CHAPTER VII
COMPANION MODELLING APPROACH AND METHODOLOGY

In the field of integrated renewable resource management (IRRM), complexity and problems are consequences at macro level emerging from diverse individual human-environment interactions. Understanding such interactions, particularly from the demand side or resource users, is needed to discover a practical development that is likely to be accepted and adopted by concerned users. However, this understanding varies due to multiple stakeholders (scientists, decision-makers, and different local resource users etc.) with different objectives, perceptions, interests etc. and involvement at multiple scales (individual and institutional level). Building a shared representation of a complex system focusing on problems being examined among these stakeholders is an important stage prior to launching an IRRM program.

The companion modelling (ComMod) approach for renewable resource management (RRM) is a highly interactive collaborative modelling process. For the ComMod process, such a shared representation can be constructed by researchers in collaboration with local stakeholders through a continuous co-learning, knowledge exchange and dialogue enhancement. Through the process, stakeholders better understand each other as well as becoming more comprehensive in their investigations into problematic situations. Based on such a shared representation, possible solutions of their choice can be collectively identified and explored through the use of simulations (Trébuil, 2008). Through the process, trust among stakeholders is also built leading to the development of more practical and acceptable IRRM. In this chapter, I present the origin of ComMod, its methodology, and recent topics of concern and interest regarding the ComMod approach and its use.

7.1. Origin of Companion Modelling

Since 1993, the GREEN research team (management of renewable resource and environment) founded by Dr. Jacques Weber has been developing modelling activities to better understand the interactions between social and ecological dynamics. This group of researchers considered that the existing methodologies of the 1980s to study IRRM were always drawn from either the angle of "an ecological system subjected to anthropologic disturbance" by ecologists, or the angle of "a social system subjected to natural constraints" by economists. GREEN research team looks at IRRM in a more integrated and inclusive way through the design of a trans-disciplinary research approach that investigates the co-viability of ecological and social dynamics by eliciting key interactions among heterogeneous stakeholders having diverse interests, perceptions and decision-making processes on a given problem (Figure 7.1).

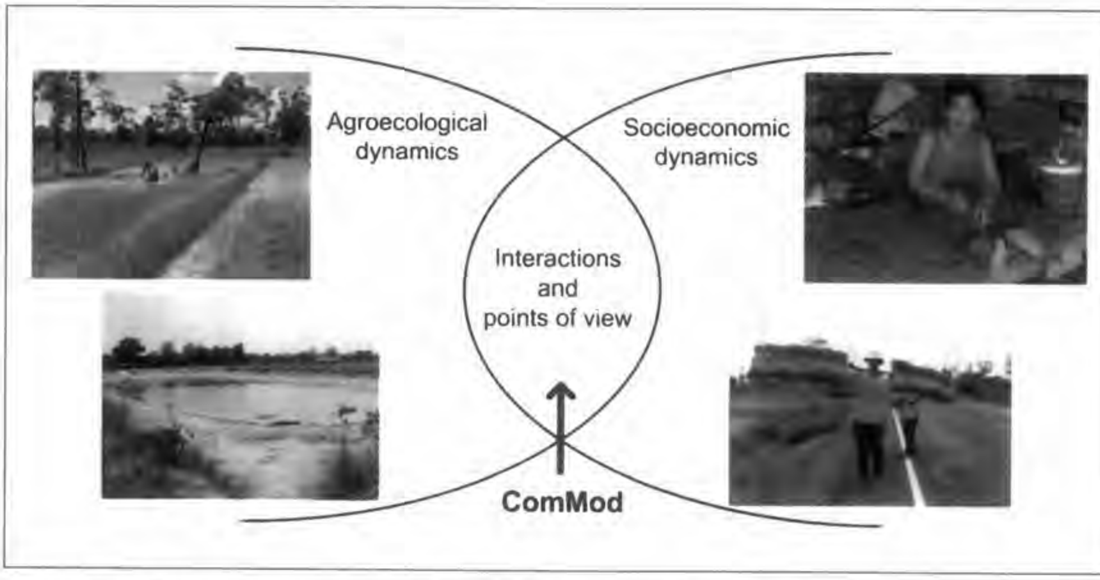
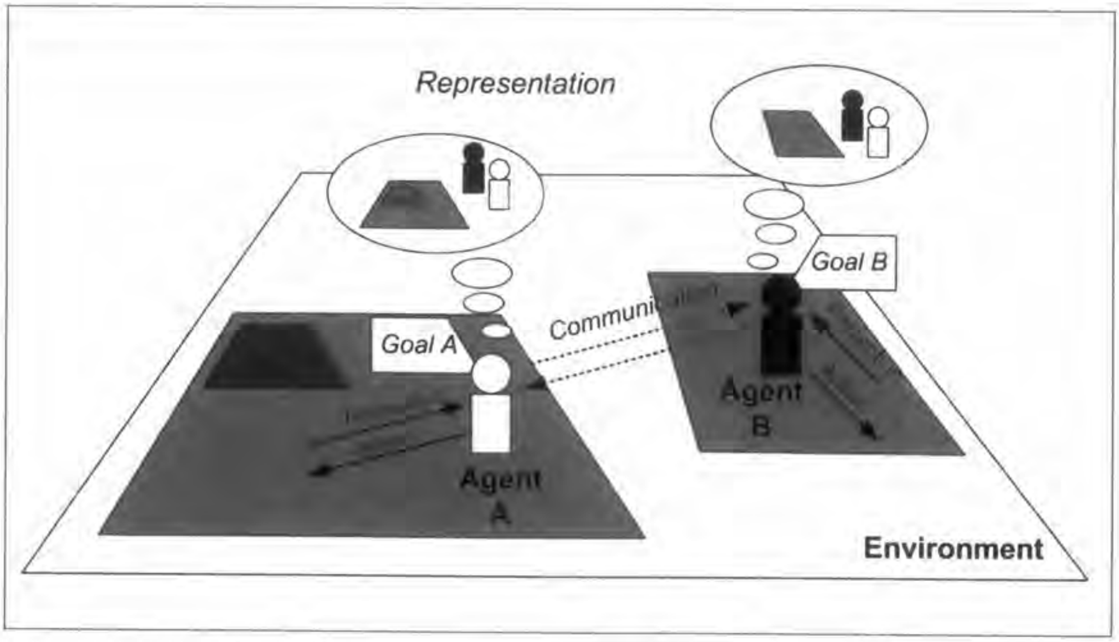


