farming communities and the representatives of the government agencies in charge of their delimitation and management. The two sides had very different objectives regarding land and forest use and contrasted perceptions about the impact of these forest conservation areas on local people livelihoods, while most of the time no mechanism was established to discuss them (Hares, 2009; Roth, 2008; Sato, 2000).

With the establishment of the Tambon (sub-district) Administration Organization (TAO) system in 1994, the RTG has launched a process of decentralization of the management of local resources and improvement of local people rights. For example, a community forest bill was recently passed after many years of debate. This new legal and institutional framework could provide an opportunity to ethnic minorities to voice their needs and truly participate in renewable resource management. This brief description of the recent evolution of land management in northern Thailand shows that the analysis of the dynamics at the agriculture – forest interface needs to be framed within the context of agrarian change as the orientation of the livelihoods of those who live in or near forests depend considerably on a rapidly changing agriculture and become more diverse (Fisher and Hirsch 2008). As an increasing number of critical issues need to be examined at the interface between the environment and society, it also describes a situation adapted to the assessment of the impact of forest conservation and reforestation measures on local agrarian systems, and to the search for adapted ways to mitigate the increasing number of local land use conflicts while facilitating the true participation of village communities in the management of local renewable resources.

This paper reports and discuss the results of a participatory modelling process implemented in the head watershed of Nan province to facilitate the mediation of a land use conflict between Hmong herders raising cattle in fallows and secondary forest areas and government agencies in charge of reforestation activities and the establishment of the new Nantaburi national park (NNP). Following a characterization of the study site, the main phases of the collaborative process and the tools used are described and the key results are presented. A discussion section draws lessons from this experiment and suggests possible methodological improvements toward a more effective use of gaming and simulation tools to facilitate the emergence of co-management of resources in similar socio-ecological systems facing land use conflicts.

## 2. Materials and methods

### *2.1. Agrarian system and stakeholder analysis*

The history of interactions between rural societies and their natural environment leads to understand the origins, causes and consequences of landscape transformations and the differentiation of livelihoods and agricultural production systems depending on their access to productive resources, regulation rules and institutional control (Mazoyer and Roudart, 1997). Interdisciplinary knowledge at the interface between socio-economic and agro-ecological dynamics is needed to interpret land use change. Key past events, forces, trends, power relations dynamics, and the respective needs of different individual or institutional stakeholders are revealed and can be used to design better ways to manage the landscape. Lambin *et al.* (2003) proposed integrated frameworks and related tools to understand the causes and relationship of driving factors of land use change: agent-based perspective relies on the individual decision making and motivations behind it, while a system perspective looks also at the organization and institutions of the society, and a narrative perspective favours depth of understanding through historical details. The agrarian system[2] diagnosis methodology combines such frameworks to produce dynamic agro-ecological zoning linked to an historical agrarian profile and the construction of typologies of local stakeholders based on their different socio-economic objectives and strategies (Trébuil and Dufumier, 1993). This methodology was used in this case study to understand the effects of forest management on farming and the origins of the current land use conflict as well as to characterize its key actors.

### *2.2. The companion modelling approach*

The outputs from this agrarian system diagnosis and stakeholder analysis were used to design an interactive and inclusive Companion Modelling (ComMod, http://www.commod.org) process to examine the land use conflict with its main actors and improve communication among them (Barnaud *et al.* 2008). During the past decade, such processes have been used by researchers and local stakeholders to co-construct shared representations of given complex issues, and to use them to explore possible solutions of their choice through collaborative simulations. The scientific posture of the ComMod researcher creates an original relation between him, the models he develops, and the field actors and circumstances. By considering him/herself as part of the system being managed, in such engaged research processes the researcher is a stakeholder among others (Bousquet and Trébuil 2005). Because most of the current problems in agrarian systems are complex, rapidly evolving, and need to be addressed in more uncertain and unpredictable environments, the main objectives of a ComMod process are (i) to better understand a complex agro-ecosystem through the collaborative construction and joint use of different types of simulation models integrating various stakeholders' points of view, and (ii) to use these models within communication platforms for collective learning to facilitate multiple stakeholders' coordination and negotiation processes leading to the definition of agreed-upon collective action plans.

The ComMod approach focuses on the management of interactions between ecological and social dynamics by relying on the Multi-Agent Systems (MAS) way of thinking. Most of the ComMod processes associate computer agent-based models (ABM) with Role-Playing Games (RPG) in various ways to facilitate the involvement of stakeholders in the co-design and use of evolving simulation tools (Ruankaew *et al.* 2010). The ComMod approach did not emerge from theoretical debates among researchers but from common problems faced in empirical research dealing with complex objects of study, but several key theoretical references of this integrative modelling approach (the science of complexity, resilience and adaptive management, multi-actor processes, constructivism, post-normal science) are presented in Trébuil (2008). In practice, a ComMod process alternates modelling in the lab. and field activities in an iterative way. Successive participatory modelling field workshops lasting 2 to 3 days are key moments of intense interactions among the participants, alternating gaming and simulation sessions and plenary debates, and completed by individual interviews at the end to better understand decisions made in the simulations and gather suggestions for the next steps. During these workshops the process facilitator's hypotheses, methods and tools are systematically made explicit, regularly questioned, critically examined, and adapted to stakeholders' needs and change in the context.

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[2] Agrarian system is defined as a historically constituted and lasting model of exploitation of the environment, a technical system adapted to the bioclimatic conditions of a given area which complies with its social conditions and needs at that moment (Mazoyer and Roudart, 1997).

### *2.3. Study site*

Doi Tiew village, a highland (900-1200 m above mean sea level) forest-farmland ecosystem located in a headwater area northwest of Tha Wang Pha District in Nan Province, was selected as it is established along the border of a recently declared national park and is also affected by government-led reforestation activities. Figure 1 shows that this Hmong farming community, who settled in this area in 1961, is presently almost surrounded by several government forest conservation agencies including several reforestation units (the Nam Khang Headwater Study Development and Conservation Unit –NKU- and Sob Sai, Nam Haen, and Nam Ngao Headwater Management Units) and the newly established NNP. In 2007, Doi Tiew had 1,307 inhabitants belonging to 170 households scattered along 2 km of the main asphalted road. The current main farming activities are upland rice production for home consumption, maize and litchi as key cash crops, and extensive cattle rearing in grasslands, fallows, and young forest plantations. But these agricultural activities, particularly cattle rearing, are increasingly constrained by the local forest management ones as NKU and NNP are increasingly limiting the extent of grazing areas available to local herders.

