Introduction to companion modeling and multi agent systems for integrated natural resource management in Asia

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This introductory chapter recalls the origins of the book at the interface between the personal interest of several colleagues from different Southeast Asian countries and a growing interest for methodological innovation in the field of integrated natural resource management (INRM) in the Consultative Group on International Agricultural Research (CGIAR). The historical development of the so-called "Companion Modeling" (ComMod) approach relying on the use of multi-agent systems (MAS) for INRM is also described, and its main principles and objectives are defined: to develop simulation models integrating various stakeholders' points of view and to use them within the context of platforms for collective learning. The ComMod methodology used to facilitate such a process in INRM is presented, with an emphasis on the combination of key tools used with stakeholders, such as conceptual models, MAS, and role-playing games. A final section introduces the diversity of the Asian experiences presented in this book and its content.

In late 1998, Dr. Benchaphun Ekasingh and her colleagues from the Multiple Cropping Center at the Faculty of Agriculture, Chiang Mai University (MCC-CMU) initiated the organization of a first training course in Asia on multi-agent systems (MAS) and integrated natural resource management (INRM). Based on Dr. B. Ekasingh' strong experience in the field of systems approaches in agriculture, she perceived the need for the introduction of innovative approaches belonging to the emerging sciences of complexity and new tools developed by researchers working in this field.. A confirmation of this perception was given a few years later when CGIAR organized several scientific workshops focusing on INRM. An important point was made at the Penang meeting in 2000 with the mention of the adaptive management concept, together with social learning and action research. Adaptive management was seen as a way to "*ensure that functional integrity of the system can increase the adaptive capacity. Adaptive capacity is dependent on knowledge (...) the ability to recognize points of intervention and to construct a bank of options for resource management*". Then, a new role for modeling was formulated in this context: "*Modeling proceeds iteratively by successive approximations usually from simple to more complex representations of system dynamics. This iterative modeling is done in close interaction with stakeholders, who, along with the modelers, use the models for scenario planning.*" . Thus, Dr. Benchaphun Ekasingh invited members of the GREEN (French acronym for the "Renewable resource management and the environment") team of Cirad to hold a two-week course at MCC-CMU in late 1999.

Since the creation of the GREEN research team by J. Weber in 1993, several researchers have been developing modeling research activities to better understand the interactions between social and ecological dynamics. A basic principle was to go beyond disciplinary approaches tackling the problem exclusively either from the angle of "an ecological system subject to anthropologic disturbance" or from the angle of "a social system subject to natural constraints". In the first case, scientists make a careful description of the dynamics of the resource and management is considered as the various forms of anthropologic exploitation of the ecosystem which can be sustained over the long term. Social dynamics are represented in terms of the type of resource exploitation they entail. In the second case, researchers generally focus on the problem of resource usage and position themselves as isolated economic agents who wish to maximize the benefits obtained from a limited resource and placing the collective use of common resources within a framework of competitive exploitation. Unlike the ecological approach or the economic approach, both of which postulate hypotheses of equilibrium and optimization to formalize situations of competition or interaction, the purpose of GREEN researchers is to look at renewable resource management in a different light by integrating the dynamics of the ecological and social dimensions and eliciting their interactions. Their main research theme is the decision-making process. Unlike the conventional decision-making process, which defines a decision as a rational calculation on the part of a more or less fully informed decision-maker, GREEN researchers consider the decision-making process as a series of interactions between stakeholders having various objectives, different perceptions, levels or kind of information, and varying degrees of importance and influence. An illustration of such frame of mind is provided in Figure 1. The objective of the researcher working on such a system is to try to understand the interactions between key processes, the social ones being driven by various interacting points of views.