Figure 7.1 Schematic representation of the focus of ComMod.

The researchers' objective is to try to understand the interactions between these key processes. Because of the complexity of current RRM problems and the rapidity of change, system modelling needs to be used at a time when innovative powerful tools emerging from computer science are available to represent human-environment systems and simulate their co-evolution (Trébuil, 2008). Through the construction of a model, knowledge sharing between stakeholders can be facilitated leading to the integration of knowledge from various sources.

This team selected Multi-Agent System (MAS), a domain of distributed artificial intelligence, to develop their modelling tools because the MAS concept also focuses on interactions among different agents who have different representations of the common system to be managed (Figure 7.2). An agent is a computer system that is situated in some environment, and that is capable of autonomous action in this environment in order to meet its designed objectives. An agent can be described as autonomous because it has capacity to adapt when its environment changes (Wooldridge, 1999). The coordination of actions or the construction of systems are consequences of interactions between relatively independent and autonomous agents, which operate within communities in accordance with what are sometimes complex modes of operation, conflict and competition in order to survive and perpetuate themselves. Organized structures emerge from these interactions, which in turn restrict and modify the behaviours of the agents (Ferber, 1999). MAS can simplify problem-solving by dividing the necessary knowledge into subunits, by associating an intelligent independent agent to each subunit, and by coordinating these agents' activities (Bousquet and Le Page, 2004).



Source: adapted from Ferber 1999.

Figure 7.2 Schematic representation of a Multi-Agent System.

Historically, one of the first ComMod experiment was carried out in Senegal River valley to study the viability of irrigated systems with a scientific model (SHADOC) presented to local farmers as a RPG (Barreteau et al., 2000). The core purposes were to understand how different coordination patterns among heterogeneous stakeholders affect the viability of their common irrigated system, to encourage them to discuss their irrigation schemes, and to support the improvement of coordination within irrigated systems. The conceptual model, SHADOC, was translated into three different artefacts aimed at specific purposes.

To better understand the dynamics of the system, the conceptual model was implemented into the computer-based MAS-SHADOC, also called SHADOC. It was designed to simulate scenarios with different operational rules in an irrigated system. To introduce it to rice growers, the SHADOC model was translated into an RPG, thus fulfilling a second purpose: to communicate the content of the conceptual model with concerned stakeholders. Afterwards, another computer MAS was developed based on the structure and rules implemented in the RPG. It aimed at testing the possibility of using it as a negotiation tool in a group discussion leading to the formulation of collective rules for the collective management of an irrigated system. In this experiment, the RPG opened the black box (Barreteau, Bousquet et al., 2001) in MAS simulations while MAS simulations allowed participants to better understand the overall behaviours of the system under different conditions.

Following the SHADOC case study, the SelfCormas experiment was also conducted in Senegal (d'Aquino et al., 2003) as a collective conception of the model that aimed to facilitate discussion on decentralized land allocation issues among local and representative stakeholders. This time, the main objective was to test directly the design of these modelling tools by stakeholders, with as little prior design work by the modellers as possible. First, players designed a game according to their own representation of their territory. The "self-design" experiments were organized in field workshops. Then researchers were able to organize a gaming session to help participants simulate a scenario by using their self-designed RPG.

These two experiments demonstrated the potential for the joint-use of RPG and ABM. This combining of the associated tools (RPG-ABM), in interaction with field work in a collaborative modelling process aiming to facilitate stakeholders' knowledge exchange about IRRM in complex systems was called "Companion Modelling" (ComMod) by the GREEN research team.