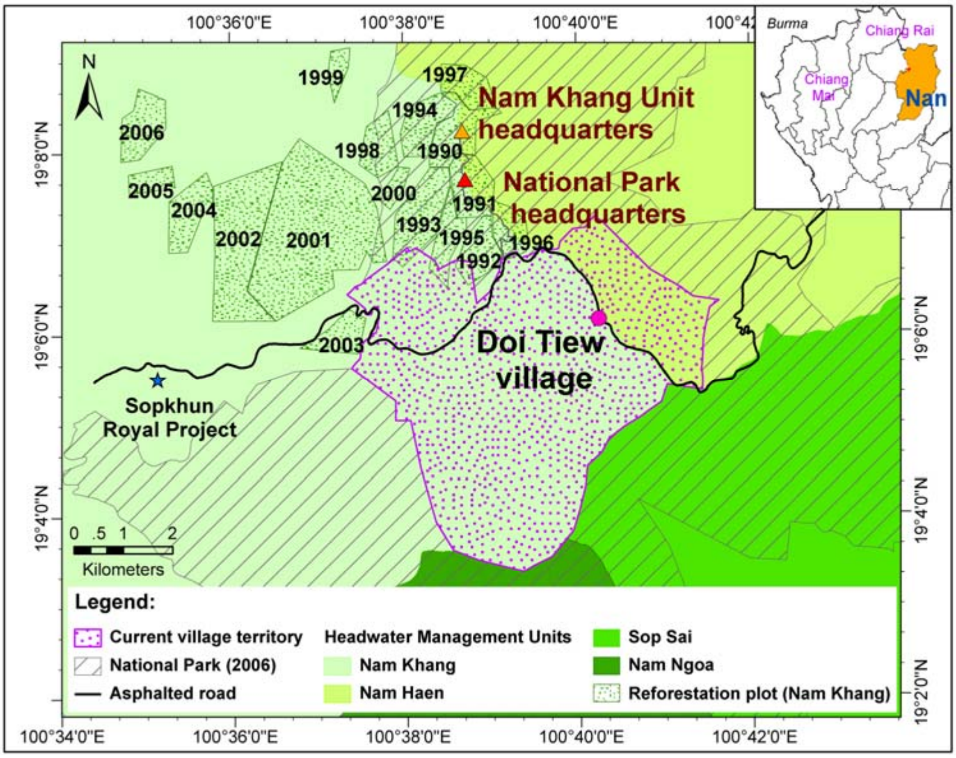



Figure 1. Doi Tiew village and of its neighbouring forest management agencies in Tha Wang Pha district, Nan Province, Northern Thailand.

### *2.4. Main sequences of the ComMod process implemented at Doi Tiew site*

Figure 2 displays the overall conceptual framework used in the implementation of the research activities. The outputs of the preliminary multi-scale agrarian system diagnosis (complementary analyses of land use change at the landscape level, socio-economic differentiation among farms at the household level, and vegetation dynamics under the influence of reforestation and cattle rearing activities at the plot level) provided knowledge for the construction of a first conceptual model of the sub-system to be managed by herders and foresters. It was improved through a series of ComMod activities based on the use of successive versions of a computer-assisted RPG (cRPG) in field workshops.

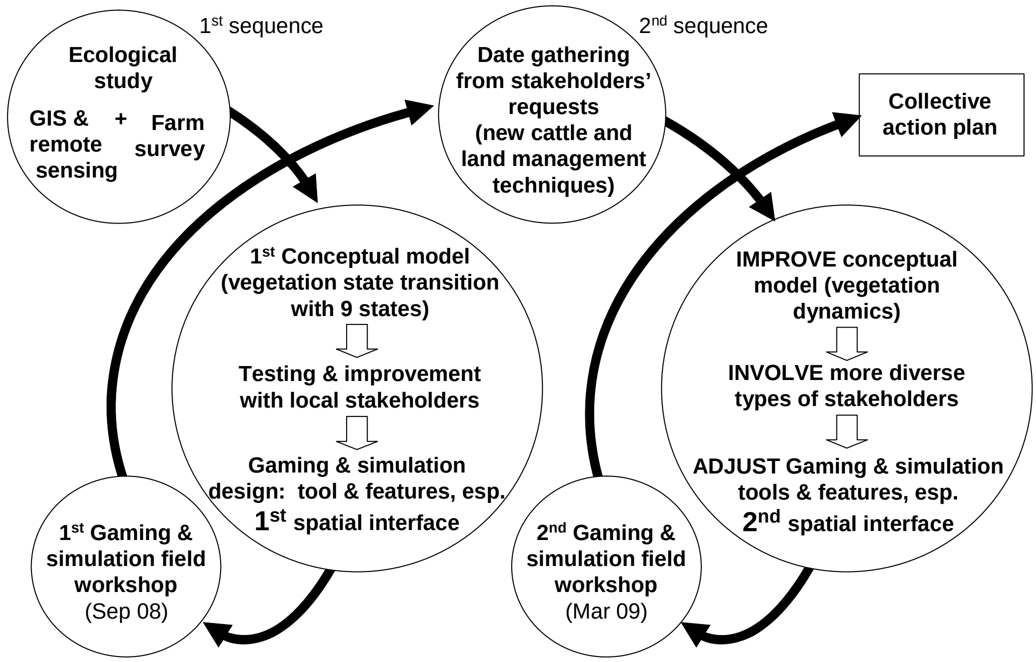



Figure 2. Successive sequences on participatory design and used of simplified landscape.

### *2.5. Two gaming and simulation field workshops using computer-assisted RPG*

Two successive field workshops were conducted using a simplified landscape as the main interface of a simulation tool called cRPG. The computer module in charge of updating vegetation states was programmed under the CORMAS simulation platform. The model description can be downloaded from the http://cormas.cirad.fr/logiciel/DT_state01.zip. Figure 3 and 4 displays the main steps of gaming and simulation sessions in the first and second field workshop, respectively, while the objectives and characteristics of these key events are described in Table 1.