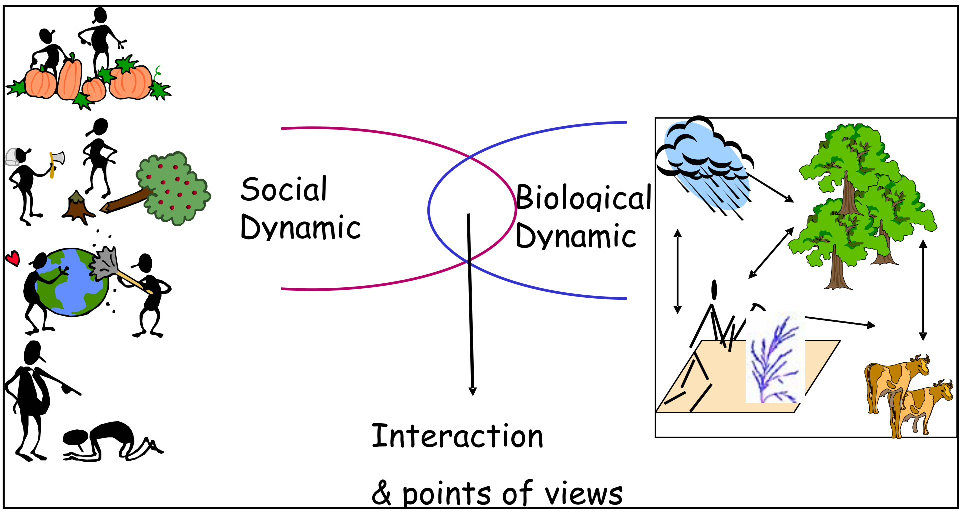


Figure 1. Schematic representation of a socio-ecological system.

In the field of modeling a choice was made to use and develop tools called multi-agent systems[1]. The aim of multi-agent systems is to understand how different processes in direct competition are coordinated. Woolridge defines an agent as "a computer system that is situated in some environment, and that is capable of autonomous action in this environment in order to meet its design objectives". An agent can be described as autonomous because it has the capacity to adapt when its environment changes. For Ferber , an agent is a physical or virtual entity, which operates in an environment, is able to perceive it and act on it, which can communicate with other agents, which exhibits an autonomous behavior that can be seen as a consequence of its knowledge, its interactions with other agents and the goals it is pursuing. A multi-agent system (MAS) is made of a set of computer processes that occur at the same time, i.e., several agents that exist at the same time, share common resources and communicate with

[1] In computer science this kind of model is called multi-agent system. In ecology they were called individual-based models. While other disciplines introduce multi-agent systems in their research field, one observes the emergence of new terms such as Agent-Based Modeling (ABM). Some people, like our group, think that ABM reflects the use of agents but do not put emphasis on interactions which is the main innovation in our approach. This is why some researchers, most of them in social sciences, use Multi-Agent Based Simulation (MABS). For the sake of simplicity we use the MAS acronym in this introduction.

each other. Figure 2 shows a schematic representation of a MAS. It illustrates the conceptual relationship between a MAS and the definition of our research object shown in Figure 1.

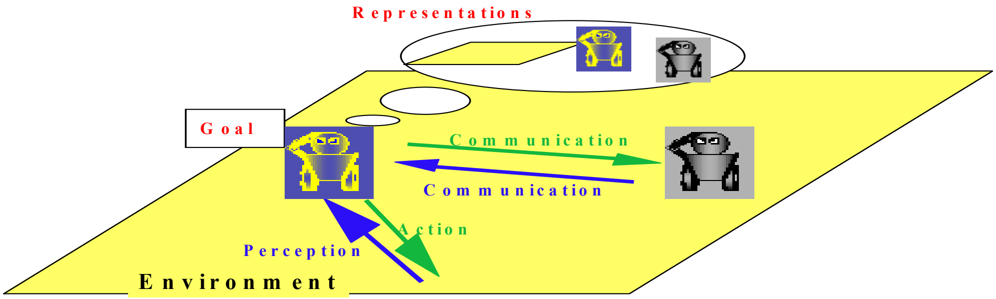


Figure 2. Schematic representation of a MAS.

In the field of MAS modeling for INRM, complementary activities were developed by GREEN researchers, PhD students or associated researchers.