In Thailand, ComMod and Integrated Natural Resource Management (INRM) was first introduced in late 1998 with the first training course in Asia organized by CIRAD at the Multiple Crop Centre (MCC), Faculty of Agriculture, Chiang Mai

University. Following this first training course, several short training courses sponsored by CIRAD, IRRI and the Asia IT&C program of EU were organized in Thailand. Researchers and lecturers from different academic backgrounds working in South and Southeast Asian countries participated in these workshops. Several of them decided to apply the ComMod approach in their research projects.

The first ComMod case study in Thailand looked at land use change due to the expansion of sugarcane plantation in upper paddy fields of Nam Phong district, Khon Kaen province (Suphanchaimart, Wongsamun et al., 2005). Another pioneer case study was conducted in the Akha village of Mae Salaep of Mae Fah Luang district, Chiang Rai province. In this experiment, a sophisticated MAS model was first implemented by researchers. It was later converted into a simpler RPG to allow local highland farmers to be able to validate the model and to examine the risk of land degradation through soil erosion in parallel with the commercialization of the local farming systems (Trébuil, Shinawatra-Ekasingh et al., 2002).

After several years of experience and the implementation of several case studies on various resource management topics on different continents (Asia, Europe, Australia, Africa), a ComMod network of practitioners was founded in 2003. Its initial purpose was to clarify the scientific posture to define a deontological framework for guiding the correct use of ComMod when dealing with multi-actor processes. The first version of the ComMod charter was published in 2003 (Barreteau, 2003a).

7.2. Companion Modelling Approach

The following section presents the theories related to ComMod. ComMod principles, objectives, methodology and tools used were also explained.

7.2.1. Main Theoretical References

Several theoretical references inspired the development of the ComMod approach and support its operating principles.

7.2.1.1. The Science of Complexity

Complexity is usually referred to a condition of numerous elements in a system with numerous forms of relationships among the elements (Nicolis et al., 1989). Definition of complexity is often tied to the concept of a 'system'. Complex systems tend to be high-dimensional, non-linear and hard to model. They can be biological, economic and technological systems etc., or in fact, a mixture of them. In a complex system, the properties at macro level emerge from interacting components and therefore, cannot be observed at individual or micro level (Janssen, 2002). The science of complexity highlights that the behaviour of a complex system due to emergence and self-organization is dynamic, uncertain, and unpredictable. The ComMod approach attempts to better understand interactions among system components that cause changes in a complex system, and modify them to explore how to lead the system towards more desired states through simulations. Through the modelling process, ComMod field collaborators (farmers, researchers etc.) are able to adapt themselves to better manage the system once they are facing the changes. Such adaptive management can protect the system from collapse.

7.2.1.2. Resilience and Adaptive Management

The definition of resilience can be considered in two disciplines. First, the engineering resilience refers to efficiency, control, constancy, and predictability - all attributes at the core of desires for safe and optimal performance. The second definition of ecological resilience focuses on persistence, adaptiveness, variability, and unpredictability - all attributes embraced and celebrated by those with an evolutionary or developmental perspective. The Canadian ecologist C. S. Holling emphasized the differences between these two definitions as tradeoffs between efficiency on the one hand and persistence on the other, or between constancy and change, or between predictability and unpredictability. Resilience is defined as the capacity that an ecosystem can tolerate the disturbance without collapsing and return to a single steady or cyclic state. This definition of resilience assumes that behaviour of a system remains within the stable domain that contains this steady state.

Resilience is conferred in human and ecological systems by adaptive capacity, which, in ecological systems, is related to genetic diversity, biological diversity, and the heterogeneity of landscape mosaics (Carpenter and Gunderson, 2001; Gunderson and Holling, 2002). In social systems, the adaptive capacity refers to the existence of institutional social networks that learn and store knowledge and experience, create flexibility in problem solving and balance power within and among social groups (Berkes, Colding et al., 2003). Adaptive management identifies uncertainties, and then establishes methodologies to test hypotheses concerning those uncertainties (Walters, 1986). Several managing tools are used not only to change the system, but as tools to learn about the system. The need for learning and the cost of ignorance are major concerns, while traditional management is focused on the need to preserve and the cost of knowledge. Adaptive management implies flexibility, diversity, and redundancy in regulation and monitoring activities leading to corrective responses and experiential probing of the ever changing circumstances of a SAES.

Resilience can be achieved by an adaptive management capacity that can determine how vulnerable the system is to unexpected disturbances and surprises that can exceed or break the system. (Holling, 2001). ComMod was inspired by the adaptive management approach, recognizing that adaptive capacity is dependent on knowledge generated by a co-learning process: essentially, through free exchange among different actors (Bousquet and Trébuil, 2005). Therefore, such knowledge exchange can result in the integration of diverse points of views. Through the co-learning process, a proposed management model can be collectively agreed upon among multiple actors.

7.2.1.3. Collective Management of Multi-actor Processes

Collective action is the pursuit of a goal or set of goals by more than one person. It is a term that has formulations and theories in many areas of the social sciences. Theories of collective action emphasise how group behaviour can, in some sense, be linked to social institutions. Collective action, or "actions taken by two or more people in pursuit of the same collective good" are typically framed as resulting in some shared outcome, or public goods (Bimber, Flanagin et al., 2005). ComMod emphasizes coordination and negotiation mechanisms among stakeholders through continual collective exchange and learning processes through interactions within social networks; from such interactions, solutions emerge. The knowledge is also constructed through the collective learning processes as defined in constructivism.

