# 9. Northern Thailand case: gaming and simulation for co-learning and collective action; companion modelling for collaborative landscape management between herders and foresters

*Pongchai Dumrongrojwatthana and Guy Trébuil*

## Abstract

Land-use conflicts between villagers and government agencies are common under the current decentralisation of resource management in Northern Thailand. They are frequently due to deep differences in interests, objectives and perceptions of the landscape resources to be managed and their use. As the complexity of the problems to be tackled increases, there is a need to design and test effective integrated, inclusive and adaptive methods fostering the co-management of the land to improve both ecological viability and social equity. Such methods should facilitate communication and the sharing of knowledge and viewpoints leading to mutual understanding, improved trust, and the design of workable co-management plans. Companion Modelling (ComMod) is a highly interactive gaming and simulation approach relying on multi-agent systems used to better understand a complex system through the co-design and joint use of different kinds of simulation models with the field actors concerned. The co-construction of a shared representation of the issue, followed by its use to simulate and assess future scenarios, facilitates multiple stakeholders' co-ordination and negotiation processes. The presentation of ComMod main theoretical references and key methodological principles is used to characterise the original posture of the practitioner who is seen as a category of stakeholder among others. This leads to a specific type of relationship with the models developed, and the local stakeholders. The operationalisation of ComMod in a process to mitigate a land-use conflict between livestock herders and foresters in a highland village is described. Its results, ranging from fostering mutual understanding to the joint design of concrete collective action, are discussed. Based on the lessons from this case study, an analysis of the strong (trans-disciplinary knowledge integration, empowerment of marginal farmers, flexibility of the approach and its simulation tools) and weak (special skills required, local facilitation and process ownership, use in multi-level processes) points of this collaborative modelling approach is proposed.

## 9.1 Context and changing role of collaborative landscape research in Northern Thailand

The sustainable management of renewable resources at the landscape level involves not only bio-physical dimensions but also the social, economic, cultural and political aspects. The search for improved landscape management is often complicated by the diversity and heterogeneity of the interconnected ecological and socio-economic systems. The fact that the diversity of stakeholders concerned with the collective management of landscape resources and environmental problems is also increasing is adding to the complexity of this task. The dynamics of interactions among such diverse factors at multiple social levels and spatial scales frequently leads to highly complex, non-linear and divergent processes and the emergence of unpredictable new phenomena (Liu *et al*., 2007; Van Paassen *et al*., 2008). As change accelerates and uncertainty increases, there is a need to opt for trans-disciplinary research approaches and methodologies to support truly adaptive, inclusive and integrated management of landscapes (Berkes and Folke, 1998).

The decentralisation of local resource management in Thailand started in the early nineties, particularly with the establishment of local administrative bodies called 'Tambon' (sub-district) administrative organisations (TAO). The remote mountainous areas of the Northern region are mainly populated by historically mobile and diverse non-Thai ethnic minority groups who practised the 'art of not being governed' (Scott, 2009) for many decades. Nowadays, differences in interest, objectives, strategies, practices and perceptions on how the forest-farmland interface should be managed leads to frequent land-use conflicts between these highlanders, administrative managers and technical government agencies, especially in headwater and forest conservation areas. During the last two decades, landscape management research, has used geographic information systems and decision support systems approaches for spatial planning, but the role of the local stakeholders was usually limited to the provision of information and consultative participation. More recently a few participatory resource management projects provided the local stakeholders with opportunities to share their different types of knowledge and points of view on issues of common interest. They improve their mutual understanding, and jointly design workable landscape management plans. But, there is still a need for innovative, integrative, inclusive and adaptive approaches for landscape management. Such processes should contribute to improve the ecological viability and social equity in this fragile highland socio-ecosystem by involving the diversity of concerned stakeholders as partners collaborating on an equal footing.

This chapter describes and discusses the implementation and main findings of a collaborative gaming and simulation process relying on the Companion Modelling (ComMod) approach. Its main goal was to mitigate a conflict over the access to grazing land between local herders and forest conservation agencies in a Hmong village located in an upper watershed of Nan province. This process was guided by an interdisciplinary research team based at the Department of Biology of Chulalongkorn University. It was initiated at the request of officials from the recently established Nanthaburi National Park (NNP) who took part in a similar collaborative modelling experiment conducted on a similar topic one year earlier at a nearby site (Barnaud *et al*., 2008; Ruankaew *et al*., 2010). The intended outcome of this collaborative landscape research was better co-ordination among the local farmers, foresters and park rangers for the co-management of the forest-farmland interface.

Following the presentation of the theoretical inspirations of the ComMod approach and the scientific posture of its practitioners, its main methodological principles and key tools are introduced. Then the collaborative landscape modelling process implemented in Doi Tiew village of Tha Wang Pha district, Nan province, is described. The subsequent section discusses the main findings regarding the production of knowledge, the influence of research and scientists on the other stakeholders taking part in the process, and the effects, especially learning ones, and impacts of this collaborative landscape research within the studied context.

## 9.2 Collaborative companion modelling for landscape management: theoretical perspectives and applied research methodology

In the fast growing family of collaborative modelling approaches, Companion Modelling (ComMod, http://www.commod.org) for renewable resource management is used by researchers and local stakeholders to design and implement highly interactive and inclusive modelling and simulation processes. They are designed to facilitate communication in multi-stakeholders platforms, to co-construct shared representations of given complex issues at stake, and to use them to explore possible solutions through the simulation of future scenarios (ComMod group, 2003). Two complementary general objectives of ComMod processes are (1) to better understand a complex socio-ecological systems (SES) through the collaborative construction and joint use of different types of gaming or/and computer simulation models integrating stakeholders' diversity of knowledge and points of view, and (2) to use these models within platforms for collective learning and to facilitate stakeholders' co-ordination and negotiation mechanisms leading to the definition of collective action plans.

### *9.2.1 Key theoretical references*

The ComMod approach did not emerge in the late nineties from theoretical debates among researchers involved in renewable resource management, but from the fact that they were facing common problems in the implementation of empirical research on complex objects of study. Because the back and forth process between theory and practice, between the laboratory and the field, is a key characteristic of this approach, the dialogue between its practitioners and several relevant schools of thought has been intensified in the past decade and with the implementation of many case studies. Below are descriptions of the main theoretical inspirations and perspective adopted by ComMod practitioners as described in a recent collective publication (Collectif ComMod, 2009).

Drawing on the science of complexity, ComMod considers socio-ecological systems (SES) as complex systems characterised by unpredictable behaviour and that are driven by successive temporary organisations framed by local interactions (Langton, 1992). Of particular interest is the analysis and interpretation of the emergence of properties at the whole system level, which cannot be understood through the observation of its individual components, but that result from interactions. This concept of emergence supports the choice made by the ComMod approach to facilitate the exchange of points of view, the integration of knowledge from various disciplines and sources (empirical, technical, expert, scientific, institutional), and a focus on interactions at the interface between biophysical and social dynamics. Complex SES, such as the spatially heterogeneous and highly variable fragile highland agro-ecosystems of Northern Thailand, are evolving continuously, in an unstable and uncertain environment, and their behaviour cannot be predicted. These characteristics have major implications on the design of ComMod processes operating iteratively, with an evolving focus in each of the successive cycles of collaborative activities depending on the process dynamics crafted step by step by the participants. They also influence the methodological choice of an agent-based modelling approach because of its openness and flexibility. Such characteristics are important for reaching an improved collective understanding of the system and for identifying the key interactions determining its functioning. Later on, the effects of these interactions can be explored in simulations run with the stakeholders to discuss how to drive the system towards a more desired state.

The concepts of resilience and adaptive management also underline the need for a better collective understanding of how the SES works as a way to improve the adaptive capacity of the stakeholders. It is also a necessary step towards the improvement of key properties like self-regulation and self-organisation. Recent definitions of these key concepts insist on the importance of interactive learning (Holling, 2001). Adaptive management of a SES implies flexibility, diversity, and redundancy in regulation and monitoring activities, leading to corrective responses and experiential probing of the ever-changing circumstances. The adaptive capacity of stakeholders is dependent on knowledge, its generation and free interchange, the ability to recognise points of intervention and to construct a bank of options to improve resource management. A ComMod process is a kind of communication and co-ordination platform to stimulate interactions among stakeholders for the generation and interchange of knowledge. This social process improves mutual understanding and creates new kinds of interactions facilitating the co-management of resources. Co-management is defined as a partnership in which local communities, resource users, government agencies, non-government organisations, and other stakeholders share the authority and responsibility over the management of a territory or set of resources. Many ComMod processes aim at setting up such co-management mechanisms (this is the case in the application presented below) and some of them may also lead to the devolution of decision-making power over resource management.

ComMod also relates to theories about collective action and the collective management of common resources and public goods (Ostrom *et al.*, 1994). The link with game theory to create institutional settings favourable to sustainable resource management is of special interest. Sustainable resource management requires agreed-upon but evolving access rules defined and enforced by the users. Trust, social capital, and the relations with institutions at higher levels in the social organisation play important roles in their creation (Ostrom, 2005). This is the reason why ComMod researchers use gaming to explore possible co-ordination and negotiation mechanisms among heterogeneous stakeholders. These games are collective learning processes taking place amongst social networks. Through the games, stakeholders experiment with different management and co-ordination options, so that acceptable solutions can emerge. Previous ComMod processes carried out in the Thai context demonstrated the usefulness of role-playing games used as simulators with the concerned stakeholders to represent the ecological and social dynamics linked to concrete collective problems. In particular, they create a non-threatening atmosphere adapted to the local cultural context (Bousquet *et al*., 2005a).

