Companion Modelling for Resilient and Adaptive Social Agro-Ecological Systems in Asia

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Abstract

The Companion Modelling (ComMod) approach for renewable resource management (RRM) is a highly interactive collaborative modelling process used by researchers and local stakeholders to co-construct a shared representation of a given complex issue, and to use it to explore possible solutions of their choice through simulations. The scientific posture of the ComMod researcher creates an original relation between him, the models he develops, and the field actors and circumstances. By considering him/herself as part of the system under study, the researcher is one stakeholder among others in such action research process.

ComMod main objectives are (i) to better understand a complex agro-ecosystem through the collaborative construction and joint use of different types of simulation models integrating various stakeholders' points of view, and (ii) to use these models within platforms for collective learning to facilitate multiple stakeholders' coordination and negotiation processes leading to the definition of agreed-upon collective action plans to mitigate their common RRM problems.

The ComMod approach relies very much on the use of Multi-Agent Systems (MAS) combined in various ways with Role-Playing Games (RPG) to facilitate Integrated RRM (IRRM) by focusing on the management of interactions between ecological and social dynamics. A ComMod process alternates lab. modelling and field work phases in an iterative but evolving way, during which its hypotheses and methodology are systematically explicated and regularly questioned and adapted.

Since the introduction of this approach and its tools in 2002, a dozen of ComMod case studies have been developed in the Southeast Asian region, most of them in Thailand. They looked at a broad range of topics ranging from highland catchment management, access to non timber forest products and cattle grazing in forest areas, crop substitution and market integration, land/water use and labour migrations, agro-biodiversity management in a rice seed system, and biodiversity conservation in coastal management.

Following a brief history of the ComMod approach and a short presentation of its theoretical references, its objectives and fundamental principles are introduced. The main phases of a ComMod process, i.e. initialisation, conceptualization, model implementation & validation, scenario exploration, and monitoring & evaluation, are also presented. Finally, the future perspectives for the development of the ComMod approach and the current hot issues being debated are briefly discussed.

Introduction

Most of the current renewable resource management (RRM) problems in agrarian systems are complex, rapidly evolving, and need to be addressed in more uncertain and

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unpredictable environments. To understand them, multiple dynamic interactions between ecological and social processes need to be taken into account, usually at different scales or institutional levels, and modelling needs to be used to help in this daunting task. Because of the growing commercialization of farming activities and strong linkages between agricultural production and environmental issues, an increasing number of concerned stakeholders need to be involved in multi-actor processes to discuss acceptable solutions to all parties and to negotiate their implementation. This is happening when administrative and political decentralization of local RRM is making progress across Asia, and particularly in Thailand since the mid-90s with, for example, the establishment of locally powerful administrative bodies like TAOs.

It is in this context that, in the large family of participatory approaches applied to RRM, and particularly in the domain of collaborative modelling, the Companion Modelling (ComMod) approach was crafted during the last 15 years. Its general objective is to facilitate dialogue and shared learning through collaborative modelling and simulation activities. This is to support collective decision-making through interdisciplinary and implicated action research processes strengthening the adaptive management capacity of local communities at the dawn of the climate change era.

To address the past failures and lack of use and impact of many modelling activities in the field of agriculture and the environment, ComMod takes to bold challenge of building models with the concerned stakeholders, on topics of their choice, and to jointly explore the future possible behaviour of their local RRM system through participatory simulations. By doing so, the relevance of these models will be guaranteed and more user friendly modelling and simulation tools could be proposed to broad stakeholders' arenas at the community level.

A brief account of the early development of the ComMod approach

At the origin of ComMod is the creation of the GREEN (Management of renewable resources and environment) research unit at CIRAD, France, under the leadership of Dr.Jacques Weber in 1993. This group of researchers wanted to improve existing methodologies in the field of collective management of renewable resources. They considered that, until the 80s, RRM issues were addressed most of the time by ecologists or by economists. While the former studied "an ecological system subjected to man-made perturbations", the latter saw "a social system subjected to natural constraints". They decided to design a trans-disciplinary research approach to investigate the co-viability of ecological and social dynamics in RRM by focusing on their interactions and the integration of different stakeholders' points of view on a given common problem.

They observed that, because of the complexity of current RRM problems and the rapidity of change, system modelling needs to be used as innovative and powerful tools emerging from computer science to represent human-environment systems and to simulate their co-evolution become available. The construction of a conceptual model is also able to catalyze interactions between researchers from different disciplines and to facilitate the integration of knowledge from various sources.