1. Development of abstract models, also called artificial societies, that help to understand the generic properties of interacting processes: models on non-merchant exchanges and reputation , models on economic tools for the regulation of economic exchanges , and models on spatial dynamics .
2. Development of models applied to concrete and local problems to understand the dynamics of natural and renewable resources and their management. Applications were developed in irrigation, wildlife management, pasture management .
3. Development of a simulation platform (CORMAS, *common-pool resources and multi-agent systems*, . This platform was developed in an inductive way by trying to select generic aspects while working on concrete applications and by integrating them into this tool.
4. Development of a Companion Modeling (ComMod) methodology for the use for these MAS tools within the community of approaches dealing with participatory modeling for collective learning and action. The ComMod method uses role games to acquire knowledge, build a MAS model and validate it, and in the decision-making process dealing with collective resource management. This will be discussed in more details below.

In 1995, F. Bousquet and C. Le Page started to propose training courses on MAS modeling for INRM. The session organized in 1999 at Chiang Mai University in northern Thailand by Dr. Benchaphun Ekasingh was the starting point of a very rich set of interactions with many Asian institutions (mainly universities) and researchers working in the field of INRM. Due to the interest of the participants, a similar training course was offered at the International Rice Research Institute (IRRI) headquarters in Los Baños, The Philippines in late 2000 and a joint IRRI-CIRAD collaborative research project based in Bangkok was designed. The collaborative project was able to reinforce its training activities thanks of a three-year grant from the Asia IT&C initiative of the European Union (EU). The objective of this EU Project was to train Asian lecturers and researchers on MAS for social sciences and INRM by inviting twelve internationally renowned European researchers to deliver one-week courses in Thailand on different specific aspects of this subject. This training process took advantage of the respective expertise available at three collaborating public universities in Thailand (Chulalongkorn University, Chiang-Mai University, Khon Khaen University) to organize each of the successive short courses. More on this training process and its effects will be found in Trébuil and Bousquet's article in the fourth part of this volume.

During this training process, several participants declared their interest to apply these approaches and tools to concrete case studies focusing on different real world issues. This volume is made of a collection of the applications initiated between 2001 and 2003. In October 2003, following a training session held at MCC-CMU, a technical workshop was organized near Chiang-Mai, for all the participants who already started an application. Papers presenting these applications at different stage of advancement were presented and collectively discussed by the group, with the objective of further improving the contributions and publishing them in a collective book. Before introducing its detailed outlines, we shall briefly present the main principles and concepts of ComMod approach.

Principles and objective of the companion modeling approach

Researchers in the field of post-normal science distinguishes two main paradigms . Schematically, on the one hand, researchers following a positivist paradigm try to discover the objective truth and to unravel natural laws driving the system. This knowledge is used to develop and deliver new technologies or new management rules. In such a context, definitions of sustainability emphasize bio-physical attributes of ecosystems and often focus on calculable thresholds below which land use for example becomes unsustainable. On the other hand, soft systems are based on the assumption that people construct their own realities through learning along social processes. Hard sciences can show that an ecosystem is endangered but the sustainable land use is defined as the outcome of human interaction 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 process through platforms of interactions. The different stakeholders, including scientists, should work out a common vision on resource management in an interactive fashion that would lead to the identification of new collectively agreed upon indicators, shared monitoring procedures, information systems, and concrete alternatives for action. The scientist role (as displayed in figure 3) is partly to feed this platform with "objectively true" knowledge on the bio-physical sub-system, and ways to collectively compare, assess, and implement concrete alternatives.