The ComMod approach also borrows from the constructivist epistemology when it tries to make explicit and share the different stakeholders' points of view and representations of the system. Reality is multiple, uncertain and subjective as it depends on one's personal experiences, objectives, and interest. Heterogeneous stakeholders perceive a common resource management problem differently; they refer to different kinds of knowledge, values and interests. Stakeholders' actions depend on their perceptions of their (ecological and social) environment, and these different (and partial) contradictory perceptions are frequently at the origin of misunderstandings and conflicts (Röling *et al*., 1998). To enable stakeholders to modify and align their perceptions, ComMod processes put much emphasis on experiential or discovery learning to facilitate the emergence of a shared collective vision (Röling, 2002).

Post-normal science attaches more importance to the improvement of the collective decision-making process than to the substance of the decision itself (Funtowicz and Ravetz, 1993). The ComMod approach adopts such a posture because of the high level of complexity and uncertainty of biophysical and human behaviour related to resource management. Researchers in the field of post-normal science consider that people construct their own realities through learning during social processes. Hard sciences can show that the landscape management of a given SES is leading to degradation. But the correction for sustainable land use depends on the outcome of human interactions leading to learning, conflict resolution, agreement, and collective action. The role of interdisciplinary teams including biophysical and social scientists is to facilitate, understand and strengthen collective decision-making processes through platforms of interactions. This also explains the importance ComMod practitioners attach to inclusive processes that associate stakeholders with diverse values, perceptions and interest with the aim of a shared representation of the system and the desired management. Specific tools are used to co-construct such a shared representation and the models used in ComMod processes are boundary objects facilitating knowledge integration and exchange to foster mutual understanding, joint learning and the emergence of new ideas among the participants (Carlile, 2002; Vinck, 1999).

From the patrimonial[13] mediation theory of co-management (Ollagnon, 1989), ComMod learned to pay attention to a prospective analysis of the long-term system evolution and the usefulness of scenario explorations for building consensus and agreement about joint goals. A patrimonial representation of the landscape links past, present, and future generations of users and managers; focuses on the owner's obligations rather than his/her rights; and promotes a common vision of landscape sustainability. Mediation is a negotiation approach in which a neutral party facilitates mutual understanding and agreement among different parties in conflict. The view of each party about the issues at stake are made explicit for the others to understand. When people agree on a shared conception of the present situation and how it will evolve, stakeholders are able to define long-term objectives. Then scenarios enabling these objectives to be reached can be collectively identified, simulated and assessed.

### *9.2.2 Adequacy of ComMod approach and methodology for the specific case*

The ComMod approach, and its underlying theory, seemed useful for dealing with several key characteristics of the case in question. There was a need to bridge the gaps, as there was a complete lack of dialogue about the management of the forest – farmland interface: the Hmong farmers cherished their empirical experience of vegetation dynamics and livestock production; the foresters cherished their technical knowledge of forest regeneration, and the university team valued their scientific knowledge about local vegetative biomass dynamics. At the start of the ComMod process, it was important to 'level the playing field', because the herders lacked formal education and there was a language barrier. The herders first needed to know what collaborative modelling was about, to raise their interest and willingness to participate. Furthermore, it was critical to create trust, because there was a deep mutual distrust between the villagers on one side and the foresters and rangers on the other.

Following the recent establishment of agencies in charge of reversing the trend of decreasing forest cover, there was an urgent need for both parties to envision a future agro-ecosystem landscape allowing better relationships between forest conservation and livestock rearing activities.

### *9.2.3 Key methodological principles and key tools*

The scientific posture of the ComMod researcher creates an original relationship between him, the models developed collaboratively, and the field actors and circumstances. Because he/she does not consider him/herself as a neutral outsider but as part of the system under study and to be managed collectively, the ComMod practitioner is involved in an engaged research process. Being an actor in the collaborative modelling process, the ComMod practitioner brings his own knowledge and point of view, while facilitating exchanges

[13] Patrimonial is defined by Ollagnon as 'all the material and non-material elements that work together to maintain and develop the identity and autonomy of their holder in time and space through adaptation in a changing environment'.

among the participants. The researcher's perception and representation of the system are presented to the participants to be criticised and improved, because the local stakeholders are firmly in the driving seat to stir the process in their preferred direction. Because of this dual role of researcher cum facilitator, ethical issues related to such a posture led the ComMod network of practitioners to define a code of practice (ComMod group, 2003). In particular, this charter recommends the systematic and continuous monitoring of the effects and impacts of ComMod interventions. Full transparency in the use of hypotheses should also be ensured. They should be explicit to other stakeholders and questioned along the collaborative modelling and simulation process.

Figure 9.1 shows a ComMod process usually consisting of several successive and self-reinforcing cycles of analysis (problem analysis), modelling (design and construction of a simulation tool) and field work (specific surveys to fill knowledge gaps, participatory workshops that comprise gaming sessions and/or participatory simulations, plenary debates, individual interviews, definition of the next steps, etc.). This process evolves in an iterative manner.

At the end of each cycle, the conceptual model representing the system under study is revised, as well as the research hypotheses. This succession of collaborative modelling and simulation activities organised in cycles focusing on different key questions, depending on the evolution of the participants' interest, is a fundamental characteristic of a ComMod process (Ruankaew, 2010). The arena of participating stakeholders can evolve from one cycle to the next, depending on the selected focus and on the needs and decisions made by the

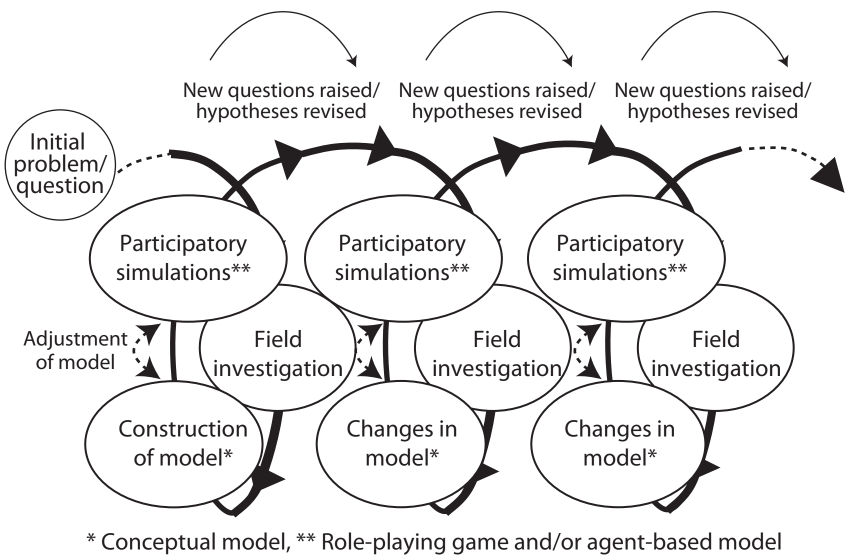



*Figure 9.1. The iterative phases of a ComMod process (adapted from Barnaud* et al.*, 2008).*

local actors. When the empowerment of 'voiceless' marginal stakeholders is a priority (like in the case study presented below), it takes villagers one or two ComMod cycles before they feel confident enough to invite decision-makers from higher levels in the social hierarchy to join the process.

Multi-agent systems (MAS) is the modelling framework used in ComMod processes because of its suitability in representing SES in a very intuitive way and its capacity to integrate knowledge of a different nature and source in a very open and flexible way (Bousquet *et al.*, 1999, 2005b). In most ComMod processes, the co-design of a conceptual model to synthesise the relevant knowledge on the issue at stake leads to the construction of a role-playing game (RPG). The RPG is used to submit the conceptual model to the local stakeholders and enables scientists to acquire more knowledge from them about the present dynamics and to stimulate exchanges. Several versions of this tool can be used depending on the process dynamics and the evolution of the stakeholders' main interest. Later on, the ultimate version of the RPG validated by the actors is converted into a computer agent-based model (ABM). Having played with the RPG, the participants understand this ABM 'playing the game' that allows far more time and cost-efficient simulations of scenarios selected by the participants, leaving much time to assess their results. This is how ComMod processes make use of the synergy between RPGs and ABMs. Various modes of association of these key tools are found on a case-by-case basis (Bousquet and Trébuil, 2005) and each of these two modelling and simulation tools can help in the construction and improvement of the other.

These simulation tools are used to facilitate individual and collective learning about the present situation, and to run scenario explorations as a way to mediate conflicts and engage people in defining suitable co-ordination mechanisms and negotiating collective action. Therefore, ComMod models are mainly seen as short-term tools. They are mainly built to facilitate communication and sharing of viewpoints and perceptions among stakeholders. Computer enhanced modelling tools are used for interactive learning, but not to predict the state or to pilot the system under study (Bousquet *et al.*, 2007).