This team selected Multi-Agent Systems (MAS), a field in the domain of distributed artificial intelligence, as their preferred computer tool because of the focus of MAS on the understanding of how different processes in interaction are coordinated and the possibility to explore better coordination mechanisms through simulation. MAS simulation tools were also selected because their principles are very much in agreement with GREEN scientists' representation of their research object: they focus on interactions among agents having different representations of the system to be managed and various positions in the interaction process; they act and transform their common environment and by doing so modify it for the other agents while this environment has also its own ecological dynamics of change. During the 90s, they developed the Common-pool Resources and Multi-Agent Systems (CORMAS, http://cormas.cirad.fr) simulation platform specifically dedicated to examine RRM issues (Bousquet *et al*., 1998).

In a seminal article they laid down the methodological basis of the ComMod approach (Bousquet *et al*., 1999). Initially this GREEN team worked mainly on natural ecosystems not yet subjected to important man made transformations, but a few years later, applications in agro-ecosystems started to be developed, and first in West Africa.

In the late 90s, O. Barreteau built a MAS model to explore the viability of a Senegalese irrigated scheme through the simulation of multiple scenarios of different sets of individual and collective rules for water use. The simulation results and the field data generated new hypotheses on how to improve the viability of the irrigation system (Barreteau and Bousquet, 2000). This first kind of use of computer simulations in interaction with field work in a well-grounded modelling process showed that it could improve the understanding of how the complex system under study is working. Later on, he introduced his model to the local stakeholders through a simplified version formalized in a Role-Playing Game (RPG) to "open the back box" of the MAS Model and to make its contents and operations explicit to its potential users. This also allowed him to compare his representation of the system to be managed with those of local stakeholders, to validate his model with local farmers, and to look with them at how interactions among water users could affect the performance of the whole irrigated system (Barreteau *et al*., 2001). This case study demonstrated how a MAS-RPG based collaborative modelling process could facilitate stakeholders' exchanges about resource management in complex systems. They called this process "Companion Modelling" because it is used in the mediation process (the social dimension of the companion) and it co-evolves with and accompany this social process (temporal and adaptive dimensions).

The following "Self Cormas" experiment in Northern Senegal went one step further by introducing the collective conception of a model through concerted exchanges between a research team and local stakeholders engaged in a land and water use conflict between herders and crop growers (d'Aquino, 2002; d'Aquino *et al.,* 2003). The model, conceived during a three-day long field workshop was only used to facilitate exchanges among stakeholders. In the first day, the participants built a RPG representing their perceptions on land use and its dynamics. In the second day, they played with this RPG and discussed their resource management problems. In the third day, a MAS model similar to the RPG and built the day before was introduced to them to explore the scenarios of interest identified by the stakeholders during their gaming exchanges on day two. These two case studies demonstrated the synergy between RPGs and MAS models, and ComMod processes usually rely on RPGs to acquire knowledge, to stimulate exchanges, to support the construction of MAS models and to validate them.

In Thailand, a first ComMod case study looking at the effects of the expansion of sugarcane plantations in upper paddy fields of Nam Phong District of Khon Kaen Province adopted the same methodology (Suphanchaimart *et al.*, 2005). Another pioneer experiment on catchment management in the Akha village of Mae Salaep of Mae Fah Luang District, Chiang Rai Province started with the construction of a sophisticated multi-levels MAS model by the researchers and its subsequent conversion into a simpler RPG used with the highland farmers to validate the MAS model and to examine the risk of land degradation through soil erosion in parallel with the commercialization of the local farming systems (Trébuil *et al.,* 2002a & 2002b). If RPGs and MAS models are key tools used in ComMod processes, there are many different ways to associate them depending on the context, the objectives, and the dynamics of a given ComMod process (Figure 1).

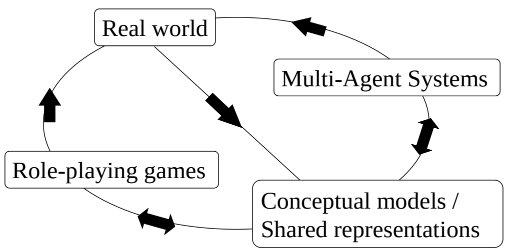

Figure 1. Linkages between actual circumstances, the conceptual model and its use in role-playing games and agent-based models in the companion modelling approach.