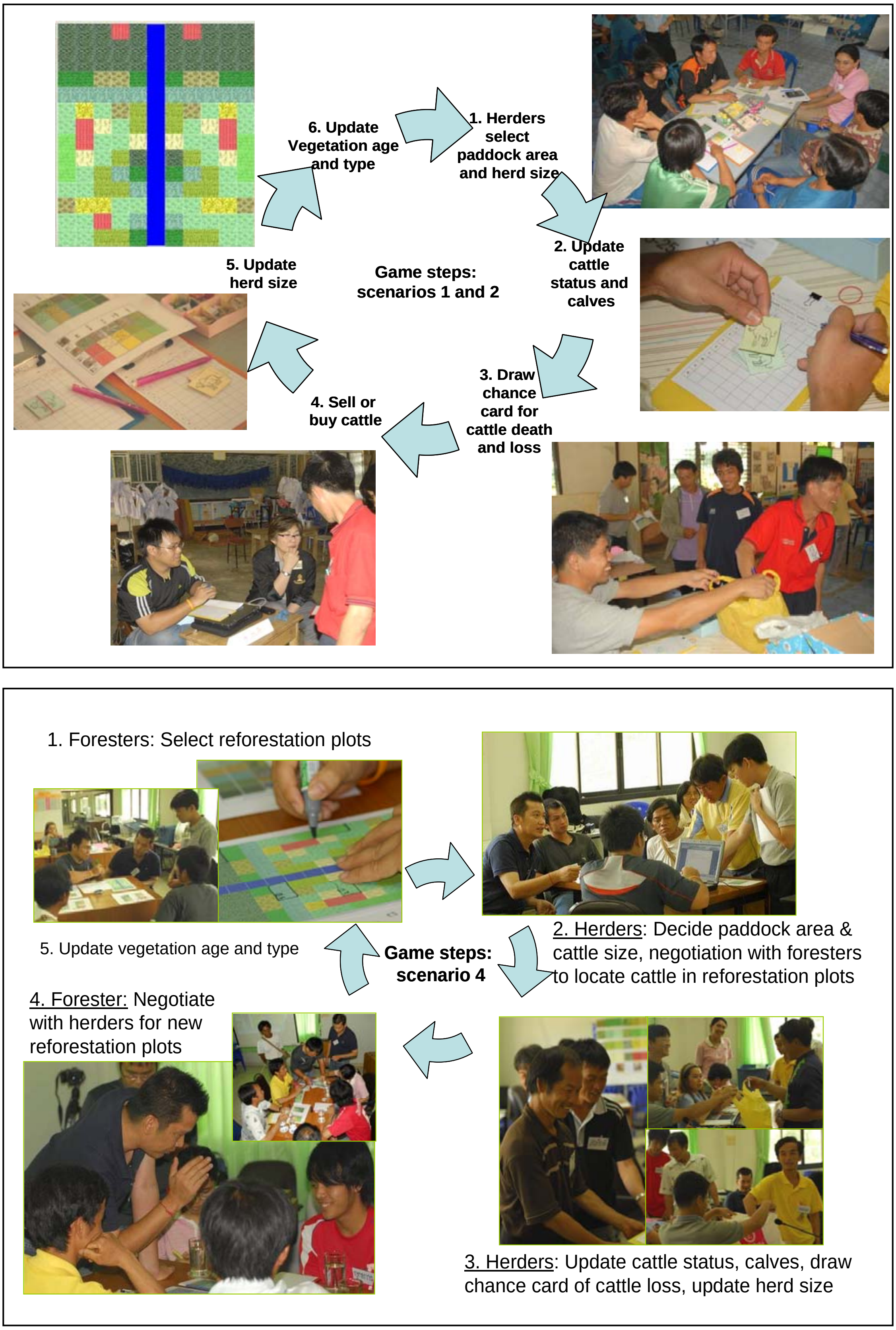



Figure 2. Main steps of a round of play for scenarios 1, 2 with herders only (top), and scenario 4 with herders and foresters (bottom) in the first gaming and simulation workshop.

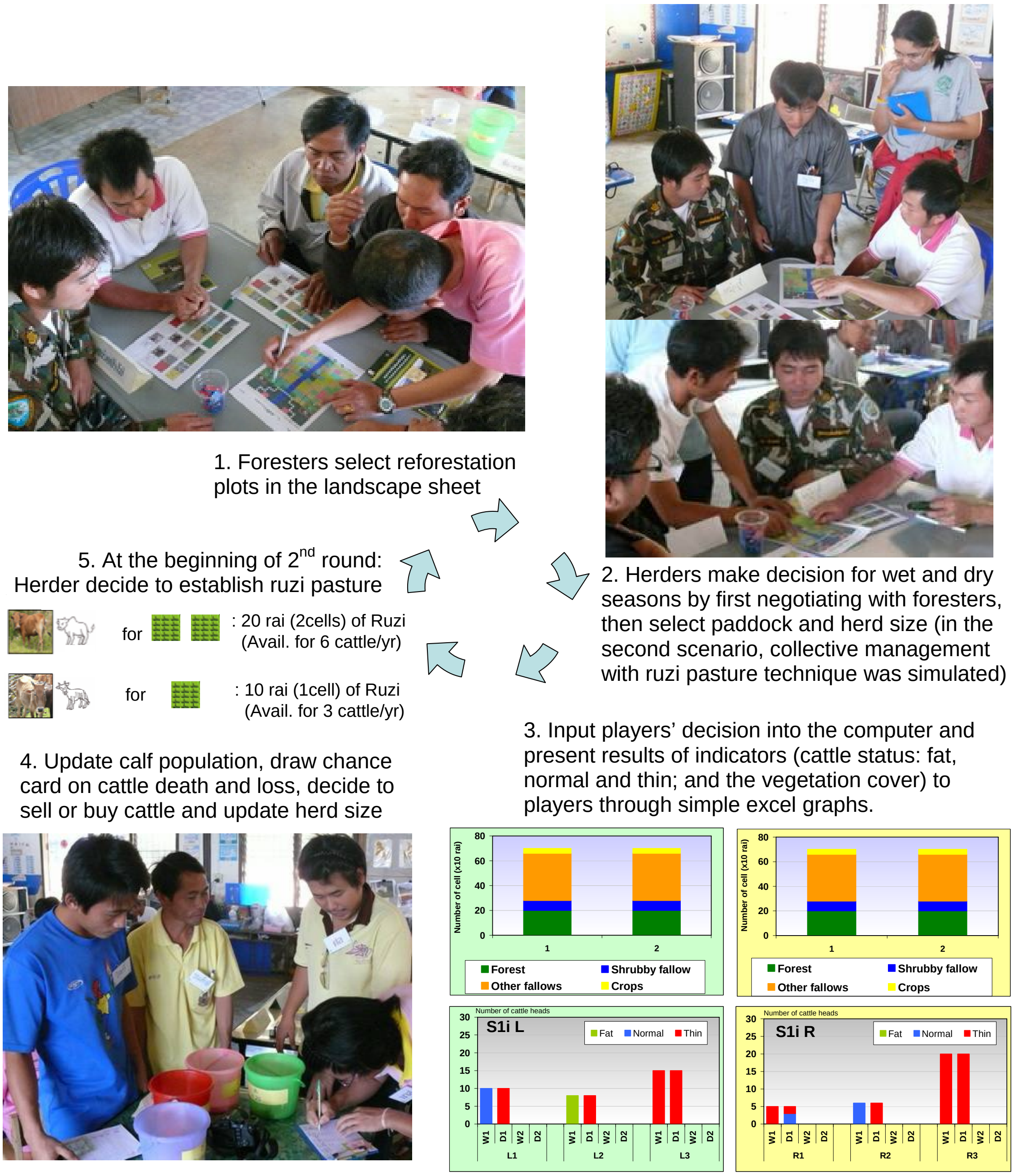



Figure 3. Main steps of a round of play in the simulation of scenarios during the second gaming and simulation field workshop.