### *9.2.4 Main phases of ComMod methodology and application to the case*

The ComMod approach proposes broad methodological principles and flexible tools but does not impose any rigid set of procedures to be strictly followed. This is in agreement with the principle of adaptive management seen as a social process taking into account the specificities of a given set of stakeholder arena and biophysical environment at a given time. Depending on the issue to be examined and the process dynamics, the research team can mobilise the set of tools in the most appropriate and adaptive way. Usually, the following main phases of a ComMod process can be distinguished, even if they do not need to be strictly implemented in succession, especially following the completion of a first cycle.

## Initialisation

A ComMod process usually starts from a request made by local stakeholder(s) to a research team to examine a concrete collective resource management problem and to search ways to mitigate it. At this early stage of the mediation approach, it is necessary to make the initial situation explicit to all concerned. The stakeholders need to be clearly informed about the issue at stake and about their interdependence in the search for a solution. A preliminary diagnostic-analysis focuses on the actors involved (their interest, strategy, decision-making and practices), the resource(s) to be managed and it/their own dynamics, and the key human-environment interactions to be represented in the models. Agrarian system diagnosis, stakeholder and institutional analyses, are examples of valuable tools used at this stage. A key challenge in this initial phase is to enable the stakeholders to express their perceptions of the present situation and of its evolution. This leads to the characterisation of the diversity of points of view among the stakeholders at the start of the process, all of them being considered as legitimate and subjective (Barnaud *et al*., 2008). This diversity of perceptions and viewpoints can be mobilised to let the stakeholders discuss the acceptance of the continuation of the current trends. It is also at this stage that the process facilitator decides, in consultation with the local stakeholders, who will be invited to participate in the first set of gaming and simulation activities. Depending on the choice made, public awareness and sensitising activities may be necessary to level the initial playing field and to deal, for example, with information and power asymmetries. This is because the facilitation of a ComMod process is not a neutral exercise as, for example, a process can be launched and designed to help marginalised and voiceless people to have their say in the decision-making process about resource use.

The Doi Tiew ComMod process was initiated by a request from the rangers from the NNP who, after taking part in a similar process held on a similar issue at a neighbouring site, wanted to examine the problem of cattle roaming in the newly established national park. The initial multi-scale diagnostic study combined an analysis of land-use change in the area based on remote sensed imagery backed by stakeholders' interviews, a characterisation of the different types of farms in the village in relation to livestock rearing, and an ecological survey on how grazing could influence the dynamics of the above-ground plant biomass (Dumrongrojwatthana, 2010). The main social aspects analysed in this preliminary diagnosis were the socio-economic heterogeneity of the herder community and the strategies and practices of the two main forest conservation agencies working in this area: the Nam Khang reforestation unit (NKU) of the Royal Forestry Department (RFD) and the NNP. The findings from the ecological survey were submitted to these herders and foresters as a first game based on a vegetation state transition model proposed by the researchers. Pictograms representing the main types of vegetative cover in the area were proposed and had to be ordered to create different successions of vegetative states depending on what human interference with natural dynamics was involved (cattle grazing, bush fire, tree plantations, etc.). This first version was enriched through the addition of relevant missing vegetation states, and validated with a group of five herders and four NKU foresters. The exercise was used to gather more empirical knowledge from the herders and foresters on the effects of cattle rearing on forest regeneration and to make them aware of gaming and simulation techniques (Dumrongrojwatthana *et al*., 2009). It ended with an agreement on a list of diverse vegetation states to be taken into account, their dynamics and relationships. This shared understanding of vegetation transitions became the core ecological module in the construction of the gaming and simulation tools. Based on this conceptual model of vegetation dynamics, the spatial representation and gaming rules of the first version of a RPG were crafted.

Following these activities, a selection of different types of herders (based on the role and relative importance of this activity on their farms) and NKU foresters (the unit leader and several of his assistants) were invited to participate in the co-design of models to improve their relevance and, hopefully, their use by simulating scenarios of their choice. The NNP rangers were not invited because their leader maintained very tense relations with the Hmong herders by insisting only on the need to keep the herds outside the park. But several young NNP rangers participated in the second field workshop to play their own role. More flexibility was expressed by the NKU foresters. While they complained about the negative effects of cattle roaming in their tree plantations, they were open to a dialogue with the Hmong herders who considered that cattle grazing had mainly positive effects on tree growth and forest regeneration.

## Co-design of models and simulation tools between researchers and local stakeholders

Model conceptualisation precedes the construction and use of a first RPG, to be followed by new versions integrating the modifications requested by the stakeholders, or focusing on different questions depending on the evolution of their interest. Throughout the process, the implementation of computer ABMs similar to the RPGs can be used to run simulations in a time- and cost-efficient way when needed. The model conceptualisation phase is a collaborative trans-disciplinary endeavour carried out through discussions, reviews of existing knowledge from various sources, and specific surveys to fill knowledge gaps. Among other possible knowledge elicitation tools, the use of the diagrammatic unified modelling language (UML) is very useful for encouraging the participants to be precise when exchanging their arguments. It also provides successive concrete outcomes and formal representations of the model taking shape gradually. These diagrammatic outcomes make it easier for the MAS modeller to implement the model under a simulation platform. Later on, these outputs also facilitate the verification of the model to check whether the implemented version is a true representation of the conceptual model. In the construction, simplifications are made, but the hypotheses related to them must be explicit, especially when scenarios are planned to be simulated with this tool at a later stage.

In the Doi Tiew case, the choice was made to build a computer-assisted RPG (cRPG) and to use it as the main simulation tool. The design of the cRPG integrated the updating of vegetation states at the virtual landscape level by the computer depending on the players' actions (selection of plots for tree plantation, delimitation of paddocks, grazing intensity in each paddock, etc.). This choice was made to maintain a gaming atmosphere without long breaks in a session. It was tested with bachelor students to improve its calibration before its use with the local stakeholders. From one ComMod cycle to the next, the cRPG evolved progressively to fit the changing main interest of the stakeholders as shown in Figure 9.2. From one version to the next, more rules were also operated by the computer following their validation in the previous gaming sessions (dynamics of cattle population, cattle losses, etc.). Its gradual development paved the way towards the final production of a fully autonomous ABM allowing time and cost-efficient simulation of land-use scenarios related to different landscape management strategies (Dumrongrojwatthana, 2010).

### Implementation and validation of ComMod models

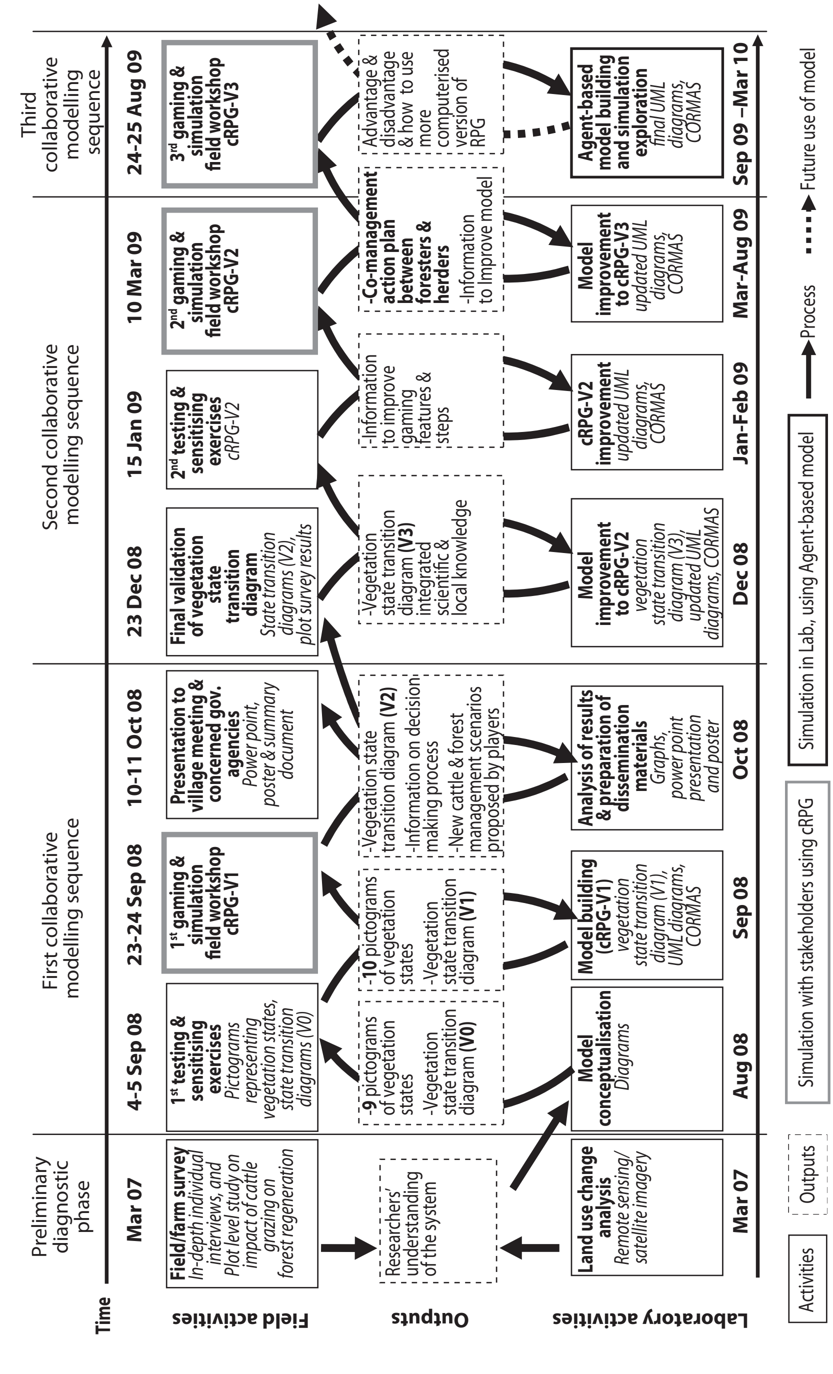
On the basis of the initial conceptual model, the RPGs or/and ABMs are implemented during this phase. Later on, they are used as boundary simulation tools in gaming or/and participatory simulations sessions with the local stakeholders. The use of RPGs precedes the introduction of an ABM replaying the game *in silico.* This is to ensure that the local stakeholders understand the components and rules of these simple models to minimise the well-known 'black box effect'. Stakeholders are invited to take part in gaming sessions in order for them:

- to understand the proposed model and relate it to their actual circumstances;
- to propose modifications or validate them after examining the individual behaviour of agents and the properties of the whole system emerging from their interactions;
- to be able to understand and follow ABM simulations run on the computer, and identify scenarios of interest to be simulated and collectively assessed.