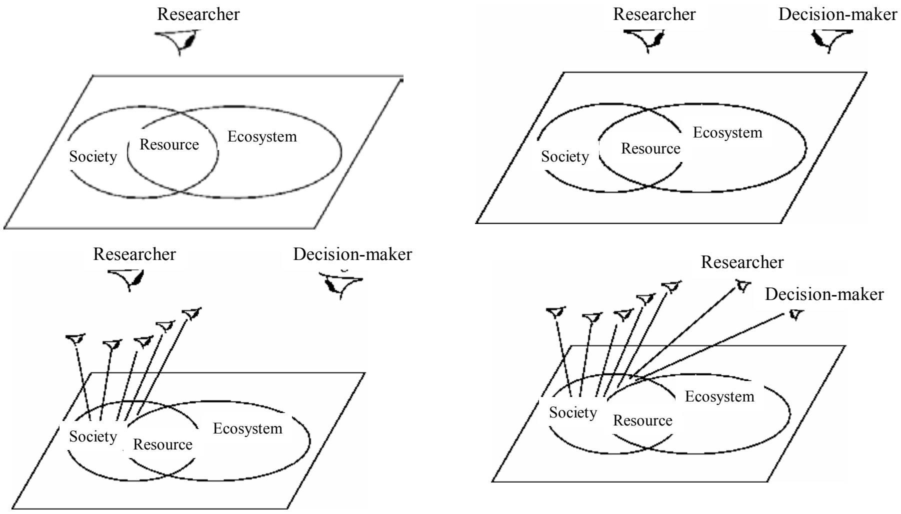


Figure 3. Evolution of the scientist role in decision making process. Top left: the scientist is perceived as having the objective point of view. Top right: the decision-maker is taken into account, the researcher is providing him with knowledge. Bottom left: with the introduction of social scientists, society is no longer considered as composed of homogenous mechanistic entities but as a set of interacting actors having various points of views. Bottom right: the researcher and the decision-maker are considered as stakeholders among others and interact for a better management of the ecosystem.

Several approaches for supporting the collective management of ecosystems were developed in the recent past and inspired the design of the ComMod methodology.

☞ Adaptive management is an approach recognizing that ecosystem management requires flexible, diverse, and redundant regulation and monitoring that leads to corrective responses and experimental probing of ever changing reality. Although the adaptive management approach 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 and to construct a bank of options for resource management. Thus, interactions with 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 devoluting power over resource management.

☞ Co-management is defined as a partnership in which local communities, resource users, government agencies, non-government organizations, and other stakeholders share, as appropriate to each context, the authority and responsibility over the management of a specific territory or a set of resources.

☞ Patrimonial mediation is an approach which contributes to the understanding and practice of co-management. “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”. A patrimonial representation of a territory, an area, or a set of resources links past, present, and future generations of managers, focuses on the owner’s obligations more than on the owner's rights, and promotes a common vision of sustainability that reconciles the needs and opinions of various actors. Mediation is a negotiating method that brings in a third, neutral party in order to facilitate agreement among the different parties involved in the process; it is an approach in which each party's views on the issue or problem are translated for the others to understand .

Management consists not only in increasing the adaptability of the ecosystem but also deals with the social process leading to this ecological state. In other words, what is important are solutions emerging from interaction. And with them comes a different portfolio of interventions including mediation to resolve conflicts, facilitation of learning, and participatory approaches that involve people in negotiating collective action.

In this 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 we have chosen. 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 particular 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 discussed. The entire mediation approach presupposes to explicit the initial situation. At this stage, stakeholders are clearly informed about the issues dividing them and about their common dependence upon a solution to the problem at the origin of the mediation process. The challenge of the initialization phase is to enable stakeholders to express their perceptions of the present situation and of its evolution. When a "map of perceptions", all equally legitimate and equally subjective, has been established and discussed, the stakeholders are asked to discuss the acceptability of the continuation of existing trends.

MAS models, like any other kind of representation of a system to be managed, can be used to increase scientific knowledge about the ecological and social processes at stake. The collective creation of a common artificial world serves to create a shared representation which is a prerequisite before to simulate various scenarios identified by the stakeholders, the scientist being one of them. Within this frame of mind, any decision, particularly if collective, is context-dependent and should be seen as a stage at a given "time *t"* in the continuous process of management of a complex issue. As Roling (1996) said, "based on their intentions and experience, people construct reality creatively with their language, labor, and technology. Different groups do this in different ways, even if they live in the same environment. The same people change their reality during the course of time in order to adjust to changing circumstances".