Following the development of several case studies in France on forest fire prevention (Etienne, 2003), in West Africa, Madagascar, and SE Asia, a ComMod network of practitioners was founded in 2003 to structure their exchanges and to capitalize on past experiments (http://www.commod.org). They realized that this kind of "implicated" action research required a clarification of their scientific posture and the definition of a deontological framework for guiding its correct use in multi-actor processes. A first version of a ComMod charter was published in 2003 (Barreteau *et al.*, 2003a) and will be revised regularly.

Since the introduction of this approach and its tools in this region in 2002, a dozen of ComMod case studies have been developed in the Southeast Asian region, most of them in Thailand. They looked at a broad range of topics ranging from highland catchment management (Chiang Rai and Chiang Mai), access to non timber forest products and cattle grazing in forest areas (Nan), crop substitution (Khon Kaen), land/water use and labour migrations (Ubon Ratchathani), agro-biodiversity in a rice seed system (Ubon Ratchathani), and biodiversity conservation in coastal management (Samut Songkram). These field experiments are documented in the "case studies" section of the e-learning module of the Ecole ComMod website at http://www.ecole-commod.sc.chula.ac.th. During this conference, three of these case studies will be presented by their team leaders, namely Panomsak Promburom (MCC-CMU), Pongchai Dumrongrojwatthana (Chulalongkorn University), and Warong Naivinit (Ubon Rajathanee University). Their presentations illustrate what is said on the ComMod methodology in this paper.

Main theoretical references of the ComMod approach

The ComMod approach did not emerge from theoretical debates among researchers but from common problems they faced in empirical research on their complex objects of study. Without going into much detail here, below are several key theoretical references of this integrative modelling approach:

a. The science of complexity: for its advances in the analysis of the emergence at the whole system level of properties which cannot be observed at the individual component level but that are resulting from their interactions. This paradigm supports the ComMod willingness to integrate various disciplines and points of view and to pay importance to interactions. The science of complexity also underlines the fact that the behaviour of complex systems is continuously evolving, unstable, uncertain, and cannot be predicted. These characteristics have major implications on the ComMod choice of a suitable modelling approach that focuses on achieving a better understanding of the system to identify what interactions govern its functioning and change, and then modify them to explore how to lead the system towards a more desired state through simulations.

b. Resilience and adaptive management: these concepts also underline the need for a better understanding of the system functioning to improve the adaptive capacity of the stakeholders, and its self-regulation and self-organization properties. Recent definitions of these key concepts insist on the importance of interactive learning about the system (Holling, 2001). 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 social agro-ecological system. Although the concept of adaptive management was conceived by ecologists, they recognize that adaptive capacity is dependent on knowledge, its generation and free interchange, and the ability to recognize points of intervention to construct a bank of options for RRM. Thus, the organization of platforms to stimulate interactions among stakeholders for the generation and interchange of knowledge are required. This social process of generation and free interchange of knowledge may lead to new kinds of interactions and to the issue of the devolution decision-making power over resource management. For example, co-management is defined as a partnership in which local communities, resource users, government agencies, non-government organizations, and other stakeholders share the authority and responsibility over the management of a specific territory or a set of resources.

c. Collective management of multi-actor processes: ComMod also relies on theories of collective action, especially regarding common resources and public goods (Ostrom *et al*., 1994). Of special interest is the linkage with the game theory and the creation of institutional settings favourable to sustainable RRM characterized by agreed-upon access rules defined by the users themselves, relations based on trust and social capital, rules defined in relation with institutions at higher levels, and that are evolving ones (Ostrom, 2005). This explains the emphasis given in ComMod processes on coordination and negotiation mechanisms among stakeholders seen as continual collective learning processes taking place in social networks in which solutions can emerge from interaction.

d. Constructivist epistemology: ComMod tries to make explicit the different points of view and representations of the system constructed by various individuals, based on their specific experiences. Various stakeholders perceive a common RRM problem differently, and refer to different kind of knowledge (including cultural values) to analyze and interpret it. Reality is multiple, uncertain, and subjective depending on ones personal experiences, objectives, and interest. Stakeholders' actions depend on their perceptions of their (ecological and social) environment (Röling *et al*., 1998), and these different (and partial) contradictory perceptions are frequently at the origin of misunderstandings and at the root of conflicts. Because they can help to modify stakeholders' diverse perceptions, ComMod puts much emphasis on individual and collective experiential or discovery learning mechanisms, because social learning leads to a shared collective and distributed cognition among the system stakeholders (Röling, 2002).