No suitable general theory for the validation of such models exists. Therefore, special attention is paid to their validation by the local experts and end users. The co-design of the baseline conceptual model and the use of RPGs to help validate MAS models are important steps in this process of social validation. In the Doi Tiew case study, the three successive field workshops organised at the site were partly dedicated to the validation by the main types of local stakeholders of the successive versions of the cRPG tool.

### Scenario identification, exploration and assessment

During the field workshops, the participants take part in iterative investigations in real and virtual worlds that stimulate their creativity. Along the process, they analyse the results of the simulations and identify, discuss and select scenarios of landscape management to be simulated to explore possible futures. This is where, compared to RPGs, ABMs are powerful




**cRPG** = computer-assisted Role-Playing Game, ABM = Agent-Based Model
**CORMAS** = Common-Pool Resources and Multi-Agent System simulation platform, **V** = version

*Figure 9.2. Overview of the successive phases of the ComMod process implemented in Doi Tiew village of Nan Province, Northern Thailand, 2007-2009.*

for running such simulations rapidly, leaving much time for the discussion of their results. These results are usually presented by using social and ecological indicators previously identified with the stakeholders. In other applications, they can display the different points of view among the stakeholders on the evolution of the system to be managed collectively. Scenario exploration activities are held either in plenary sessions, or within small and more homogenous groups of stakeholders. This depends on what is the best way to promote the most inclusive assessment of the simulation results. Very often, this phase generates new knowledge and questions feeding the preparation of a new ComMod cycle.

In Doi Tiew, the simulations were organised either in plenary sessions or with the herders only. In this second case, at the start of the process, the objective was to familiarise them with the simulation tool and to build up their confidence before playing with the foresters, while in the third cycle the goal was to train more herders in the use of the simulation tool with the help of the former players. By the end of the first field workshop, a scenario of common interest to the herders and NKU foresters was selected. The gaming sessions demonstrated that the establishment of the NNP and the continuation of the current tree plantation and cattle grazing practices were leading to a rapid decrease in grassland areas in the landscape. The herders proposed introducing artificial pastures and the NKU forest unit proposed conducting a joint experiment on a fenced 10 ha plot of their land. The second version of the cRPG simulator integrated this technical innovation and its use showed the herders that a collective management of their herds would allow them to maximise the benefits of cattle grazing in fenced sown pastures. At this stage, district officials were invited to take part in the process and the livestock officer offered to provide *Bracharia ruziziensis* seeds for this experiment. Another administrative officer was also invited by the herders to witness the negotiation of this joint action and its implementation because their trust in the foresters' commitment was still limited.

## Monitoring and evaluation of the process effects and impact

There is no suitable monitoring and evaluation methodology for organising a critical and reflexive assessment of such a highly interactive modelling process. But suitable procedures are needed to analyse its different (immediate and longer term, direct and indirect) effects and impacts at individual and collective levels. Recently, a specific reflexive and critical monitoring and evaluation system was published by Jones *et al*. (2009) to be used separately with the designer of the ComMod process and the other participants. This methodology looks at the effects generated by the process in terms of learning about the system, about oneself, the others and the interdependency, the ecological and social dynamics. It also monitors the change in communication (within and between social networks), perceptions, decision-making, behaviour, and finally individual farm practices and collective action. Continuous monitoring is needed to keep track of the process dynamics because much is happening in the field between formal events such as participatory gaming and simulation workshops. A critical assessment of the process is needed at end of each cycle. To organise such activities in a systematic way, a logbook is used to closely monitor the process.

The version used in the Doi Tiew case study comprises three types of documents: (1) an Excel file, providing a chronological account of all the activities related to the implementation of the ComMod process, together with a listing characterising its participants; (2) a set of activity reports, accessible from the master Excel file; and (3) a set of additional documents such as interviews, recorded gaming or simulation sessions, etc. The logbook is filled in every week during the implementation of the ComMod process. The master Excel file provides macro functions allowing automatic statistical treatments of the information. Of particular interest is the analysis of social networks and their evolution along the process. They are used to investigate changes in the relationships between the participants and how they are linked to the implementation of ComMod activities. The logbook data can be processed with the NetDraw software package (available at http://www.analytictech.com) to visualise exchanges among stakeholders and knowledge sharing in each successive phase of the process.

## 9.3 The companion modelling process in Doi Tiew village

Figure 9.2 provides an overview of the whole collaborative landscape modelling and simulation process implemented in Doi Tiew village over three years to improve the management of the forest-farmland interface at this site. The research team that co-designed and facilitated this process consisted mainly of three researchers. The main process facilitator (and first author of this chapter) was a tropical ecologist and doctorate student specialised in vegetation and animal population dynamics. He was supported by a human geographer cum system agronomist (second author of this chapter), and an ecological modeller with skills in the development of MAS simulation tools (this aspect of the work dealing with tool development is not emphasised in this chapter, for more details see Dumrongrojwatthana, 2010). Throughout the process, this team was assisted by several students who took part in testing sessions to calibrate the simulation tools, and in the facilitation of the successive gaming and simulation workshops. The three sequences of ComMod activities performed are briefly described below to highlight how the process was crafted with the local stakeholders and adapted to changes in the context and the focus of their interest.

### *9.3.1 First collaborative landscape modelling and simulation sequence*

Starting from a situation of mistrust between the two parties, the goal of the first sequence was to facilitate communication between herders and foresters by building a shared representation of forest regeneration at the landscape level in relation to cattle rearing and tree planting activities. The highlight of the sequence was a two-day gaming and simulation field workshop. It was held with 16 herders only in the village on day one to raise their interest in the proposed process and to prepare them to play with the foresters at the district administrative office (seen as a neutral place) the following day. This first version of the cRPG-v1 was used at the village school where a dozen Hmong herders with a low level of formal education were invited to discover, criticise and improve the cRPG-v1 simulation tool. Two groups of herders made decisions on the use of the same virtual landscape in the absence of forest protection activities. One group decided to raise cattle in individual scattered paddocks, while the second group opted for a more collective management of individual herds in a single large paddock. Following the gaming session, the computer displayed, side by side and year by year, the vegetation dynamics resulting from these different choices of cattle management. The herders were able to explain the differences observed in the vegetation dynamics and were introduced to the comparative analysis of scenarios. At the end of the day, half of them agreed to pursue the participatory modelling and simulation activity with NKU foresters at Tha Wang Pha district office the following day.

In the morning session of the second day, the herders explained a replay of the previous day's gaming session to introduce the use of the simulation tool to the NKU foresters. They did it by emphasising the importance of the continuation of cattle rearing for their livelihoods. Then a new gaming session started in which the foresters selected two new plots to be planted with trees at the start of every crop year, before the establishment of the herders' paddocks on the virtual landscape. In the game, the foresters played their actual practice of trying to enlarge patches of tree plantations year after year. But after several years they started discussions with the herders to negotiate their access to the most suitable plots for tree planting. On their side, the herders were interested in negotiating the access to young plantations for cattle grazing when faced with shrinking grassland areas. The dynamics of the gaming session showed them that this would not be enough to make their extensive cattle rearing system sustainable. The afternoon debate showed that there was mutual interest in the introduction of artificial pastures in the landscape. Both parties asked the research team to modify the simulation tool to accommodate this technical innovation. The herders made it clear that they would not take part in a second field workshop if it did not focus on this precise question. Because of their low level of trust in NKU foresters, they also requested the presence of district administrative and technical officials to witness the following part of the process.

The gaming workshop allowed the participation of a few players only, and it was important to communicate about what happened and to disseminate the lessons learned from this event to the wider community of local stakeholders. Several participating herders presented the main results with a slide presentation to the whole village community during a monthly meeting. A document summarising the findings was also distributed. Similar presentations were also made by the research team to the foresters of the neighbouring Sob Khun Royal Project, the District Livestock Development (DLD) Office and at the Nanthaburi National Park (NNP) headquarters. Two large-format posters in the local language showing the process of this first gaming and simulation sequence and its main results were posted in the village and at the NKU office to facilitate further exchanges between players and non-players.