In brief, the main principle of the ComMod approach is to develop simulation models integrating various stakeholders' points of view and to use them within the context of platforms for collective learning. This is a modeling approach in which stakeholders participate fully in the construction of models to improve their relevance and increase their use for the collective assessment of scenarios. The general objective of ComMod is to facilitate dialogue, shared learning, and collective decision-making through interdisciplinary and "implicated" action-oriented research to strengthen the adaptive management capacity of local communities.

By using such an approach, we expect to be in a better position to deal with the increased complexity of INRM problems, their evolving and continuous characteristics, as well as the increased rapidity of changes and number of stakeholders.

Companion modeling methodology: the use of MAS and role-playing games

MAS simulation tools were selected because their principles are very much in line with GREEN scientists' representation of their research object. This can be seen when comparing figure 1 and figure 2. They focus on interactions among agents having different representations of the system to be managed and various status in the interaction process. They act and transform their common environment which will be modified for the other agents. By doing this economists would say that they generate "externalities" while this environment has also its own ecological dynamics of change.

We used these MAS tools in a cyclic ComMod process displayed in figure 4. It is made of three stages which can be repeated as many times as needed :

1. Field investigations and search of the bibliography supply information and help to generate explicit hypotheses for modeling by raising a set of initial key questions to be examined by using the model;
2. Modeling, i.e 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.

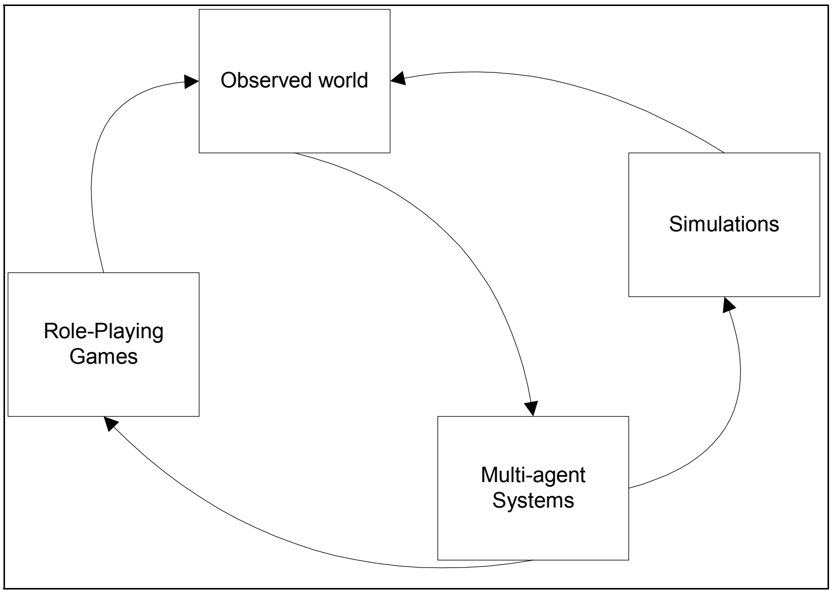


Figure 4. The companion modeling cycle.

We named this process "companion modeling" because it is used in the mediation process (the social dimension of the companion) and it co-evolves with this social process (temporal and adaptive dimensions). The next question was about how to use these models in an interactive way with stakeholders? In agreement with the above-mentioned principles, a model, which is a given kind of representation among other possible ones, should be presented in an explicit and transparent way to avoid the "black box effect" as much as possible when it is proposed to users. We were inspired by the work of several scientists working in the field of environmental management who developed and used role-playing games (RPG) for collective learning or collective action . Intuitively, a MAS model could be seen as a RPG simulated by the computer. Consequently, we proposed to set up RPGs, similar to MAS models , with the objective of inviting real stakeholders to play the game in order for them:

- to understand the model, and more precisely to understand the difference between the model and reality,
- to validate it by examining the individual behaviors of agents and the properties of the system emerging from their interactions, and by proposing modifications,
- to be able to follow MAS simulations on the computer, and to propose scenarios to be assessed and discussed following their simulations.