Table 1. Description of the first participatory gaming and simulation (G&S) field workshop.

| Activity | First G & S field workshop (23-24 Sep 08) | | | | Second G & S field workshop (10 Mar 09) | |
|---|---|---|---|---|---|---|
| | Day 1 - morning | Day 1 - afternoon | Day 2 - morning | Day 2 - afternoon | Morning | Afternoon |
| Location | Doi Tiew School | | District Office | | Doi Tiew School | |
| Objectives | - Introduction of the gaming tool to newcomers (similar activity to sensitizing exercise).<br>- To explore with herders what needs to be modified in the researchers' representation of the system. | - To investigate herders' decision - making process and interactions regarding cattle rearing and forest regeneration.<br>- To prepare the herders to participate in G & S sessions with foresters by giving them more time to understand the G & S tool. | - To present day 1 - pm results to foresters and show how the cRPG works.<br>- To demonstrate how the cRPG works without entering players' decision on cattle raising and reforestation. | - To investigate the foresters' and herders' decision - making processes and interactions.<br>- To stimulate communication, collective learning and sharing of knowledge and perceptions between herders and foresters. | - To take stock of the evolution of the process and explain the new gaming tool (cRPG -V2) and the objectives of G & S.<br>- To facilitate communication and discussion and to improve trust among stakeholders.<br>- To explore herders' individual decision making regarding the new cattle and land management techniques | - To facilitate communication and discussion and to improve trust among stakeholders.<br>- To explore herders' collective decision making regarding the new cattle and land management techniques |
| Types of participants and number (in bracket) | - Herders (13)<br>- Researchers (4)<br>- Assistants (7) | - Herders (14)<br>- Researchers (4)<br>- Assistants (7) | - NKU foresters (3)<br>- Herders (8)<br>- Researchers (3)<br>- Assistants (7) | | - Herders (5)<br>- Nam Khang Unit foresters (2)<br>- National Park officials (3)<br>- District Livestock Development official (1)<br>- Researchers (1) and assistants (6) | - Herders (5)<br>- NKU foresters (2)<br>- NNP officials (3)<br>- Researchers (1) and assistants (6) |
| Main tool used | - RPG using pictograms of vegetation states | - cRPG - V1 | - Simulation using cRPG - V1, no human decision) | - cRPG - V1 | - cRPG – V2 | - cRPG – V2 |
| Scenarios (number of rounds simulated) & activity | - Herders indicate the next vegetation state based on given cattle number and paddock size. | - S1 (3 rounds): 2 groups of herders manage cattle, no reforestation plots.<br>- S2 (1 round): 2 groups of herders manage cattle with reforestation plots of different ages located in landscape by researchers. | - S3 (10 time steps): demonstration of vegetation dynamics with reforestation plots and without cattle in the landscape. | - S4 (4 rounds): herders and foresters manage a common landscape, negotiation is allowed, and different age of reforestation plots set in landscape sheet by foresters. | - S5 (3 rounds): herders manage cattle individually & facilitator assigned the order of play among herders | - S6 (4 rounds): herders manage cattle collectively |
| Expected Outputs | - Updated vegetation state transition diagram (V2) with larger group of participants | - Herders' understanding of the gaming tool and features<br>- Improved communication among herders | - NKU foresters' understanding on how the G & S work and decision | - A shared representation on forest regeneration<br>- Improved communication among them<br>- Suggestions on how to improve the process. | - Improved understanding on local stakeholders' decision making processes regarding the new cattle and forest management techniques.<br>- Improved communication and trust among stakeholders. | - A collective action plan to be actually implemented. |

## 3. Results

### *3.1. Recent land use change and agrarian transformations explaining the current conflict*

Table 2 summarizes the findings from the agrarian system analysis and provides an historical explanation of the current forest and farming situation. In particular, in relation to the cattle raising activity, 4 types of farms can currently be found in the village as shown in Figure 4.

Table 2. Recent transformations of Doi Tiew agrarian system, 1961-2008.

| Variables | 1961 - 1980 | 1980 - 1990 | 1990 - 2008 |
|---|---|---|---|
| **Ecological system** | - Scattered agricultural area inside the dense forest cover | - More forests encroachment in the southern part | - Clear separation between conservation and farm land<br>- More encroachment on steep land |
| **Technical practices** | - Manual techniques<br>- Long fallow period of up to 12 years | - Using handheld machines, i.e. sprayer<br>- Fallow period became shorter at 5 - 8 years | - Short fallow period of 2-3 years, permanent cultivation on some very small holdings<br>- Heavy machinery (trucks, rice mills) |
| **Cropping systems** | - Upland rice for home consumption<br>- Opium poppy for sale | - Maize for animal feed is the main cash crop<br>- Upland rice for home consumption<br>- Introduction of litchi as intercrop in maize or rice fields | - Upland rice for home consumption<br>- Litchi becomes the main cash crop. Some farms close to the stream are irrigating their orchards |
| **Livestock rearing system** | - Poultry<br>- Cattle raising in natural forest for own consumption, savings & ceremonies | - Poultry<br>- Cattle raising in natural forest for animal sales more than savings | - Poultry<br>- Cattle raising in natural forest, reforestation areas and fallows for animal sales and savings |
| **Non – timber forest products** | - Bamboo shoots, mushrooms, other edible vegetables, hunting animals (wild boar, birds, etc.), medicinal plants, palms for roof making, woods/bamboo for house construction | | - More limited in what can be harvested due to government laws<br>- More important to poor households for own consumption |
| **Demo - graphic pressure** | - Low (~50 HH, ~200 inhabitants.)<br>- Farm land for illegal occupation easily available | - Medium (~100 HH, ~500 inhabitants)<br>- Suitable farm land almost occupied by early immigrants from the lowlands | - High (~170 HH, 1,300 inhabitants in 2007)<br>- Smaller holdings inherited from parents, expansion of agricultural area not allowed by law |
| **Access to market** | - Low, mainly through opium poppy activity | - Medium in earlier phase and high in late phase due to more experience and connection with lowland farmers and merchants | - High, due to good transports and telecommunication infrastructures<br>- Farmers can negotiate prices or select among traders before sales |
| **Inputs** | - No external inputs | - External inputs are used: start using fertilizer on maize, for handheld machines, etc. | - Higher use of external inputs: fertilizers, pesticides, herbicides, and for heavy machines |
| **Rural credit** | - None | - Farmers borrow from neighbours in the same clan and without interest rate | - Plus loans from the village fund, Bank for Agriculture & Agricultural Cooperatives with low interest rate |
| **Land tenure** | - No land title due to the location of village is in headwater area (class 1A watershed)<br>- Land occupation is illegal but farmers pay a tax to the government | | |
| **Labour market** | - From households and through mutual help | | - Decrease of mutual help<br>- Hired labour from the village at maize and litchi harvesting<br>- Start working off-farm in town |
| **Agricultural incomes** | - From opium poppy | - 50% from maize & cattle, unless own a large herd | - From sales of litchi and maize more than cattle |
| **State interventions** | - 1965 – 1972: counter insurgency against the Communist Party of Thailand<br>- Villagers moved to lowlands areas | - Development projects from government agencies : new crops to replace opium poppy and reduce shifting cultivation | - 1990: reforestation policy implemented by establishing the Nam Khang Headwater Development and Conservation Unit<br>- 1996: implementation of forest conservation policy, establishment of the Nantaburi National Park<br>- Villagers attempt to negotiate the park boundary with the manager<br>- 2006: manager decided to cut - off 46% of the initial size of the park |
| **Socio-economic differentia-tion** | - Not much differences among households | - Early settlers accumulate farm land and cattle<br>- Diverse types of farming household appear | - More diversity of farm types based on available farm land, cattle assets and investment capacity |