7.2.1.4. Constructivist Epistemology

Constructivism is an epistemology supporting the learning process, and views all of my knowledge as "constructed". It assumes that reflecting any external "transcendent" realities is not necessary, and convention, human perception and social experience is contingent. The common thread between all forms of constructivism is that they do not focus on an ontological reality, but instead on the constructed reality. Reality appears as something actively constructed (Röling et al., 1998) and is often perceived and managed differently by individuals depending on their perceptions of the environment, which in turn may lead to conflicts. ComMod realizes the importance of different stakeholders' perceptions when looking at a common IRRM problem. ComMod attempts to integrate not only various scientific disciplines, but also the various points of views of local stakeholders into a shared representation regarding the problem at stake through a communication and social learning process.

7.2.1.5. Post-normal Science

Post-normal science characterizes a methodology of inquiry that is appropriate for cases where "facts are uncertain, values in dispute, stakes high and decisions urgent"(Funtowicz and Ravetz, 1993). It is primarily seen in unpredictable long-term issues where we possess less information than we would like. Post-normal science postulates that works (research, development of action plans etc.) based exclusively on scientific knowledge under normal science cannot deal with conditions of high uncertainty. It is necessary to promote the communicative rationality on the basis of shared learning, collaboration, and the development of consensus about action to take between experts and local people (Röling et al., 1998). The role of interdisciplinary teams, including natural and social scientists, is to understand and strengthen collective decision-making processes through a platform of interactions among stakeholders. ComMod takes into account such roles to support the integration of interdisciplinary knowledge from diverse sources (local, expert and scientific ones). In the ComMod approach, shared learning between stakeholders is supported through the use of mediation tools such as RPG and ABM that evolve through the collaborative modelling process. As a consequence, stakeholders better understand their situation and each other, and a common representation about problems being examined by stakeholders is also developed through the evolving mediation.

7.2.1.6. Patrimonial Mediation

The patrimonial approach is defined by Ollagnon (1991) 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". Patrimonial mediation contributes to the understanding and practice of co-management of renewable natural resources. Mediation is a negotiation approach that brings in a neutral party to facilitate agreement among different parties in conflict. From the patrimonial mediation approach, ComMod was influenced by the importance given to its analysis of a system's evolution in the search for acceptable solutions to common problems.

7.2.2. Principles and Objectives of ComMod

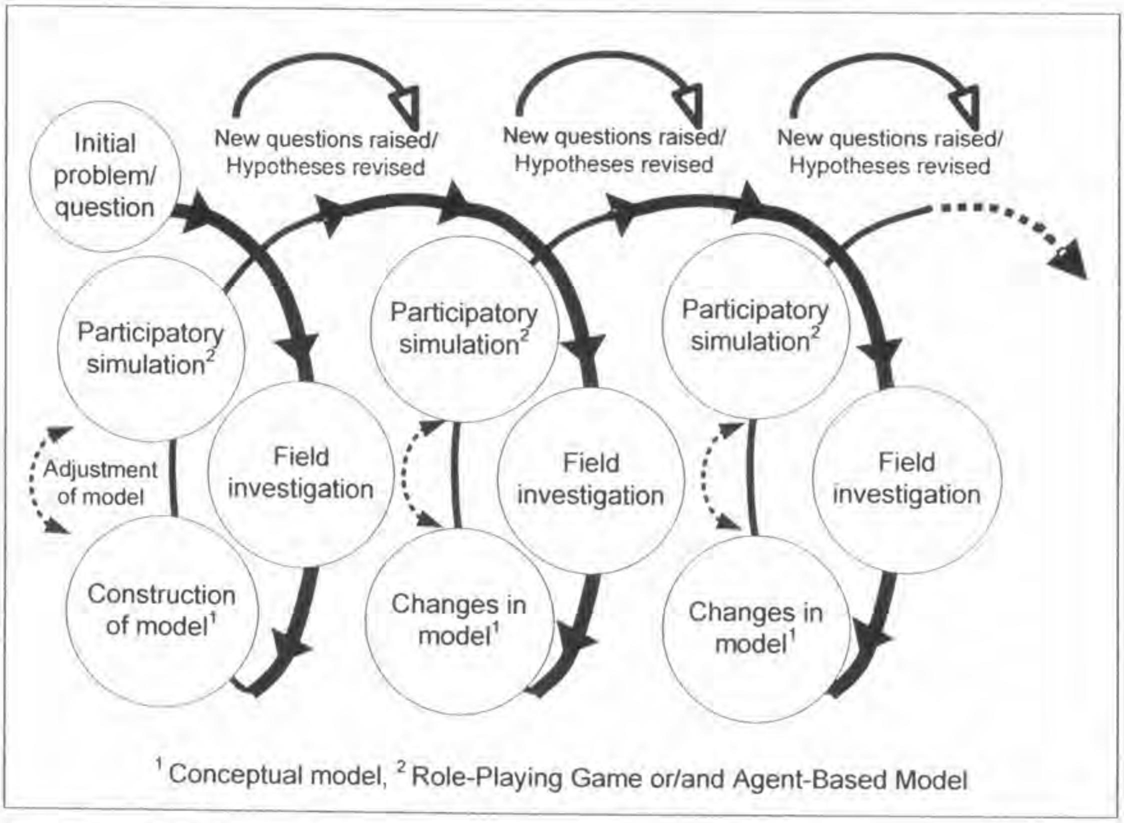
7.2.2.1. Fundamental Characteristics of ComMod Approach

a. Researchers' posture:

ComMod is an action-oriented research approach that always involves multiple stakeholders throughout the process to ensure that the diverse perceptions of a given common RRM problem are included. Because we are dealing with complex and very dynamic research objects, which are uncertain, and consist of multiple and legitimate points of view, the ComMod researcher becomes an actor of the system under study, and a facilitator of exchange among participating stakeholders. The researcher plays a dual role: (i) to generate new knowledge on a system or on the ComMod approach itself, and (ii) being an actor of the system, to improve it through changes in the stakeholders' perceptions, interactions, and actions (Trébuil, 2008). Therefore, the ComMod researcher needs to avoid the risk of manipulating local actors, or being manipulated by them. To respond to such concerns, the ComMod charter recommends the systematic monitoring of the effects and impact of ComMod activities, and the hypotheses made in the ComMod process should be transparent and explicit to all participating stakeholders.

b. A back and forth iterative and continuous process between laboratory and field activities:

ComMod calls for continuous and iterative confrontation between theory and reality. It is based on iterative back and forth phases between the laboratory (model implementation), and field activities (interviews, specific field surveys, and/or participatory modelling and simulation workshops) generating a succession of evolving loops (Figure 7.3).



Source: adapted from Barnaud, 2006.

Figure 7.3 Representation of a ComMod process.

There are three main stages in a ComMod process that can be repeated as many times as needed (Bousquet et al., 2005).

1. Field investigations and a literature search supply information and help to generate explicit hypotheses for modelling by raising a set of initial key questions to be examined by using the model.

2. Modelling, that is, the conversion of existing knowledge into a formal tool to be used as a simulator.
3. Simulations, conducted according to an experimental protocol, to challenge the former understanding of the system and to identify new key questions for new focused investigations in the field.

7.2.2.2. Dual Objectives and Specific Contexts of the ComMod Approach

When practicing the ComMod approach, two objectives are: (i) to develop simulation models integrating various stakeholders' points of view to improve understanding of interactions related to a RRM problem being studied; and (ii) to use simulation models within the context of platforms for collective learning to facilitate dialogue among multiple stakeholders, and support coordination and negotiation processes leading to collective decision and action plans to mitigate RRM problems. Thus, ComMod can be used in two specific contexts.

a. Knowledge production on a complex system:

The context of knowledge production depends on a special relationship between actual circumstances in the field and the model. Such knowledge can be built through the co-construction of a shared representation of the system in forms of models. These models can be conceptual ones, represented by diagrams, RPGs, ABMs, or a combination of various types. In general, the researcher starts by formalizing the existing knowledge to diagrams called Unified Modelling Language[10] (UML) (Fowler, 2004). These UML diagrams are subsequently implemented into RPGs and/or ABMs that are used by research teams to facilitate group model building among stakeholders. The discussions lead to new knowledge and questions, forcing the researcher to revise his/her initial hypotheses and enrich the conceptual model. This cyclic process generates a family of models representing the outcomes of repeated interactions between researchers and field collaborators. Models also aim at seeking mutual recognition. Such mutual recognition is gradually and collectively perceived during the model implementation in the collaborative modelling process.

b. Facilitation of collective decision-making in a complex system:

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[10] The Unified Modelling Language (UML) is a family of graphical notations, backed by single meta-model, that help in describing and designing software systems.

This second specific context implies methodological research to facilitate the joint management of a complex system. ComMod intervenes upstream of any technical decision to support the deliberation of concerned actors towards the production of a shared representation of the problem at stake. Based on such a shared representation, stakeholders are able to identify possible collective management to mitigate the problem. The ComMod process tries to support the management of ecological and social uncertainty by local actors. While guiding them towards an agreement on desirable long term objectives through the collective exploration of scenarios, it prepares them to be ready to adjust their behaviour and actions on the way, in agreement with the principles of an adaptive management approach. ComMod does not include the other possible steps of the mediation process, particularly those dealing with more quantitative expertises (Bousquet et al., 2005).

7.2.3. Main ComMod Methodological Steps in Association with Key Tools Used

The ComMod methodological phases, and choices of tools used are, in fact, very flexible. Five phases presented in this section are commonly implemented. But it is not obligatory for ComMod practitioners to exactly follow these phases. Adjustment and rearrangement may happen depending on the context of each case study at a given time, and on the evolution of the process.