We started different applications to assess whether models combined with RPGs could be used successfully to support collective decision-making, the design of concrete action plans, and to explore and evaluate different participatory uses of these associated tools. In 1998, a first application dealing with the viability of an irrigated scheme in Sénégal was proposed by Barreteau . He simplified a complex MAS simulation model to build a RPG and used it with several stakeholders and subsequently proposed a new MAS model allowing to explore scenarios with stakeholders. Several months later d'Aquino also relied on a RPG linked to a MAS model in the Senegal river delta with a different perspective: his objective was to collectively prepare a RPG with stakeholders and later on translate it into a MAS model for scenario simulation. This was done during three-day long participatory workshops held with different resource users and local decision-makers. Boissau and Castella started similar applications on land-use changes in northern Vietnam uplands and designed their own "SAMBA" process . Aubert working on plant resource management in Madagascar and Etienne's research in the field of sylvopastoral management planning also produced other applications using different kinds of associations between MAS simulation models and RPG. As the number of case studies and researchers involved in this kind of work increased, a small community of users sharing this approach was born and two important ethical and methodological issues emerged at this juncture.

Very much like in the case of other participatory approaches for resource management, it appeared that the status and legitimacy of the researcher and of the proposed process itself could be questionable. Following the development of this first set of applications, this group of researchers could feel the need for a ComMod charter to precise their stance and to guide users of this approach. Thanks to the circulation of several successive draft versions discussed among twelve authors, a first document was produced and published. This charter is available at http://cormas.cirad.fr/en/reseaux/ComMod/charte.htm and we briefly summarize here the main points examined in this short document.

The ComMod charter postulates that all the assumptions to be made and which are backing the modeling work should be voluntarily and directly subjected to refutation. Having no *a priori* implicit experimental hypothesis is also an objective implying the adoption of procedures to unveil such implicit hypotheses. The impact of the ComMod process in the field has to be taken into consideration as soon as the first steps of the approach are implemented, in terms of research objectives, quality of the approach, quantified monitoring and evaluation indicators. Particular attention should also be given to the process of validation of such a research approach, knowing that a general theory of model validation does not exist, and that procedures differing from those used in the case of physical, biological, and mathematical models need to be considered. The charter also proposes to distinguish between two specific contexts when using this approach: the production of knowledge on a given complex system, and the support to collective decision-making processes. While the first context deals with systems research via a particular relationship to field work, the second one corresponds to methodological research to facilitate the concerted management of such systems.

- In the first case, the key ComMod challenge is to deliver an improved understanding of the interacting processes related to the resource management problem being examined rather than a "turn key" itinerary for renewable resource management. This understanding relies on a special relationship between the field and the model: instead of proposing a simplification of stakeholders' knowledge, the model is seeking a 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, and constitutes the fundamentals of participatory modeling.
- In the later case, even if it is not covering the whole process of mediation by itself, ComMod is significantly contributing to it. This approach intervenes upstream of any technical decision to support the deliberation of concerned actors, to produce a shared representation of the problem at stake, and to identify possible ways toward a collective management and alleviation of the problem. Meanwhile, ComMod does not include the other possible steps of the mediation process, particularly those dealing with a more quantified expertise (type and size of a new infrastructure, estimation of productions and costs, etc.).

An original characteristic of the ComMod methodology is the flexible association of key tools such as RPGs and MAS simulation models, but also GIS, surveys and interviews, etc. Table 2 shows a classification of these associations as proposed by Barreteau .

	Underlying conceptual models are different	Same conceptual model
Model and game are used at the same time	- the model supports the game - the model is included into the game - the game is a communication tool between the model and the reality	- the game <u>is</u> the model
Model and game are used successively	- the game helps to learn how to use the model	- model of the game to repeat it rapidly - the game is used to validate the model - the model is sued to support game design - the game is used to support model design - co-construction of the model and game - the model is a benchmark

Table 2. Classification of the categories of joint use of a computerized model and a role-playing game based on the similarities of conceptual models and time of use.