Each of these main types of farms could be described as follows: Type A farmers who never raised livestock, or did not raise any cattle for many years, generate the main share of their income from off-farm activities such as wage employment or petty trade. Type B farmers are resource-poor farmers growing upland rice for self-subsistence and maize and litchi for sale on small holdings (usually less than 1.6 ha), and managing a cattle herd of about 2-15 heads. Their cattle graze mostly in the forest and reforestation areas and the sale of these animals is a significant source of their cash income. Type C farmers generate their income from the sales of maize and litchi grown on 1.6 to 3.2 ha of farmland, and daily wages. Their cattle herds (2 to 25 heads per household), which graze in forest or reforestation areas and on fallow land, also provide a secondary source of cash income. Compared with type B farmers, these production units have a higher capacity to invest in feeding and caring for their cattle. Type D farmers get their cash income from the same range of crops as type B and C farmers, but harvested on usually more than 3.2 ha per holding. However, cattle rearing is their main source of income and the size of their herds can exceed 40 heads per household. These well-off large herders have a stronger capacity to invest in agriculture. The ratio of type A, B, C, and D is approximately 1, 9, 4, and 1. This extensive differentiation among local farm types was useful for selecting the participants and designing of collaborative modeling activities and tools.

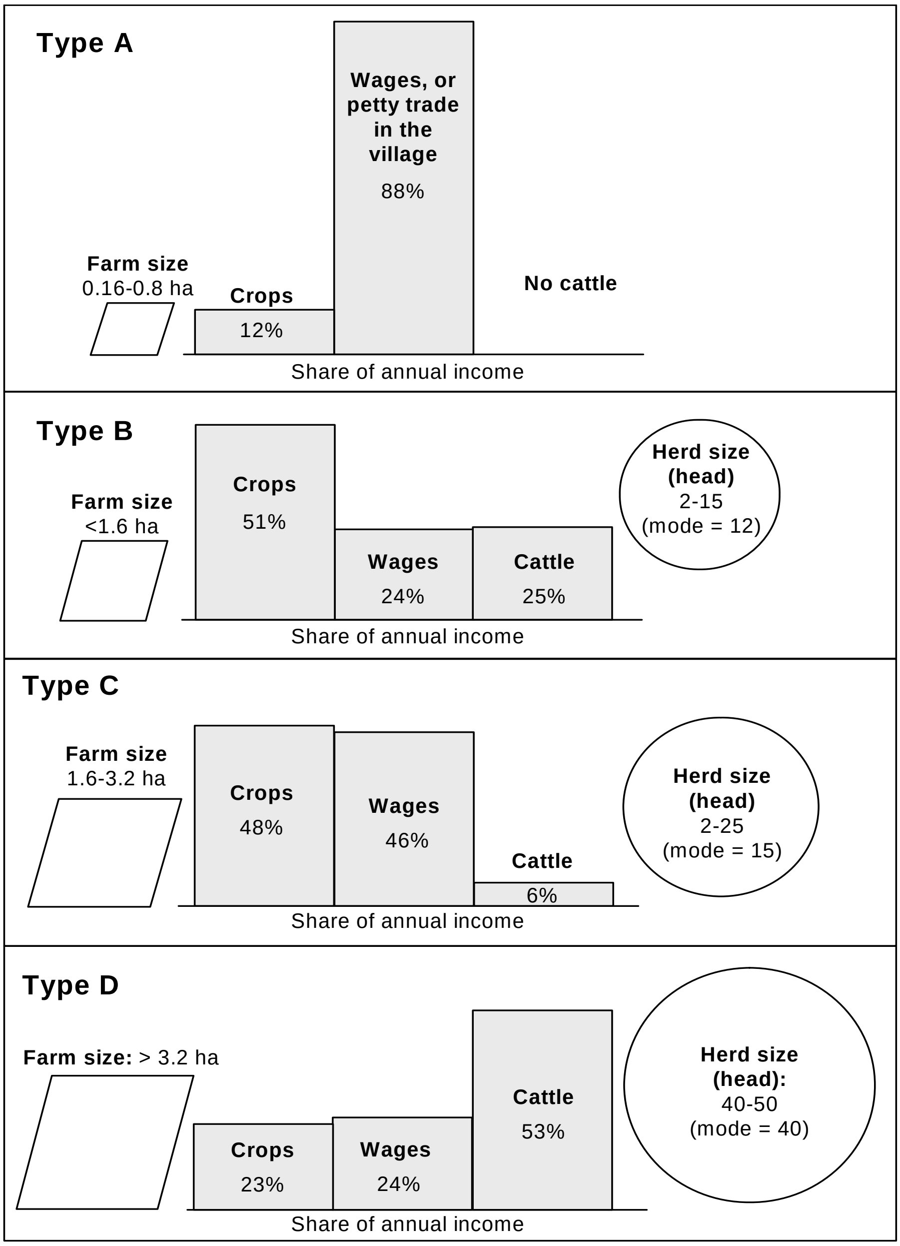



Figure 4**.** Farmer typology of Doi Tiew village in relation to cattle raising. Farm size, herd size and composition of annual household income for 2007 crop year.

### 3.2. *Reaching an agreement on vegetation dynamics*

The preliminary ecological survey at the plot level provided a sound dataset to represent the local vegetation dynamics. The research team assembled its knowledge in a first state transition diagram submitted to herders and foresters who modified it based on their empirical and expert knowledge. The group of forester asked to add a pictogram called "*Chromolaena* mixed with *Imperat*a fallow." Thereafter, the herders and the foresters were able to manipulate these pictograms to represent vegetation successions. The modified diagram used for coding the first version of the computer-assisted RPG (CRPG-V1), the main tool in the first gaming and simulation workshop, is shown in Figure 5.