### *9.3.2 Second collaborative modelling and simulation sequence*

At this stage, the local herders and foresters agreed to hold a dialogue about the landscape management issue. But they insisted on focusing the process on their preferred way of mitigating the land-use conflict to allow the continuation of livestock rearing in parallel with forest regeneration. To satisfy this request, the second sequence was designed and implemented to facilitate the design of a co-management action plan. This sequence was composed of four complementary activities as follows: (1) final validation of vegetation state transition diagram following the integration of *Bracharia ruziziensis* artificial pastures as requested by the herders; (2) modification of the cRPG to produce a second version integrating the simulation of the new cattle and land management techniques proposed by stakeholders; (3) test of the cRPG-v2 simulator with NKU and NNP officers (introduction of this tool and its use to the NNP rangers who joined the process at this stage); and (4) implementation of a second gaming and simulation field workshop at the site, with more diverse participants (i.e. NNP and DLD officials) to design a collective action plan. The final validation of the state transition diagram took into account the improved understanding of interactions between cattle rearing, tree plantation activities and forest regeneration achieved at completion of the first sequence.

A similar gaming and simulation session to that in the first sequence was organised in which the national park occupied the highest part of the virtual landscape with NNP rangers playing their role by punishing the owners of cattle trespassing in the park. The same kind of comparison of different cattle-grazing strategies and practices as in the first sequence was implemented. One of them showed that the advantage of introducing artificial pastures would be maximised through the collective management of individual herds (Dumrongrojwatthana, 2010). The subsequent plenary discussion focused on the preparation of a joint experiment to test this technical innovation on a ten hectares plot of land offered by the NKU foresters. The DLD officer offered to obtain the Bracharia grass seeds and several herders volunteered to provide animals for this experiment.

### *9.3.3 Third collaborative modelling and simulation sequence*

At this stage of the collaborative modelling process, some herders were concerned by the limited number of villagers involved in the gaming and simulation activities so far. They asked to be able to use the simulator to 'train' more herders for them to better understand the concrete action plan agreed upon with NKU foresters. By doing this, they also wanted to engage them in its implementation. They also requested further modification of the simulation tool to integrate key cropping activities in the village such as upland production of rice, a local staple food.

To accommodate these requests, the cRPG evolved into a more autonomous third version (cRPG-v3). It was tested with players who participated in the first and/or second workshops, as well as with other herders who had never participated in this ComMod process. The last phase of this third sequence consisted of the implementation of this fully autonomous ABM to be used to simulate, explore and compare the results of various landscape management scenarios with more participants in further participatory simulations. They will be designed to out- and up-scale the ComMod process at this site because other neighbouring communities are facing the same kind of land-use conflict, while the ABM replay of gaming sessions *in silico* could be used to brief local administrators and other decision-makers about the outcomes of this ComMod process.

Figure 9.3 displays the qualitative and quantitative evolution of the stakeholder participation in the three successive cycles of this ComMod process. If field workshops mobilised between 12 and 27 participants during the three cycles, the out-scaling activities were conducted with approximately one hundred villagers. The increased diversity of stakeholders during the second cycle occurred at the request of the herders. While on the contrary, their new focus on engaging more herders in the collective action by training them to use the ABM simulation tool to simulate scenarios led to a far more homogeneous stakeholder arena in the final sequence.

## 9.4 Research results and outcomes of the collaborative landscape research process

### *9.4.1 Knowledge exchange and production for sustainable landscape management*

The logbook data permits an assessment of the exchange of different kinds (empirical, technical, expert and scientific) of knowledge during the whole ComMod process. Because more activities were carried out with the Hmong herders, 42% of the time was spent sharing their empirical knowledge with other stakeholders. The research team used 24% of the time to share its scientific knowledge. Inputs of technical and institutional knowledge occurred mainly in the second cycle of the process and represented only 5% of the time spent implementing the whole process for each of this two categories. These data show that in such a process, the farmers are able to express their point of view and arguments at length. This is very different from the classic extension or consultation processes in which they act mainly as receivers of information and knowledge provided by other parties.

These knowledge exchanges led to the production of a common vegetation state transition diagram used to represent vegetation dynamics at the landscape level. The use of pictograms associated with each of the main type of vegetative cover was efficient for knowledge elicitation between researchers, herders and foresters (Dumrongrojwatthana, 2009). The initial series of pictograms and transition rules from one state to another (number of years, natural or man-made change) proposed by the plant ecologist were completed by the herders and foresters. This led to two slightly different versions at the beginning of the first cycle and the researcher merged them into a new conceptual model of vegetation dynamics. This

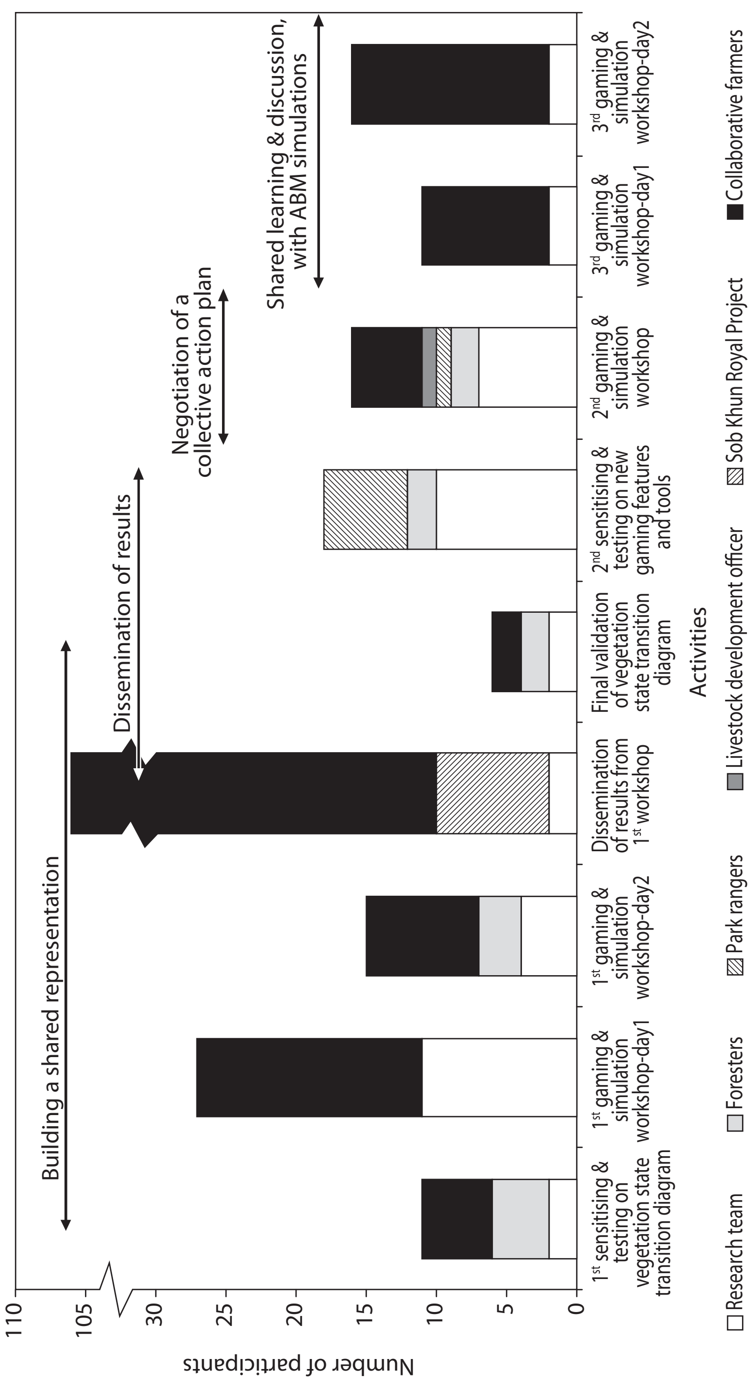



*Figure 9.3. Dynamics of stakeholder participation along the ComMod process implemented at Doi Tiew site of Nan province, Northern Thailand, 2007-2009.*

model was used to regulate vegetation dynamics on the virtual landscape in the gaming and simulation sessions of the first field workshop and was finally accepted by all participants. In the second cycle, the cRPG tool was found to be flexible enough to accommodate the addition of new pictograms (such as *ruzi* pastures, upland rice fields) as requested by the local players.

The virtual landscape shown in Figure 9.4 was based on the 2003 land-use map of the village territory.

A North-South transect comprising a gradient of the main different types of land use and land cover was simplified into a grid where one pixel was equivalent to 3.2 ha. A given pictogram from the conceptual model was assigned to each cell to mimic the main heterogeneities of the actual landscape. The landscape was symmetric to allow two (left and right) groups of 5-6 herders each to play with several foresters to manage one half of the landscape separately by implementing their preferred strategies (for example, individual versus collective management of herds).