7.2.3.1. Initialization of a ComMod Process

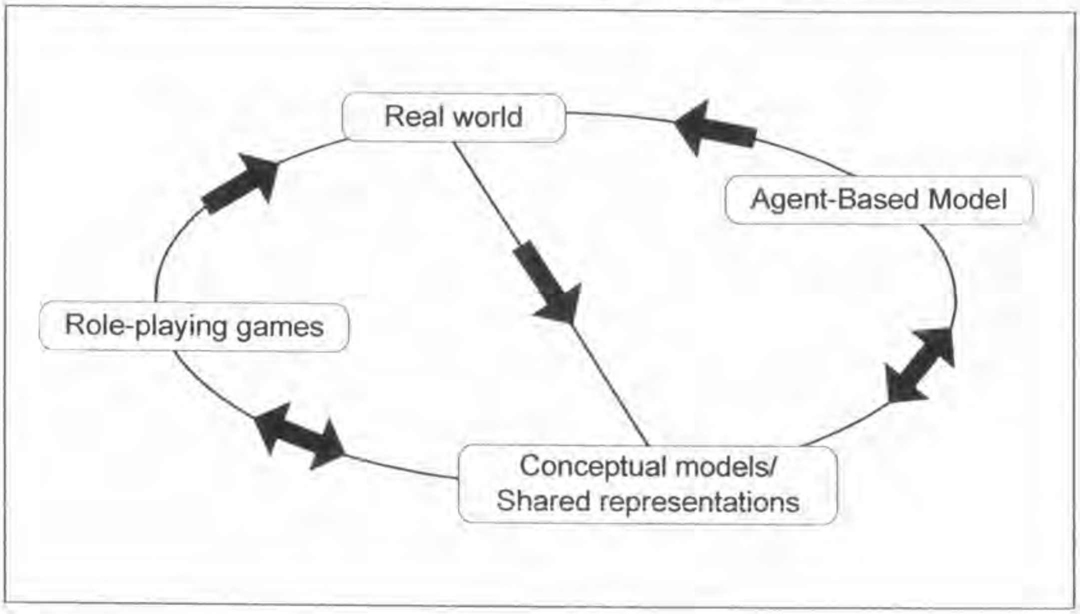
Stakeholder involvement is needed as early as possible, even if it is in the initial stages prior to launching the ComMod process. First, definitions of problematic issues or questions to be examined have to be precisely defined. Then, it is beneficial for the researchers to acquire from stakeholders enough information about human-environment interactions related to the defined problems and questions formulated in the first step. This information also fills gaps in the researchers' knowledge. At the same time, stakeholders are also clearly informed about the types of activities that they are about to engage in the ComMod process. Moreover, this initialization provides a chance for the researchers to be more conversant with potential future participants in the ComMod process. Several techniques (agrarian system diagnosis, stakeholder analysis etc.) are used to establish such a preliminary knowledge, and mutual trust. These preliminary findings during the initialization are useful to formalize an initial conceptual model, and to select appropriate participants for the subsequent ComMod process.

7.2.3.2. The Co-construction and Conceptualization of Models with Stakeholders

This step is considered the entry point of the ComMod process that usually starts from conceptualization followed by the construction of a RPG and ABM. The preliminary knowledge is usually elucidated in the conceptual model through the use of UML diagrams. UML diagrams have proved that they are useful in encouraging participants to exchange their arguments. UML diagrams are a family of graphical notations, backed by a single meta-model, that help in describing and designing software systems, particularly software systems built using the object-oriented (OO) style. Furthermore, UML diagrams are useful to verify whether the model implemented is working (Fowler, 2004; Rumbaugh, Jacobson et al., 1999). UML diagrams are grouped into two main types: static and dynamic diagrams. The structure and relationship between components in a system is usually represented by a static UML class diagram. Meanwhile, the dynamic part of the system such as decision-making processes is often depicted by UML sequences and/or activity diagrams.

7.2.3.3. Implementation and Validation of ComMod Models

Based on the initial conceptual model, a simple RPG or/and ABM are implemented to be used in gaming or /and participatory simulation sessions (Trébuil, 2008). Figure 7.4 shows the linkage and cyclic use between RPG and ABM in ComMod methodology. A number of studies have employed RPG as a mediation tool to synthesize stakeholders' perceptions toward the current situation including decision-making rules to accomplish a given task under a given environment assigned in the game. Outputs from the game are used for validation and improvement of the model. The model is then used as a tool for scenario exploration with stakeholders. Neither the types of tools, nor sequence and number of their use is restricted in the ComMod methodology. Other tools like GIS, surveys, interviews, debate, and small focus group discussion, are also used as needed. Different combinations of tools are used depending on the objectives set for a field activity. In general, the RPG is used when the objective is to examine interactions among participants, and data acquisition, while the ABM is usually used for data elicitation, and scenario exploration.



Source: Barreteau, 2003b.

Figure 7.4 Linkage between actual circumstances, the conceptual model and its use in role-playing games and agent-based models in the ComMod approach.