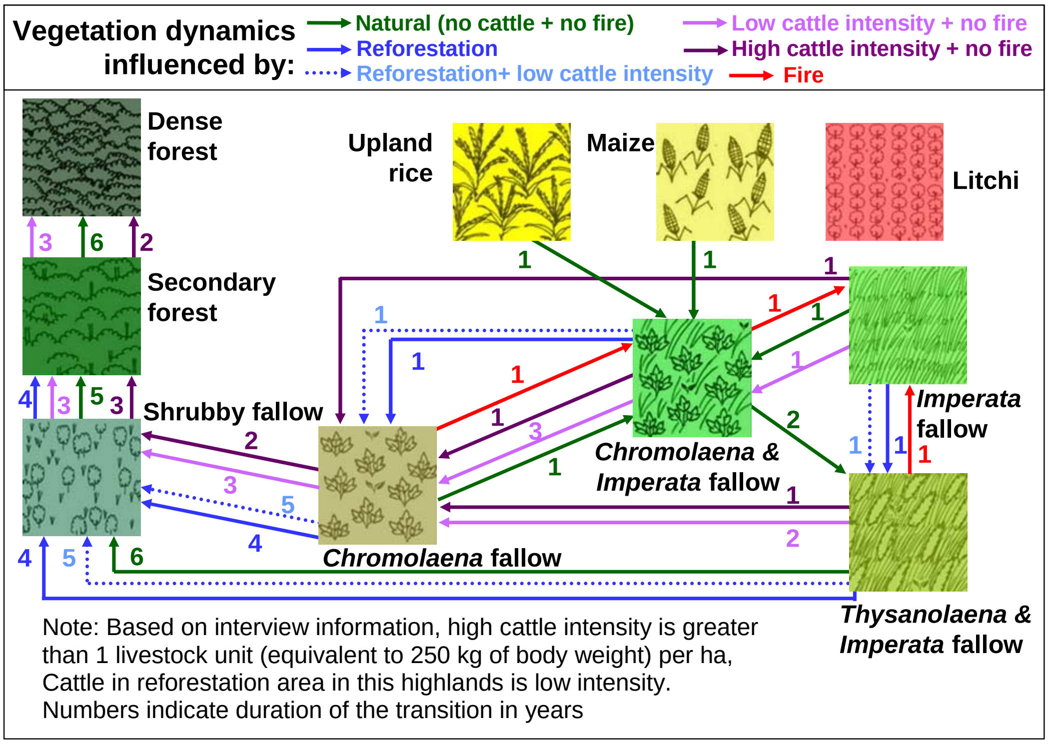



Figure 5. Vegetation state transition diagram used for coding the first version of the agent based model.

### 3.3. *A co-designed gaming and simulation interface at the landscape level*

To visualize vegetation dynamics at the landscape level, a transect of the 2003 land use map of the area was selected and simplified to make it more abstract while retaining the actual gradients and diversity of land cover classes as shown in Figure 6 (Dumrongrojwatthana *et al.* 2009). The same set of pictograms used in the vegetation state transition diagram was used and the virtual landscape was made symmetric to facilitate the visual comparison of the results of contrasted land management strategies adopted by two (left and right) groups of players, such as individual vs. more collective herd management.

Each cell in the virtual landscape corresponded to 3.2 ha in reality and this interface was large enough to be used by 10-12 herders (managing a total of approximately 100 heads of cattle) and several foresters for displaying their land management decisions and practices in simulation gaming sessions based on the cRPG tool.

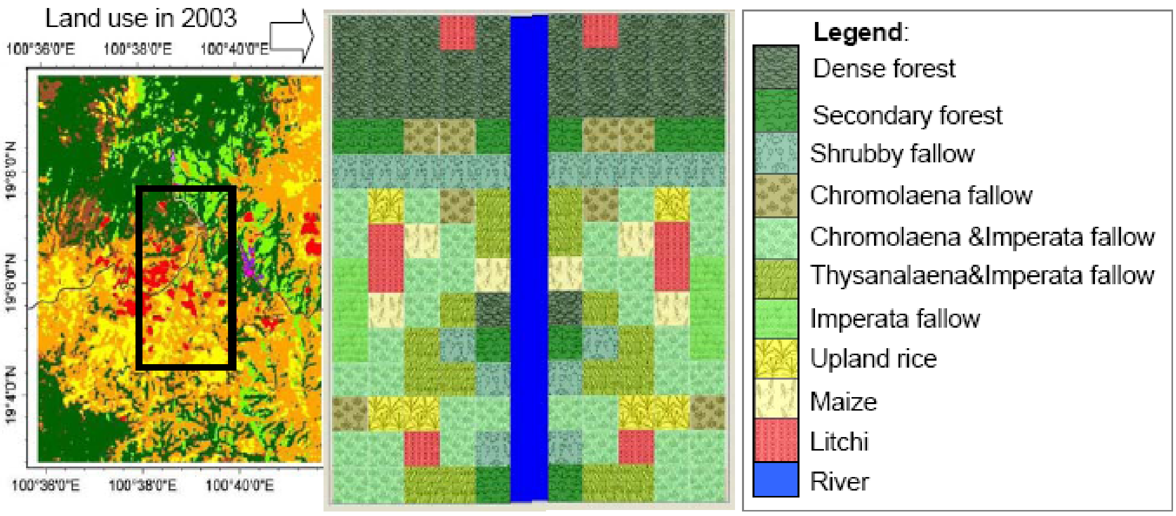



Figure 6. The spatial interface of the first version of the computer-assisted Role-Playing Game used with Doi Tiew villagers in Nan province (green shade = forest, yellow shade = farm land).

### *3.4. Results of the first ComMod sequence and participatory modelling sessions*

The activities of this sequence showed that both the herders and foresters were able to use their own knowledge to understand the vegetation dynamics displayed in the gaming sessions and to manage the proposed virtual landscape. It was found that, although it could be seen as complex by an outsider, the simplified landscape representing the local forest-farm land interface was not difficult to understand by the stakeholders as most of its features were familiar to them in actual circumstances. They could easily realize that the upper part corresponded to the conservation area managed by the NNP because of the domination of the dense forest pictograms. Most of the players could remember quickly the meaning of these pictograms and their use to display patterns of landscape. Those who did not understand central Thai language asked further explanations to their neighbours. Exchange of perceptions, shared learning, and improved coordination between herders and foresters was achieved through the joint use of this common virtual landscape.

In the first gaming and simulation field workshop, the herders used the game to introduce their idea about land management to foresters by showing their cattle raising strategies. One group of herders pooled a small herd and used the paddock rotation technique (Figure 7) by alternating grazing between the upper and lower parts of the virtual landscape. Another group raised cattle individually. After four rounds (corresponding to four years) different landscapes emerged from these contrasted management strategies. On their side, foresters faced more difficulties to find new cells unoccupied by herders for reforestation and they had to start negotiation with the herders in a productive discussion and exchange of viewpoints on landscape management.

Figure 8 displays an example of the simulation results of a scenario showing a gradual decrease of the area suitable for cattle grazing. Over time, while foresters had more difficulty to find new plots for tree plantations, herders found less and less grassy fallows for their herds.

In the plenary debate that followed the simulation sessions at the end of this first ComMod sequence, the herders and foresters agreed on the need to introduce new cattle rearing techniques based on artificial pastures of *Brachiaria ruziziensis*. (ruzi grass) and paddock rotations. They requested the research team to modify the cRPG-V1 tool accordingly to be able to simulate the landscape dynamics with these innovations in place.