At the end of a gaming and simulation session, differences between the two landscape management strategies implemented were displayed, compared and analysed. These debriefings were very interactive and useful to check whether the components and rules of the simulation tool were well understood. Each party provided its explanation of the landscape dynamics displayed and a debate on these arguments facilitated by the research team followed. The rapidity with which the herders assimilated the use of this tool in the first field workshop was rather surprising, as well as their confidence when commenting on the replay of the first gaming session to the foresters the following day. They were clearly taking this simulation tool seriously and used it to enhance communication and mutual understanding with the

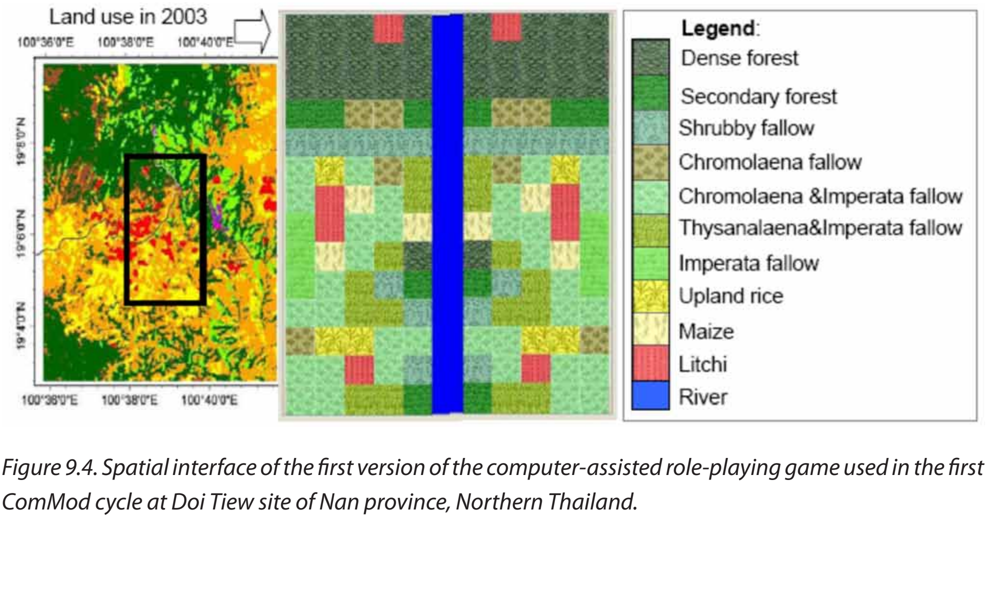



*Figure 9.4. Spatial interface of the first version of the computer-assisted role-playing game used in the first ComMod cycle at Doi Tiew site of Nan province, Northern Thailand.*

foresters about the importance of livestock rearing to them and the positive effects of this activity on forest regeneration. In the following gaming session, the foresters' strategy for gradually building patches of tree plantations was made explicit and the herders negotiated grazing rights in tree plantations older than five years. But this was not enough to feed the herds as the gradual reforestation of the landscape increased the scarcity of suitable grazing land with herbaceous vegetative cover. This resulted in a decreasing cattle population and poorer quality of cattle carcasses produced under constant grazing pressure. Land use and cattle population dynamics showed clearly that extensive cattle rearing would not be viable in the near future. This prompted several herders to look at how to increase forage production to be able to pursue livestock rearing, while others decided to abandon this activity and focus on crop production. But the transformation of the relationship between herders and foresters generated new ideas during the plenary debate on the results, especially an agreement on the need to test new forage production and cattle management techniques.

Two complementary technical innovations, i.e. the introduction of artificial pastures and rotational grazing, were introduced in the debate by the herders to address the issue of the increasing scarcity of suitable grazing land and for the production of higher quality meat products. They also addressed the foresters' interest in a decrease in the cattle grazing pressure in young tree plantations, as well as the rangers' goal of suppressing roaming animals in the area. This was a bold decision by the herders who have been practising only very low external input, land and labour extensive cattle rearing on natural pastures for several decades. But now they were aware of the fact that such practices would no longer be ecologically or economically viable. The matter became urgent to the herders and their engagement in the process increased. They wanted to sit firmly in the driver's seat and made clear to the research team what should be the focus of the next round of ComMod activities.

The second sequence assessed the proposed technical innovations with the updated version of the simulation tool, with the ultimate goal, depending on the simulation results, of negotiating a concrete co-management action plan. The simulations showed that, while rotational grazing on natural pastures would only be of limited interest, a collective management of herds could maximise the benefits of establishing artificial pastures (Dumrongrojwatthana 2010). This finding influenced the definition of the joint experiment on the introduction of *Bracharia ruziziensis* pastures on ten hectares of land provided by NKU foresters. The idea of launching a joint field experiment on artificial pastures was clearly a step toward a more technical and concrete assessment of this innovation in actual farming circumstances, something that was beyond the role assigned to the cRPG simulation tool.

### *9.4.2 Influence of research and scientists on the other categories of stakeholders*

If the initiation of this collaborative landscape research came from a request made to the research team by the local NNP stakeholder, the scientists played a central role in the design and facilitation of the first cycle of ComMod activities as seen in Figure 9.5a.

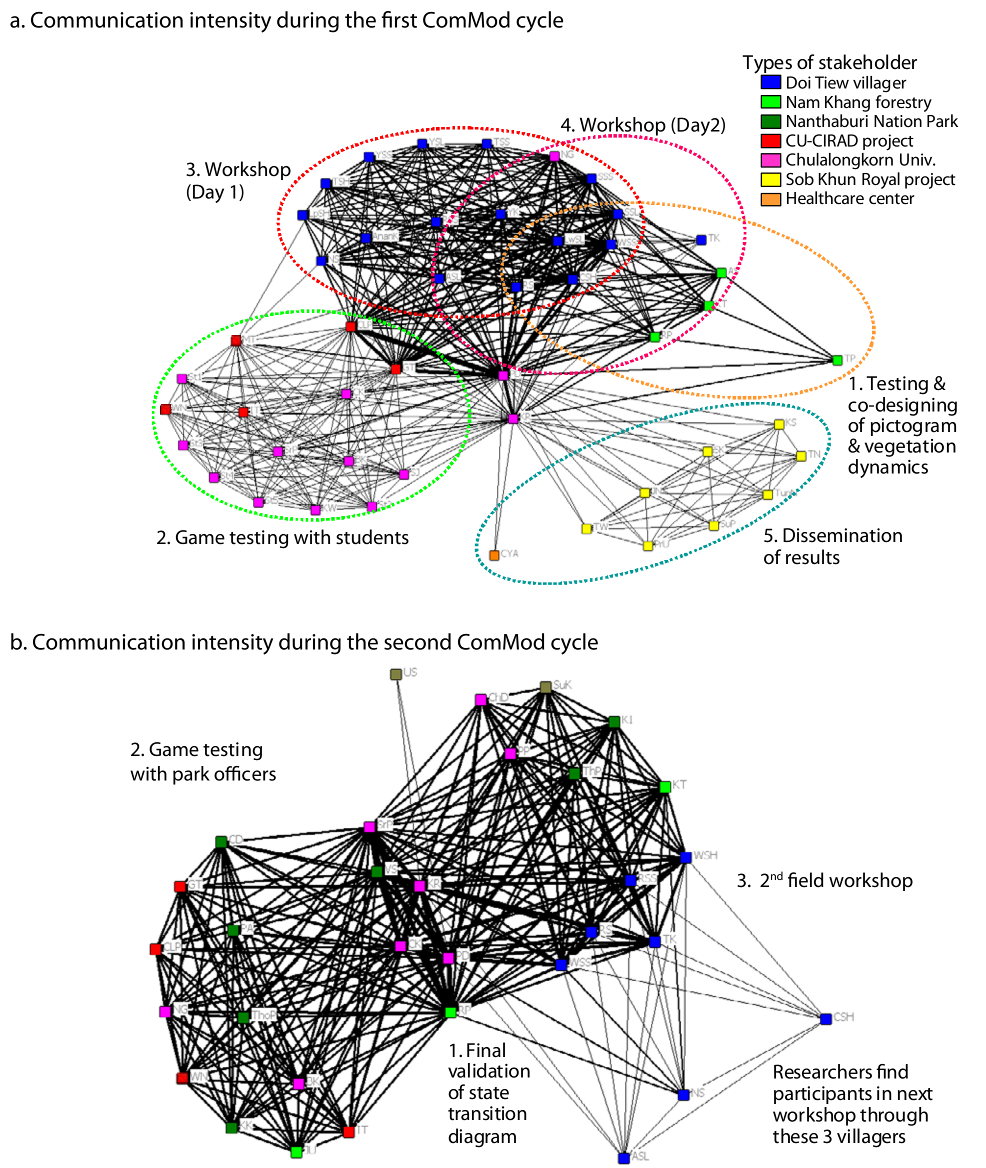



*Figure 9.5. Communication intensity among the different categories of participants in the first (a) and second (b) ComMod cycles implemented at Doi Tiew site of Nan province, Northern Thailand (line thickness is proportional to time spent interacting).*

The figure displays the intensity of communication among the different categories of participants. The thickness of the lines is proportional to the intensity of communication between two given participants in the process. This was unavoidable because of the initial deep mistrust between the parties in conflict. But by the end of the fist sequence, the interactions between herders and foresters increased. More intensive exchanges between these two categories of key stakeholders are shown in Figure 9.5b displaying communication among the participants in the second cycle on testing innovative cattle rearing techniques and negotiating a collective action plan. Most of the participants being already familiar with the simulation tool, the role of the research team in this second round was mainly to facilitate the simulation exercises and the exchanges among local stakeholders.