e. Post-normal science: such a posture favours the improvement of the collective decision-making process, more than the characteristics of the decision itself (Funtowicz & Ravetz, 1993). Commodians adopt this type of posture because of the high level of uncertainty related to the facts, social challenges, problem definition, etc. they deal with in complex issues. Researchers in the field of post-normal science consider that soft social-ecosystems are based on the assumption that people construct their own realities through learning along social processes. Hard sciences can show that an agro-ecosystem is endangered but its sustainable land use finally depends on the outcome of human interactions and agreement, learning, conflict resolution and collective action. As a consequence, the role of interdisciplinary teams including natural and social scientists is to understand and strengthen collective decision-making processes through platforms of interactions.This also explains the importance given by ComMod to integrative processes associating different stakeholders having diverse values, perceptions and interest, but who are all concerned by the problem at stake.

f. Patrimonial mediation: ComMod also borrowed the importance of a prospective analysis of the system evolution from the patrimonial mediation approach (Ollagnon, 1989), and it uses such exploration of possible futures to facilitate the definition of common long-term goals by the stakeholders. Patrimonial[3] mediation contributes to the understanding and practice of co-management. A patrimonial representation of an area or a set of resources links past, present, and future generations of managers, focuses on the owner's obligations more than his/her rights, and promotes a common vision of sustainability that reconciles the needs and opinions of various actors. Mediation is a negotiation approach that brings in a neutral party to facilitate agreement among different parties in conflict. When mediating a conflict, each party's views on the problem at stake are translated for the others to understand.

ComMod relies on simulation tools to implement such prospective 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 MAS) are mainly seen as short-lived simulation tools built to facilitate communication among stakeholders through the expression of their multiple points of view and perceptions of phenomena on a given issue and at a given time of their choice. In such a context, computer enhanced modeling becomes a tool for interactive learning instead of a tool to pilot the system. A classic use of simulation is prediction, but this is not the option chosen by commodians because of the unpredictability of complex systems. The very long term of complex systems, such as the ones we have to deal with in INRM, cannot be predicted in the economic and social fields, though it is partially decidable. As Weber and Bailly (1993) said, "because the very long term is beyond the scope of prediction, if we wish to take it into account in the analysis of environmental problems, we must give ourselves very long-term reference points or objectives to guide the possible or impossible pathways of development. The long-term approach must inevitably be based on a scenario". Because rules result from interactions among stakeholders, they are legitimized in the eyes of all stakeholders and they incorporate their perceptions. It is on the basis of a shared conception of how the present situation should evolve that stakeholders are able to "decide" on very long-term objectives. On that basis, scenarios enabling these objectives to be reached can be collectively identified, simulated and discussed.

Two fundamental characteristics of the ComMod approach

a. The ComMod posture: the researcher's point of view is only one among other legitimate ones

This posture is a consequence of the adoption of constructivism by the commodians who recognize the existence of multiple legitimate points of view and of the uncertainty of facts and analyses. Far from being an expert proposing "solutions" to a problem, the ComMod researcher becomes an actor of the system under study and a facilitator of exchanges among its stakeholders. His perception and representation of the system is presented to the other stakeholders to be criticized and improved. In a ComMod process, the researcher plays a

[3] *"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".*

dual role: (i) to generate new knowledge on a system or on the ComMod approach itself, and (ii) being an actor of this system, to improve it through changes in the stakeholders' perceptions, interactions, and actions. Ethical issues related to such a posture led the ComMod group to define a deontological code framed in a ComMod charter to avoid the risk of manipulating field actors. In particular, the charter recommends the systematic monitoring of the effects and impact of ComMod interventions, and transparency in the use of hypotheses that should be made explicit to other stakeholders and be questioned all along the ComMod process.

b. A back and forth iterative process between lab. and field activities generating a succession of evolving loops

Figure 2 shows that a ComMod process is usually made of several self-reinforcing sequences alternating theoretical, analytical, and modelling activities with field work (specific surveys, field workshops including gaming sessions and/or participatory simulations, interviews, etc.) in an iterative but evolving fashion. At the end of each loop, the conceptual model representing the system under study is revised as well as the research hypotheses.