Regarding model validation purposed by Gilbert (2008), two areas need to be examined when validating models: (i) the fit between a theory and the model of that theory, and (ii) the fit between the model and the real-world phenomenon that the model is supposed to simulate. The first one is evaluated by comparing the distribution of expected simulated results with a variety of parameter settings to a number of propositions about the form of the relationships expected between variables derived from theory used. Comparing the model and empirical data is another validation technique. In cases where abstract models[11] , whose objective is the development of theory, are used, no empirical data are needed to compare with the model. For the middle range models[12], the criterion is if the simulation generates

[11] Abstract models aim to demonstrate some basic social process that may lie behind many areas of social life. These models are not intended to be used as empirical descriptions of any real-world phenomenon. They are seen as part of the process of the development of a theory

[12] Middle range models aim to describe the characteristics of a particular social phenomenon, but in a sufficient way that their conclusions can be applied widely, rather than just one set of circumstances. The generic nature of these models means that it is not usually possible to compare their behaviours exactly with any particular observable instance. Instead, one expects to be satisfied with qualitative resemblances.

outputs that are qualitatively similar to those observed in the social world. It is only the facsimile models[13] that require empirical data to be compared to simulations. In this case, the model is the regression equation which computes the predicted values of the dependent variable. Models implemented through a ComMod process are often classified as middle range models.

RPGs and ABMs are the most frequently used tools, usually in association, because of their similarities derived from the same conceptual model. RPGs and ABMs are particularly well-suited to representing complex situations and doing prospective studies, as they are able to incorporate randomized and somewhat unpredictable dynamics. Actually, RPGs are models of actual situations, and they are much closer to reality and easier for people to use than ABMs. However, RPGs are rather cumbersome to build and operate, quite costly to use, and cannot be used to provide continuous support in evolutionary decision-making processes. Moreover, RPGs do not allow the set up of sufficiently incremental and iterative processes that progressively integrate new information and knowledge. Thus, RPGs are usually used to help participants engage in the design of the model as well as to facilitate their understanding of ABMs to be used later for simulations.

The RPGs are thus able to simulate scenarios that are imagined by participants and to generate group discussion of possible interactions between users and resources. ABMs are used to explore issues more rapidly and systematically, with the richer and more incremental processes. Based on the SelfCormas experiments RPGs were tested as a progressive way of designing novel ABMs that are more suitable for integrating perceptions of the people involved.

Because of the similarities between these two tools, it is possible for participants to relate to the RPG to ABM and the system under study. Playing games can help participants to understand the structure and operations implemented in the ABM, and reduce its "black box effect" for participants. Table 7.1 summarizes the importance of the initial conceptual model and proposes a classification of situations based on mode of association between the conceptual model, the RPG, and the ABM.

[13] Facsimile models are intended to provide a reproduction of some specific target phenomenon as exactly as possible, often with the intention of using it to make predictions of the target's future state, or to predict what will happen if some policy or regulation is changed.

Table 7.1 Classification of types of joint use of an agent-based model and of a role-playing game based on the differences and similarities of their conceptual models and time of use.

The conceptual model is	*Different*	*Same*
ABM and RPG are used at the same time	• ABM supports the game • ABM included into the game • The game is a communication tool between ABM and reality	• The game is the model
ABM and RPG are used in succession	• The game helps to learn how to use the ABM	• ABM of the game to replay gaming sessions • Game used to design ABM • Game used to validate ABM • ABM used to design the game • Co-construction of ABM and the game

Source: Barreteau, 2003b

Special attention is drawn to the validation process of the models. Since concerned stakeholders are involved throughout the research process, the co-designed models are consistently and collectively validated by these participating stakeholders. ComMod relies on simulation tools to implement such participatory analyses and scenario explorations, to facilitate individual and collective learning, as well as to mediate conflicts and to engage people in negotiating collective action. Therefore, ComMod models (RPGs or ABM) are mainly seen as short-lived simulation tools built to facilitate communication among stakeholders through the exchange of their multiple points of view and perceptions of phenomena on a given issue and at a given time.

7.2.3.4. Scenario Identification, Exploration and Assessment

Through the ComMod process, participants are usually able to relate the virtual world to real circumstances. Their creativity also increases, enabling them to identify interesting scenarios to be simulated to discover their possible choices of RRM. ABMs are favoured in this activity because they are far more time and cost efficient than RPGs for such a purpose. The ABM can run faster, is repeatable, and presents more synthetic outputs (maps, histograms, diagrams spreadsheets, etc.) with better visualization. These benefits leave more time for their joint assessment that is generally organized in either small homogeneous groups of stakeholders, or in a plenary session.

7.2.3.5. Monitoring and Evaluation (M&E) of ComMod Effects and Impact

There is not yet a specific M&E methodology to assess the effects and impact of such highly interactive and dynamic ComMod processes. But during 2006-2008, a project specifically addressing this M&E issue was carried out. This M&E methodology will look at the various ComMod effects on the participants in terms of learning on the system, on oneself and others, and their interdependence, on the ecological and social dynamics, but also on changes in communication (social network), perceptions, decision-making, behaviour, and finally, practices (Gurung, Promburom et al., 2008).