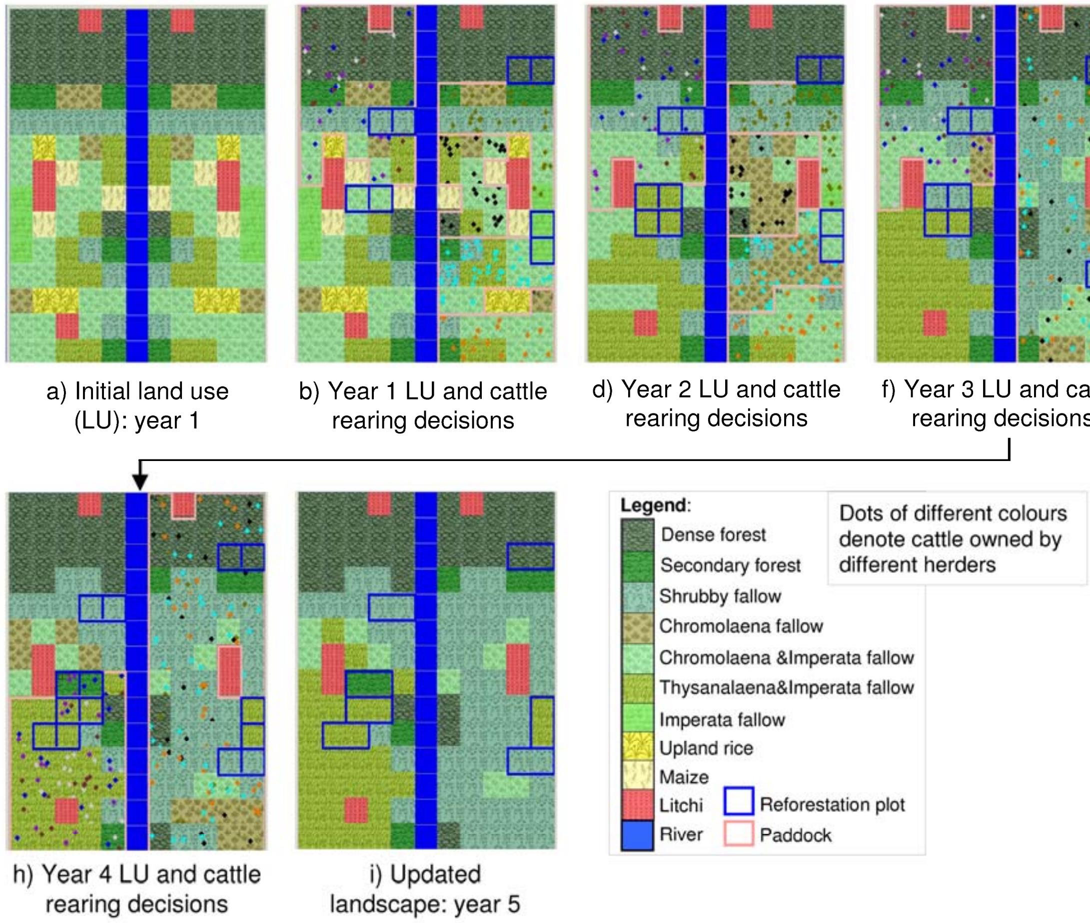
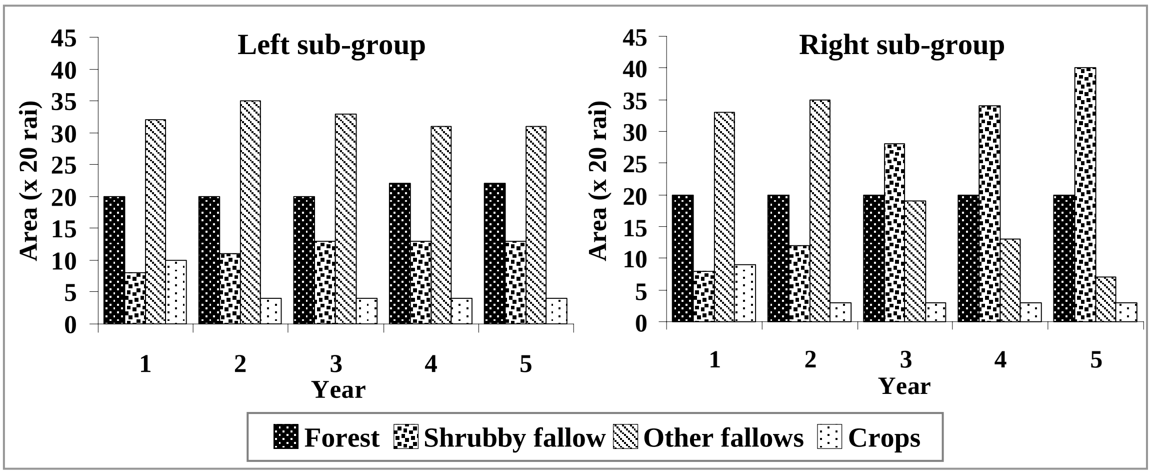



Figure 7. Landscape dynamics emerged from herders' and foresters' strategies in first workshop. In front of the landscape sheet, they discussed and requested to test new cattle and land management scenarios.




*Note: Forest = Dense forest + secondary forest cells; Crops = Upland rice + Maize + Litchi cells*

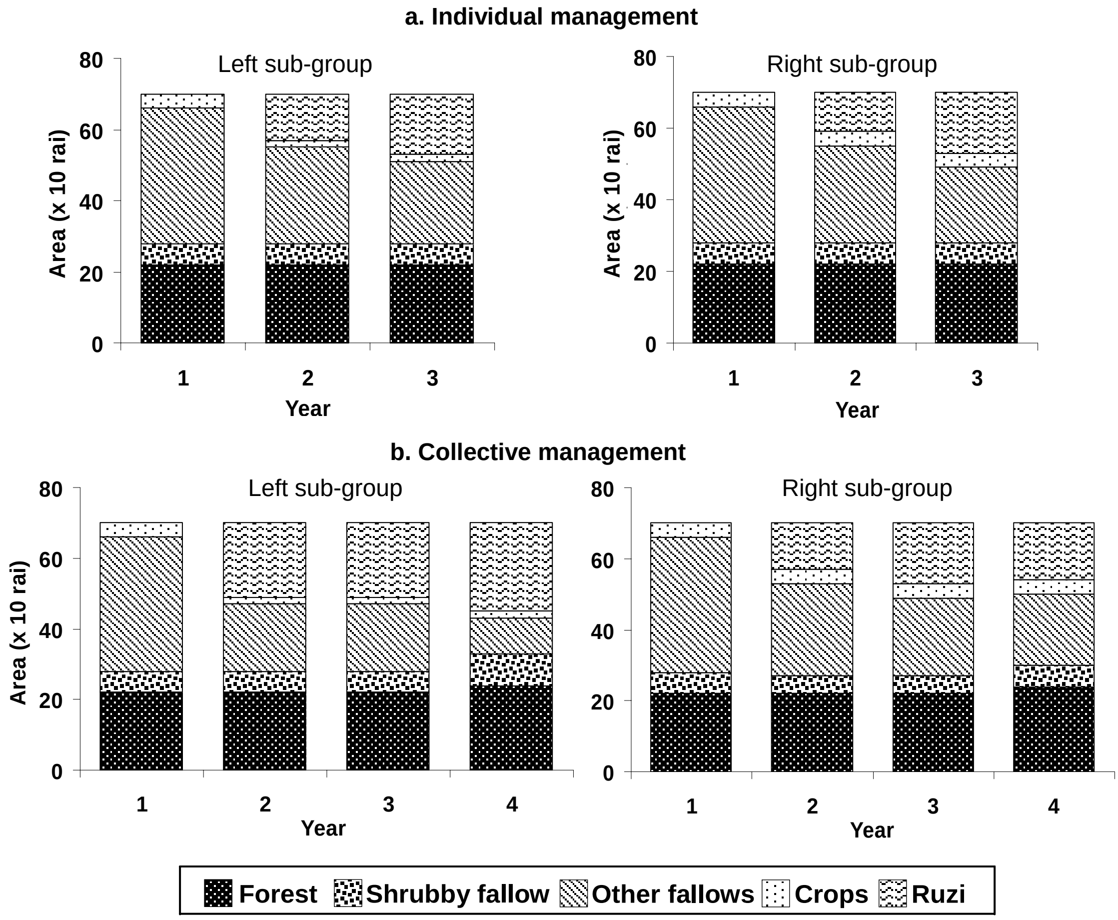
Figure 8. Vegetation dynamics during the simulation of a scenario with two groups of herders and one group of foresters managing the same landscape (scenario 4) in the first gaming and simulation workshop.