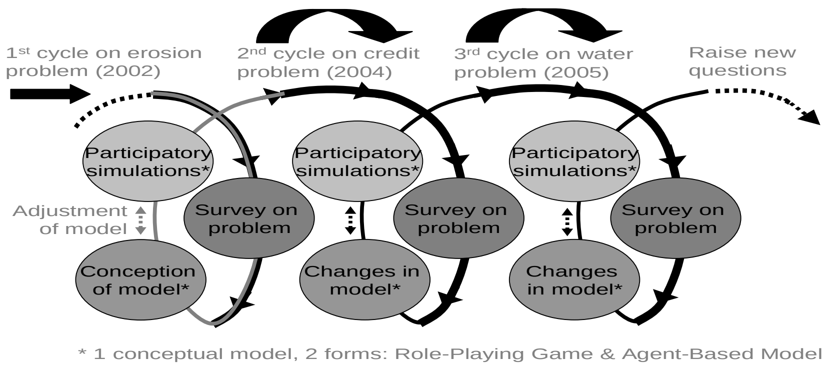

Figure 2. A representation of the ComMod process on catchment management in Mae Salaep Akha village of Mae Fah Luang District, Chiang Rai province, 2002-2005. (Barnaud *et al*., 2006; Barnaud *et al.,* 2007).

This kind of continual, iterative and evolving collaborative modelling succession of loops is a typical of a ComMod process. The arena of participating stakeholders can evolve from one loop to the next, depending on the needs and the decision made by the local actors. In some cases, it took villagers one or two ComMod cycles before to feel confident enough to invite decision-makers from higher levels in the social hierarchy to join in the process.

The dual objectives of the ComMod approach

The two main objectives of a ComMod process are:

(i) to develop simulation models integrating various stakeholders' points of view to better understand how a given social agro-ecological system is structured and is evolving,

(ii) to use them within the context of platforms for collective learning to facilitate multiple stakeholders' coordination and negotiation processes to support the emergence of agreed-upon collective action plans to mitigate common IRRM problems.

Therefore ComMod can be used in two specific contexts:

(i) to produce new knowledge on a given complex system,

(ii) to support collective decision-making processes.

While the first context deals with systems research via a particular relationship between modelling and to field activities, the second one involves methodological research to facilitate the concerted management of resources in complex systems.

a. Knowledge production on a complex system

In this first context, the production of new knowledge is the main objective. The companion process is an iterative research one aiming at a better understanding of the system under study, particularly its ecological and social dynamics, and the various points of view facing each other in the local stakeholders' arena. To improve his/her knowledge of the system, the research team organizes a confrontation of existing viewpoints on the system. Its main objective is the co-construction of a shared representation of the system integrating inputs from these existing viewpoints. The model corresponding to this representation could be a conceptual and diagrammatic one, a role-playing game, a computer MAS, or several of those various types. Most frequently, the researcher starts by assembling a formal presentation of the existing knowledge on the problem at stake. This output is proposed to the other stakeholders in simulation sessions followed by discussions leading to new knowledge and questions forcing the researcher to revise his/her initial hypotheses. Based on the lessons learned from the first sequence of activities, a new updated version of the model is usually built and used again with the stakeholders. The repetition of such loops generates a family of models representing as many milestones along the researcher's interactions with the field actors. An original characteristic of ComMod models is that there is no attempt to build a final, or more sophisticated one. Each of the successive models produced along the process corresponds to the existing knowledge and key preoccupation of the actors at that precise moment, and could become useless soon after its use in field workshops. The ComMod models are mediation tools to facilitate the mutual recognition of everyone representation of the problem under study. Such mutual recognition lies on indicators which are gradually and collectively built during the implementation of the case study in a truly participatory modelling process. These indicators of the system state and dynamics can be used in the assessment of future possible scenarios in a later stage.

b. Facilitation of decision-making in a complex system

In this second kind of context, ComMod is significantly contributing to the process of mediation and negotiation among the concerned stakeholders. ComMod intervenes upstream of any technical decision to support the deliberation of the concerned actors by organizing their interactions and paying attention to their differences in perceptions, interest, strategies, and unequal decision-making power in the negotiation. Beyond the production of a shared representation of the problem at stake, the goal here is to identify possible ways toward a collective management and mitigation of the problem. In such a context, the commodians adopt a truly post-normal posture to facilitate the enrichment of the collective decision-making process through the constructive elicitation and confrontation of subjective viewpoints and criteria used by the various stakeholders to justify their positions. The process tries to support the management of ecological and social uncertainty by the 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 adaptive management approach promoted by ComMod. Meanwhile, ComMod does not include the other possible steps of a mediation process, like a more quantitative and technical expertise on the specifications of a possible solution (type and size of a new infrastructure, estimation of productions and costs, etc.).