Regarding activities implemented in a ComMod sequence, Le Page proposed a more detailed 12 stage sequence, highlighted in the following box (Box7.1).

Box 7.1 A ComMod sequence with 12 stages.

1. Sensitizing activities: introduction of the ComMod approach to key stakeholders requesting to look into a given development question, and assessment of its suitability and possibility for use in the local context.
2. Definition of the key question to be examined, by the process leaders and, sometimes, other stakeholders as well.
3. Inventory of relevant scientific, expert, and indigenous knowledge available through literature review & complementary diagnostic surveys to fill the gaps.
4. Knowledge elicitation for modelling via surveys and interviews.
5. Co-design of the conceptual model with stakeholders concerned by the question being examined.
6. Choice of the tool (computer-based or not) and model implementation.
7. Model verification, validation and calibration with local stakeholders.
8. Identification and definition of scenarios with local stakeholders.
9. Exploratory simulations with local stakeholders.
10. Dissemination of the outputs to stakeholders who did not participate in the process.
11. Monitoring - evaluation of the effects of the ComMod process on participants (awareness, knowledge, communication, behaviour, decisions, practices, etc.)
12. Training of interested stakeholders on using the tools produced during the collaborative modelling process.

Source: Personal communication with Christophe Le Page, a pioneering ComMod practitioners.

7.3. Current Hot Topics on ComMod

Up-scaling and out-scaling

As a bottom-up approach, ComMod and its tools used often begin to tackle a problem at the individual level to create a shared representation of an aggregation of individuals. Most ComMod case studies are site and context specific. This has brought about robust discussion on the hot topic of dealing with the possible scaling-up and scaling-out the use of ComMod process and tools. Scaling-up is an institutional expansion, based on positive feedback, from adopters (often grassroots organizations) to other key stakeholders (policy makers, donors, development institutions) who have the power to out-scale the process (Prell et al., 2007). Scaling-out is the spread of project outcomes (i.e., changes such as the use of a new technology, a new strategy, etc.) from farmer to farmer, community to community, within the same stakeholder groups. In other words, scaling-up is the process by which policies, norms, mental models, etc., change in such a way as to support a scaling-out (adoption) process.

The possibility to upscale the use of ComMod approach is being examined. A case study in Nan province, northern Thailand, investigated the conflict between the National Park authority and villagers over forest resources, which was so high that they rarely communicated to each other. ComMod and a hybrid simulator (RPG-ABM) successfully initiated the communication between these two groups of stakeholders (Ruankaew, Le Page et al., 2008). The case study has shown that the National Park officers gained an increased awareness of the villagers' circumstances and points of view. Likewise, the villagers learnt about the consequences of the proposed regulations by the National Park, and agro-ecological dynamics and socioeconomic equity issues.

I have observed changes among participating stakeholders who have adopted new strategies or technologies as a result of knowledge exchange among participating stakeholders in many ComMod case studies. However, according to the limitations of M&E of ComMod effects, the pioneering M&E projects were used to systematically examine such changes in some ComMod cases (Gurung et al., 2008). Some cases, such as a conflict over water sharing between upstream and downstream villages in

Bhutan (Gurung, 2006), have indicated successful institutional expansion, a consequence of up and out scaling of the use of the ComMod process and tools.

To successfully generate the up- and out-scale effects, ComMod practitioners often underline the need for more sensitizing activities prior to engaging all concerned stakeholders in a ComMod process. Such sensitizing activities are also important to better facilitate a bottom-up dialogue between less powerful stakeholders and stakeholders at higher institutional levels.

Power relations and local ComMod practitioners

The legitimacy of the designers, and its facilitators and models in the ComMod process is often discussed among ComMod practitioners when dealing with multiple stakeholders with different levels of power in a community. The recognition of the underlying power dynamics and motivations for participation are precondition for a successful process (Prell et al., 2007). The role and management of power relations in a ComMod process is being debated among ComMod practitioners. A study by Barnaud et al. (2006) has specifically addressed the analysis of power relations in a ComMod process carried out in Mae Salaep village, Chiang Rai province, Northern Thailand. One main limitation of that ComMod implementation was the different way of thinking about the same problem between ComMod participants and non-participating villagers. The author suggested that before launching a ComMod project, more sensitizing activities about ComMod methodology and project objectives should be carried out with all stakeholders equally. The author also mentioned the need to find a local people and train them to become an autonomous and neutral facilitator, who can continue applying ComMod methodology and developing tools, in particular RPGs, in the village. This concern is especially acute once a ComMod process has been implemented. A qualified person (educational background, current job, etc.) is often not easy to recruit. Besides that, it takes time to train and develop a personal mental model about the ComMod approach and methodology to be able to apply it without inadvertently manipulating the process.

A ComMod experiment carried out in the Lam Dome Yai watershed, Ubon Ratchathani province, Thailand, definitely confronted these challenges mentioned above. However, a researcher who took several ComMod short training courses thought that ComMod is a promising approach to better understanding human-environment interactions in this watershed. The ComMod process of the Lam Dome Yai case is presented in the next chapter.