### *3.5. Results of the second ComMod sequence and set of participatory modelling sessions*

A similar set of activities than in the first sequence was implemented with the cRPG-V2 modified simulation tool (for more details see Dumrongrojwatthana 2010). Several time-consuming steps of the game (such as updating herd size after each year / round of play and the cattle status – fat, normal or thin- depending on the satisfaction of their forage needs) were also managed by the computer in this new version. It was calibrated to be played with 6 herders, several foresters and NNP rangers as the NNP boundary and management rules were also implemented in this 2nd version of the simulation tool. Following a first sequence focusing on understanding and agreeing on the simulated sub-system, the second sequence of activities aimed at facilitating collective decision making on landscape management.

After simulating the effects of different modes of communication among them on land use dynamics, herd size and cattle status, the herders learned that the collective management of their herds allowed a more extensive establishment of ruzi pastures as seen in Figure 9.

In the subsequent plenary debate, the herders and foresters agreed to implement a joint experiment on 10 ha of land provided by NKU in order to test the feasibility of such cattle management techniques in actual circumstances. The District livestock officer who observed the proceedings agreed to provide the ruzi seeds and was asked by the herders to witness the implementation of the agreed upon action plan between them and the foresters.




*Note: Forest = Dense forest + secondary forest cells; Crops = Upland rice + Maize + Litchi cells.*

Figure 9. Land use dynamics according to two modes of communication among herders simulated by two groups of herders in the second field workshop.

## 4. Discussion

### *4.1. Improved communication and trust between herders and foresters*

These two initial sequences of the ComMod process were successful in improving dialogue, knowledge sharing and exchange of perceptions on landscape dynamics between the parties in conflict. The initial diagnostic activities played an important role in the preparation of the following ComMod activities as the diversity of stakeholders, their different strategies and power relations had to be taken into account. For example such information was needed to select the participants invited to take part in the first sequence and, depending on the results, to manage a suitable evolution of the stakeholders' arena in the following ones. Because the level of trust between the tow main parties is not high yet, district officers were called by the herders to witness the proceedings and monitor the implementation of the agreement.

The use of tools easy to understand by the Hmong herders (but not too much realistic to encourage creativity), the transparency of the methodological choices made, and the increasing influence of the users on the characteristics of the simulation tool and the focus of the proceedings led to a good involvement of the stakeholders in knowledge sharing and collective learning activities. At the end of the second sequence, the herders requested to train more villagers with the simulation tool to facilitate change in cattle rearing activities and the implementation of the action plan.

### *4.2. Key role of the process facilitator*

This "human interface" is initially in charge of multiple tasks, such as assembling the knowledge base about the issue at stake, building the initial versions of the gaming and simulation tools, sensitizing the stakeholders about the proposed collaborative modelling activities and tools, establish and maintain dialogue among the parties in conflict, be adaptive and drive the process based on requests received from the participants, etc. Beyond the initial phases of the process in which the research team plays this multiple role, there is a need to train a local facilitator to be able to involve more stakeholders in the process and to monitor its effects. In the Doi Tiew case study, we observed that former players with a good understanding of the simulation tool were very efficient at training newcomers or disseminating the results of field workshops at village meetings. This is why a third ComMod sequence is being implemented to test the use of a more autonomous computer ABM (cRPG-V3) to facilitate such a farmer to farmer training process (for more details see Dumrongrojwatthana 2010).

### *4.3. Specificities of ComMod models*

The Doi Tiew case study illustrates the production of a series of evolving models and simulation tools along a ComMod process. There is no *a priori* attempt at making more and more sophisticated tools and frequently simple models are effective ones. Successive versions of the simulation tools can be used to describe the evolution of the process based on shifts of focus made by the participants. In the early phases, these models are usually used to integrate knowledge from various sources and to facilitate the exchange of points of view. Later on, they play a crucial role in supporting negotiation and collective decision-making. Much flexibility of the modelling framework is needed to be adaptive to the stakeholders' requests and multi-agent systems offer suitable simulation platforms to do that.

### *4.4. Diversity of effects on the participants*

The main immediate effects observed on the participants in the Doi Tiew case study so far are threefold. There is an increased awareness of the herders of the need to change their cattle rearing system to make this activity more sustainable and adapted to expanding forest and tree plantations. There is also a growing sense of interdependence among villagers and between them and forest agencies to tackle the land use conflict effectively. A second important effect deals with knowledge acquisition at both the individual and collective levels. This is illustrated by the choice of a collective management of cattle to be used in the planned joint experiment. Finally, the ComMod activities produced change in perceptions among the participants, leading to a significant improvement in the level of trust between herders and foresters. But it still needs to be reinforced through the implementation and monitoring of the agreed upon action plan.

## 5. Conclusion: further steps and improvements

The following activities aim at further improving the stakeholders' individual and collective adaptive capacity to rapid change. The implementation of the joint experiment on collective management of cattle in ruzi pastures established on foresters' land will be an important step toward a co-management of the forest – farmland interface in this area.

In parallel, a fully autonomous simulator is being developed to be able to simulate more scenarios in a time and cost effective way. It will also be used to respond to new requests received from the local stakeholders, such as the integration of cropping system dynamics in the simulation tool made by herders who plan to abandon cattle rearing to focus on crop production.

A local facilitator will also be identified among the motivated participants in the process and will be trained to maintain the process and monitor its impact.

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