By the end of the first cycle, the local stakeholders were driving the process. They were rather surprised to see that the researchers accommodated their wishes and modified their models according to their wishes. Compared to their previous experiences with researchers, there is no doubt that this behaviour contributed to more trustworthy relationships between the process facilitators and the villagers. This was again the case at the end of the second cycle when the herders asked the research team to spend time out-scaling the process with them by training more villagers on using the more autonomous and less time-consuming third version of the cRPG simulation tool. At this stage, the experienced players who took part in the previous field workshops were able to explain what this tool was doing to the newcomers in Hmong language. This was a critical stage for the main process designer and facilitator cum doctorate student who had to keep responding to the requests made by these motivated herders while fulfilling the academic requirements of his degree training in a time-bound framework. It is at this stage that the need for a local facilitator equipped with skills to manipulate the simulation tool with new players became obvious to sustain the positive momentum of the process.

### *9.4.3 Effects and impacts of the collaborative research process within the studied context*

These collaborative landscape modelling and simulation activities established a communication channel between herders, foresters and rangers. The dialogue led to an improved mutual understanding of their respective perceptions of land-use dynamics, objectives and practices. The improvement of trust between the villagers and the forest conservation agencies was also noticeable. Since the negative perception felt during the initial visit of the research team to the village (after which the village authorities checked the institutional attachment of its members on internet through a young migrant working in the tourism industry!), there was a very significant improvement in trust between the villagers and the research team. The ComMod posture of the research team facilitating collective decision-making by local stakeholders and the implementation of a rather longwinded process in their preferred direction clearly helped to achieve that. The villagers clearly said that they understood this team was not in the village simply to make a study and issue recommendations.

Knowledge exchange led to an improved understanding of the on-going dynamics of the forest-grazing land interface for all the participants (including researchers). Most of the herders rapidly understood the features and operation rules of the cRPG simulation tool after a couple of rounds of play (one round simulating one year in a 4-5 year long gaming session). They also made pertinent suggestions (such as the addition of features and options needed for them to make their decisions, the adjustment of technical parameters regarding cattle population dynamics, etc.) to improve its successive versions and to better represent the system they manage. This case study proved the efficiency of combining in a flexible way RPGs and computer simulation tools to bridge the digital gap among users. The process has so far been successful in engaging reluctant villagers who have received no (or only a low level of) formal education in the collective exploration of the future of their surrounding landscape.

But, as expected from the determined Hmong participants, as soon as they made up their mind about ways to practically improve the co-existence between cattle rearing and forest regeneration, the herders requested to move from the virtual world of the agent-based simulation to the negotiation of a field experiment to test the technical innovations found suitable to the parties in conflict. The joint implementation of a rather large-scale experiment on the feasibility to raise pooled herds on *Bracharia ruziziensis* artificial pastures established on foresters land could be seen as a starting point toward the co-management of the forest-farmland interface by local villagers and foresters. During the plenary debate that followed the participatory simulations in the third cycle, the herders expressed their increased awareness of the need for a collective management of their farming activities. They seem ready to move in that direction by testing an acceptable way to allow reforestation of this upper watershed while improving livestock rearing. They proposed a zoning of the village territory between annual crops and animal grazing activities and also suggested inviting the village committee members and the sub-district representatives managing the development funds to join further collaborative landscape simulation activities. Their proposition was backed by the village chief.

## 9.5 Discussion

### *9.5.1 Effectiveness of ComMod adaptive methodology and flexible tools for generating knowledge, learning, negotiation, and collective action*

Starting from an initial situation characterised by a deep mistrust between the main categories of stakeholders, the ComMod process implemented in Doi Tiew village has now reached the stage of joint implementation of an agreed concrete action plan. The co-design and interactive use of methodological tools facilitating communication, sharing of perceptions, improvement of mutual understanding and trust among the participating stakeholders played a major role in this significant achievement. Compared to earlier ComMod processes implemented in the same region (Bousquet *et al.*, 2005b; Ruankaew, 2010) and their evaluation (Van Paassen *et al.*, 2008) more attention was given in Doi Tiew to preliminary sensitising activities with the disadvantaged marginal Hmong farmers. They were able to better understand the objectives of the process and increased their interest and confidence. They played a crucial role in securing a positive start by engaging the reluctant Hmong herders. Full gaming and simulation sessions with the foresters, and later on with the park rangers, were introduced only when the herders felt ready to confront their opinions and arguments with them.

The simulation tools made extensive use of visualisation techniques (pictograms, virtual landscape, etc.) to avoid face-to-face discussions between the conflict parties and to overcome the severe language barrier (many Hmong herders do not speak Thai). These visuals, that rely on components that farmers could rapidly relate to their actual circumstances (vegetation states, gradient of forest degradation in the landscape, etc.), facilitated the perception and understanding of key phenomena and simulations of landscape dynamics. The choice of a symmetric virtual landscape allowing the visualisation of contrasted management strategies enhanced the assessment of the consequences of decisions made by the players on landscape dynamics. The participants were comfortable with this abstract virtual landscape and never requested a more realistic spatial interface until the agreement on a concrete action plan. While the first cRPG-v1 simulation tool was mainly efficient in stimulating joint learning, the second version was more focused on facilitating the negotiation of a common action plan based on technical innovations introduced by the players. The more autonomous third version was tailored to facilitate communication between already experienced and new participants in the process. These successive versions of the cRPG tool demonstrated how the use of a first prototype creates new users' questions and related needs leading to an evolving process of collective learning and decision-making, up to the beginning of self-organisation in the last phase.

These flexible and rather simple models were designed and modified in a transparent way, and were used as boundary objects (Carlile, 2002; Vinck, 1999) in conflict mediation with the heterogeneous arena of stakeholders. They supported knowledge elicitation (by revealing hidden preferences) and stimulated exchanges of viewpoints and co-learning leading to improved trust. This facilitated joint decisions about the direction of the next steps and the related evolution of these frontier simulation tools. The implementation of this kind of very adaptive collaborative modelling approach places a great demand on ComMod modellers because they have to provide timely responses to stakeholders' changing demands. While being very productive and dedicated to the creation of useful models, this mode of trans-disciplinary collaboration is not easily compatible with the implementation of a research agenda bound by a classic project-based mode of operation.

Time management and the availability of the stakeholders concerned to take part at the right time in time-consuming joint activities, such as a series of gaming and simulation sessions is of paramount importance to create and maintain a productive momentum. This was a limitation in the case study reported here as farmers' priorities determined by the agricultural calendar and academic constraints faced by the main process facilitator cum doctorate student did not allow the implementation of key field activities at the most suitable time. Coding the successive versions of the cRPG tool under the computer simulation platform required special skills to be learned. This was also an obstacle to the timely delivery of the simulation tool meeting the stakeholders' successive shift of interest as field workshops needed to be postponed by a few months.

### *9.5.2 Organisation of stakeholder involvement and engagement*

#### Legitimacy of the intervention

The status of Chulalongkorn University at the national level and the backing of provincial authorities provided legitimacy to the research team when implementing an action research process in the area. The NNP agency made the initial request to the research team but its local leader at that time still refused to compromise with the herders regarding the co-ordination of cattle grazing and park management rules during the second cycle of the process. Consequently, the negotiation of a co-management plan took place between the Hmong herders and the NKU foresters, with district administrators and technicians acting mainly as observers. From a methodological point of view, plenary debates after simulation sessions were systematically associated with individual interviews with all the participants the following day. This promoted a rather equitable expression of all the participants' viewpoints. The interviews were also used to reinforce the relationship between the modelling process and actual circumstances in the field. The legitimacy of the process could be further improved if, as now proposed by the herders, village committee members and representatives of the well-funded and influential sub-district administration could also participate actively in the process. But for this to happen and to build on promising preliminary results, there is an urgent need to identify and train a local facilitator to replace the process designer and lecturer-researcher in this role.

#### Evolution of the stakeholders' arena

The heterogeneity of the stakeholders' arena taking part in the ComMod activities was mainly driven by the herders' willingness to play with NKU foresters in the first cycle and their subsequent request to involve land administrators and the DLD technician to monitor and ensure the foresters' accountability and to facilitate the introduction of a technical innovation. Following a third cycle focusing on strengthening the herders' participation, they seem ready to up-scale the process and are advocating the invitation of local administrators up to the sub-district level to take part in collaborative landscape management as well. This proposition is timely as a local facilitator should take over the key role of 'human interface' to increase the local ownership of the process, maintain its momentum and monitor it now that there is less need for new collaborative modelling and simulation inputs.

The cRPG tool used in the first sequences did not allow for the participation of many villagers in gaming and simulation sessions. But the autonomous ABM tool produced at the end of the third sequence allows the involvement of more interested people in a time- and cost-efficient way. The computer simulations of scenarios run with it are also going to be used to disseminate the results to more indirect stakeholders, like projects and other villages facing similar land use conflicts in the neighbourhood. The presentation of such simulations in Hmong language by engaged Doi Tiew herders who took part in the simulation workshops are particularly efficient and convincing.