In this second context, knowledge production is also achieved but is not the main goal. It is just a methodological aspect used to support the facilitation of the decision-making process which is the real focus here.

Main phases of ComMod methodology

In the iterative ComMod process, the co-construction of conceptual, MAS models, and RPGs occurs. Each of these modelling tools helps in the analysis and improvement of the others. While the ComMod approach proposes methodological principles and tools, it does not impose any rigid set of procedures to be strictly followed when using them in a given context. This is in agreement with the principle of adaptive management seen as a social process which needs to take into account the specificities of a given set of stakeholders, in a given ecological environment, at a given period of time, with people interested to examine a given RRM problem in a given time frame. Based on such specific conditions, the research team can mobilize the set of tools in the most appropriate and adaptive way as the process evolves. 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 after a first ComMod cycle has been completed.

a. Initialization of a ComMod process

A ComMod process starts from a concrete collective RRM problem and a request by some stakeholder(s) to examine it and to search for acceptable ways to mitigate it. At this stage, the stakeholders need to be clearly informed about the issues dividing them and about their common dependence upon a solution to the problem. The mediation approach presupposes to explicit the initial situation. Several techniques are used to establish a preliminary diagnostic-analysis focusing on the actors involved in the issue at stake, the concerned resource(s) and it/their dynamics, and the key human-environment interactions to be represented in the models. Agrarian system diagnosis, stakeholder and institutional analyses, etc. are valuable tools to be used at this stage as the challenge of the initialization phase is to enable stakeholders to express their perceptions of the present situation and of its evolution, in order to characterize the diversity of points of view in the stakeholders' arena.

When a map of perceptions and viewpoints, all considered as equally legitimate and subjective, has been established, the stakeholders can be asked to discuss the acceptability of the continuation of existing trends.

It is at this stage that the ComMod facilitator and some of the other stakeholders, will decide who will be initially invited to participate in the collective activities, and to what extent public awareness and sensitizing activities are needed to level the initial playing ground before launching them. Facilitating a ComMod process is not a neutral exercise as, for example, a process can be launched and designed to help marginalized and voiceless people have their say in the decision-making process. But the ComMod charter requires to make all the initial hypotheses transparent, to avoid any implicit one, and to revisit them regularly.

b. The co-construction & conceptualization of models with stakeholders

ComMod is an approach in which stakeholders are asked to fully participate in the construction of models to improve their relevance and to increase their use by simulating scenarios of their choice and through the collective assessment of their results. Usually a phase of conceptualization precedes the construction of a RPG, a MAS model to run simulations, or both. This conceptualization phase is a collaborative interdisciplinary endeavour carried out through discussions, reviews of the existing knowledge from various sources, and specific field surveys to fill gaps. Among other possible knowledge elicitation tools available, the use of the diagrammatic Unified Modelling Language (UML) has proved to be very useful at this stage because it encourages the participants in this conceptualization phase to be precise when exchanging their arguments. It also provides successive concrete outcomes and formal representations of the agreed upon model taking shape gradually. It is then easier for the MAS modeller to implement a MAS model based on these diagrammatic outcomes, and, later on, they also facilitate the process of model verification carried out to check if the implemented model is a true representation of the conceptual one. In the construction of a conceptual model, simplifications are made, but all the hypotheses related to them must be explicit, especially if scenarios are planned to be simulated at a later stage.

c. Implementation and validation of ComMod models

Based on the initial conceptual model, concrete RPGs or/and MAS models are implemented in this phase to be used in gaming or/and participatory simulations sessions as ComMod favours the interactive use of models with stakeholders. But, to be in agreement with the above-mentioned principles, any kind of model, which is only a given kind of representation among other possible ones, should be presented to its users in an explicit and transparent way to avoid the well-known "black box effect" as much as possible. Early ComMod practitioners were inspired by several scientists working in the field of environmental management used RPGs for collective learning and action. Intuitively, a MAS model could be seen as a RPG simulated by the computer. Consequently, ComMod proposes to build RPGs similar to MAS models (or vice versa) with the objective of inviting stakeholders to play the game for them:

- To understand the model, and more precisely the difference between the model and reality,

- To validate it by examining the individual behaviour of agents and the properties of the whole system emerging from their interactions, and by proposing modifications,

- To be able to understand and follow MAS simulations run on the computer, and to propose scenarios to be collectively assessed and discussed following their simulations.