Figure 9.5 shows the pertinence of using a logbook for qualitative and quantitative analyses of social dynamics and to critically reflect on the process implementation. More detailed visualisations of the intensity of interactions among the categories of participants, e.g. on a cycle-by-cycle basis, are useful, as well as the observation of the evolving centrality of the most active participants (Dumrongrojwatthana, 2010). Filling the logbook on a weekly basis is a somewhat tedious task, but powerful computer tools facilitate the construction of social network graphs and the analysis of their evolution over time. The logbook data can also be used to monitor coalition and power relation dynamics in collective landscape management processes.

### Engagement and collaboration of social and biophysical scientists

It is presently widely accepted that improved dialogue and integration of bio-technical and social science perspectives needs to be achieved in the context of sustainable landscape development. The case study reported here showed the usefulness of MAS models (either conceptual models, low tech RPGs or high tech ABMs) to integrate agro-ecological (vegetation dynamics in this case) and social (stakeholders' diversity and their interactions) knowledge. This modelling approach facilitates communication, mutual understanding and decision-making among researchers from different disciplines involved in the representation of a complex system to be examined with local stakeholders. The evolution of the conceptual model and its related simulation tools accompanies the gradually improved researchers' understanding of the land management system and feeds more exchanges across disciplines. Of particular interest are the phases during which hard choices have to be made to keep the model simple and focused on local stakeholders' interest. Each version of the model is associated with selected indicators used to assess simulation results. Usually one deals with the ecological dynamics, the evolution of the area under forest cover in this case study, while the other one looks at the agro-economic performance of the system (change in the size of the cattle population and the quality of the carcasses). Each member of the family of models built over time constitutes a milestone testifying this evolution of the shared representation of the system under study as influenced by the shift of interest and focus of their end users.

## 9.6 Conclusion

In a ComMod process, local stakeholders are in the driving seat and the course of action is uncertain. The engaged posture of the ComMod researcher could be uncomfortable in a classic project-based research context. This could be further complicated by the multiple roles played by a ComMod process designer and facilitator. As soon as it becomes feasible, it is preferable to let a local stakeholder manage the facilitation activities with the added advantage of increasing the local ownership of the process. But time is needed to identify the legitimate person with the right skills and to transfer the methodology and tools to her. Such a transfer is needed to achieve the objective of an acceptable balance between scientific and societal pursuits of collaborative landscape planning without jeopardising the ComMod researcher situation in academia. Another dilemma deals with the dissemination of this approach in a cost-efficient way. Relying on already trained stakeholders equipped with adapted simulation tools to train new participants can help address this challenge. But further methodological developments are still needed to use such an approach in multilevel processes encompassing larger areas.

## Acknowledgements

The authors are grateful to Dr. Christophe Le Page for his very dedicated assistance in the implementation of the simulation tools. They also thank the Challenge Program on Water and Food (CPWF) of the CGIAR, the Ecole Commod Project, Asia IT&C Programme of the European Union, the Science for Local Project under Chulalongkorn University Academic Development Plan, the Office of the Higher Education Commission of the Royal Thai Government, and the French embassy in Thailand for supporting this research.

## References

Barnaud, C., G. Trébuil, P. Dumrongrojwatthana and J. Marie, 2008. Area study prior to companion modelling to integrate multiple interests in upper watershed management of Northern Thailand. Southeast Asian Studies 45(4): 559-585.

Berkes, F. and C. Folke (eds.), 1998. Linking ecological and social systems: Management practices and social mechanisms for building resilience. Cambridge University Press, Cambridge; UK.

Bousquet, F. and G. Trébuil, 2005. Synergies between multi-agent systems and role-playing games in companion modeling for integrated natural resource management in Southeast Asia. In: Proceedings of the International Conference on Simulation and Modeling 2005 (SimMod 2005), 17-19 January 2005, Rose Garden Aprime Resort, Bangkok, Thailand, pp. 461-469.

Bousquet, F., O. Barreteau, C. Le Page, C. Mullon and J. Weber, 1999. An environmental modelling approach. The use of multi-agent simulations. In: F. Blasco, A. Weill and F. Paris (eds.), Advances in environmental and ecological modelling. Elsevier, Paris, France, pp. 113-122.

Bousquet, F., G. Trébuil and B. Hardy (eds.), 2005a. Companion Modeling and Multi-Agent Systems for Integrated Natural Resource Management in Asia. Cirad & International Rice Research Institute, Los Baños, Laguna, Philippines, 360 pp.

Bousquet, F., G. Trébuil, S. Boissau, C. Baron, P. d'Aquino and J.C. Castella, 2005b. Knowledge integration for participatory land management: The use of multi-agent simulations and a companion modelling approach. In: A. Neef (ed.), Participatory approaches for sustainable land use in Southeast Asia. White Lotus, Bangkok, Thailand, pp. 291-310.

Bousquet, F., J.C. Castella, G. Trébuil, C. Barnaud, S. Boissau, S.P. Kam, 2007. Using multi-agent systems in a companion modelling approach for agro-ecosystem management in South-east Asia. Outlook on Agriculture 36(1): 57-62.

Carlile, P., 2002. A pragmatic view of knowledge and boundaries: Boundary objects in new product development. Organization Science 13: 442-455.

Collectif ComMod, 2009. La posture d'accompagnement des processus de prise de decision: les references et les questions transdisciplinaires. In: D. Hervé and F. Laloë (eds.), Modélisation de l'environnement: entre natures et sociétés. Éditions Quae, France, pp. 71-89.

ComMod group, 2003. Our Companion Modelling approach. Journal of Artificial Societies and Simulation 6 (1). Available at: http://jasss.soc.surrey.ac.uk/6/2/1.html.

Dumrongrojwatthana, P., 2010. Interactions between cattle raising and reforestation in the highland socio-ecosystem of Nan province, northern Thailand: A companion modelling process to improve landscape management. Unpublished doctorate thesis, Paris Ouest Nanterre La Défense University, Paris, France, 345 pp.

Dumrongrojwatthana, P., C. Le Page, N. Gajaseni and G. Trébuil, 2009. Co-constructing an agent-based model to mediate land use conflict between herders and foresters in northern Thailand. Proceedings of the 24th Annual Landscape Ecology Symposium, Landscape Patterns and Ecosystem Processes. April 12-16, 2009. The Cliff Lodge, Snowbird, UT, USA. p 55.

Funtowicz, S.O. and J.R. Ravetz, 1993. Science for the post-normal age. Futures 25: 739-755.

Holling, C.S., 2001. Understanding the complexity of economic, ecological and social systems. Ecosystems 4(5): 390-405.

Jones, N.A., P. Perez, T.G. Measham, G.J. Kelly, P. d'Aquino, K. Daniell, A. Dray and N. Ferrand, 2009. Evaluating participatory modeling: Developing a framework for cross-case analysis. Environmental Management 44: 1180-1195.

Langton, C.G., 1992. Life at the edge of chaos. In: C.G. Langton, C. Taylor, J.D. Farmer and S. Rasmussen (eds.), Artificial life II, Addison-Wesley, Reading, MA, USA, pp. 41-91.

Liu, J., T. Dietz, S.R. Carpenter, M. Alberti, C. Folke, E. Moran, A.N. Pell, P. Deadman, T. Kratz and J. Lubchenco, 2007. Complexity of coupled human and natural systems. Science 317: 1513-1516.

Ollagnon, H., 1989. Une approche patrimoniale de la qualité du milieu naturel. In: N. Matthieu and M. Jollivet (eds.), Du rural à l'environnement: la question de la nature aujourd'hui. L'Harmattan, Paris, France, pp. 258-268.

Ostrom, E., 2005. Understanding institutional diversity. Princeton University Press, Princeton, NJ, USA. 376 pp.

Ostrom, E., R. Gardner and J. Walker, 1994. Rules, games and common-pool resources. University of Michigan Press, Ann Arbor, MI, USA.

Röling, N.G., 2002. Beyond the aggregation of individual preferences: Moving from multiple to distributed cognition in resource dilemmas. In: C.S. Leeuwis and R. Pyburn (eds.), Wheelbarrows full of frogs: Social learning in rural resource management. Royal Van Gorcum, Asen, the Netherlands, pp. 25-47.

Röling, N.G. and M.A. Wagemakers, 1998. A new practice: Facilitating sustainable agriculture. In: N.G. Röling and M.A. Wagemakers (eds.), Facilitating sustainable agriculture: Participatory learning and adaptive management in times of environmental uncertainty. Cambridge University Press, Cambridge, UK, pp. 3-22.

Ruankaew, N., C. Le Page, P. Dumrongrojwatthana, C. Barnaud, N. Gajaseni, A. Van Paassen and G. Trébuil, 2010. Companion modeling for integrated renewable resource management: a new collaborative approach to create common values for sustainable development. International Journal of Sustainable Development and World Ecology 17(1): 15-23.

Scott, J.C., 2009. The art of not being governed: An anarchist history of upland Southeast Asia. Yale Agrarian Studies Series, Yale University Press, New Haven, CT, USA. 442 pp.

Van Paassen, A., C. Barnaud and I. Patamadit, 2008. Rethinking participatory research in renewable resource management. Proceedings of the World Congress of the International Association for Media and Communication Research (IAMCR), Stockholm, Sweden.

Vinck, D., 1999. Les objets intermédiaires dans les réseaux de cooperation scientifique. Contribution à la prise en compte des objets dans les dynamiques sociales. Revue Française de Sociologie XL(2): 385-414.