An original characteristic of the ComMod methodology is the flexible association of RPGs and MAS models, but also of other tools (like GIS, surveys, interviews, etc.) used as needed. Table 1 emphasizes the importance of the initial conceptual model and proposes a classification of situations based on similarities between the conceptual model, the RPG, and the MAS simulation model.

Special attention is also given to the process of validation of such models, knowing that a general theory of model validation does not exist. Procedures differing from those used in the case of “hard science” models and more adapted to the “soft systems” examined by ComMod need to be considered. Commodians focus on a social validation of their models by their end users. In particular, the co-construction of the baseline conceptual model and the use of RPGs to help validate MAS models are important steps in such social validation process.

Table 1. Classification of types of joint use of a computer agent-based model and of a role-playing game based on the similarities of their conceptual models and time of use. (Adapted from Barreteau 2003b).

The conceptual model is:	Different	The same
MAS model and game are used at the same time	- MAS model supports the game - MAS model included into game - The game is a communication tool between MAS model & reality	- The game is the model
MAS model and game are used in succession	- The game helps to learn how to use the MAS model	- MAS model of the game to repeat gaming sessions far more rapidly - Game used to design MAS model - Game used to validate MAS model - MAS model used to design the game - Co-construction of the MAS model and the game - MAS model is used as benchmark

d. Scenario identification, exploration and assessment

Usually, the successive iterations between real and virtual worlds practiced by the participants stimulate their creativity. Following the social validation of the models, they are able to identify interesting scenarios to be simulated in order to explore possible futures of their RRM system. This is where MAS models are powerful to run such simulations in a very time and cost efficient way compared to RPGs, leaving much time to debate the results of the simulations. These results are usually presented according to pertinent indicators previously identified by the stakeholders and/or according to different points of view on the evolution of the system. Scenario exploration activities could be organized either in plenary sessions, or within small and more homogenous groups of stakeholders, depending on what is the best way to promote the most inclusive assessment of the simulated scenarios. Very often, this phase generates new knowledge and questions which could feed a new ComMod cycle.

e. Monitoring & evaluation of ComMod effects and impact

No suitable M&E methodology exists to assess the different effects and impact of highly interactive ComMod processes. A specific project is under way to test such procedures on more than 30 case studies worldwide. It is moving toward the adoption of an adapted reflexive and critical monitoring & evaluation system, to be applied separately to the ComMod designer of the case and to the other participants. This M&E methodology will look at the various effects on the participants generated by a ComMod process in term of learning on the system, on oneself and others and their interdependence, on the ecological and social dynamics, etc. but also on changes in communication (social networks), perceptions, decision-making, behaviour, and finally practices. The evaluation reports of two Northern Thailand cases are available on the Ecole ComMod website at http://www.ecole-commod.sc.chula.ac.th

Concluding remarks

Even if no concrete application of ComMod on this topic has been attempted so far, it is clear that this approach can go a long way in promoting the adaptive management of agro-social-ecosystems facing climate change, and for the collective mitigation of its effects in less (ecologically and socially) vulnerable communities. In Thailand, relevant topics that could be examined with their concerned stakeholders include the management of the forest – farm land interface, including community forest and land rights issues, land use in low lying coastal areas and people migrations, crop substitution for biofuel production, etc.

Among the current hot issues being discussed in the ComMod group of practitioners are the legitimacy of this approach, and of its facilitator and models, the management of power relations in ComMod processes, the organization and management of multi-level processes to move beyond the majority of community-based case studies recently implemented, and how to better involve decision-makers at higher levels in ComMod processes. The modelling methodology (representations of the spatial environment, the agent behaviour and decision making, the diversity of social organizations, etc.) and the way models are used (with special attention to human and artificial agent interactions) are also being continuously refined.

Beyond the organization of training courses on the ComMod and IRRM in agrarian systems, more and more e-learning, e-gaming, and e-library resources are made available on the web at http://www.ecole-commod.sc.chula.ac.th and http://www.commod.org.

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