This table emphasizes the importance of the preliminary conceptual model. In some cases the RPG is used as a tool for collective conceptualization , but usually a phase of conceptualization precedes the construction of a RPG, a MAS simulation model or both. Very often, this conceptualization phase is an interdisciplinary endeveour carried out through discussions, reviews of the bibliography, and field surveys or experiments. The use of the graphical Unified Modeling Language (UML) has proved to be very useful at this stage because it obliges the participants in the conceptualization process to be precise and provides gradually successive concrete outcomes of the agreed upon model. It is then more easy to implement it and these diagrammatic outcomes also facilitate very much the verification process to check that the implemented model is a true representation of the conceptual model.

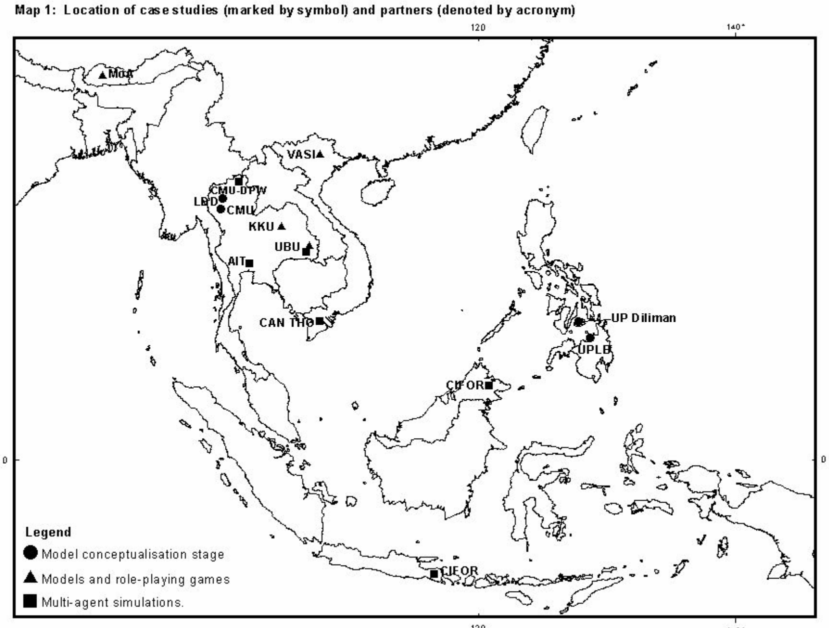
The classification shown in table 2 also relies on similarities between the conceptual model, the RPG, and the MAS simulation model. When the conceptual model is not the same, one tool is usually used to support the other one. This is the case when MAS models provide a dynamic environment to the players of a game or, conversely, when a RPG is used to explain what the MAS model is actually doing. When the conceptual models for the RPG and the MAS are different, there are mutually supportive during the phase of design and problem analysis: the RPG facilitates the sharing and modification of the conceptual model with stakeholders while the MAS model allows fast simulations of various scenarios proposed by the actors. In the iterative ComMod cycle a co-construction of the model and of the game occurs, each one allowing the analysis and improvement of the other.

While the ComMod approach proposes methodological principles and tools, it does not impose any rigid set of procedures to be strictly followed when using these tools. For example, D'Aquino et al. (2002) present a comparison among five different ComMod experiments. This key characteristic 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 (the scientist being one among them) in a given ecological environment at a given period of time. Given the context and the constraints, the researcher(s) mobilizes the set of tools in different ways.

Asian experiences and book outline

This volume presents a choice of various Asian case studies using the Commod approach. Some of these applications, located on Map 1, are still at a preliminary phase of their development, some are more advanced stage.

Map 1: Location of case studies (marked by symbol) and partners (denoted by acronym)



ı case study

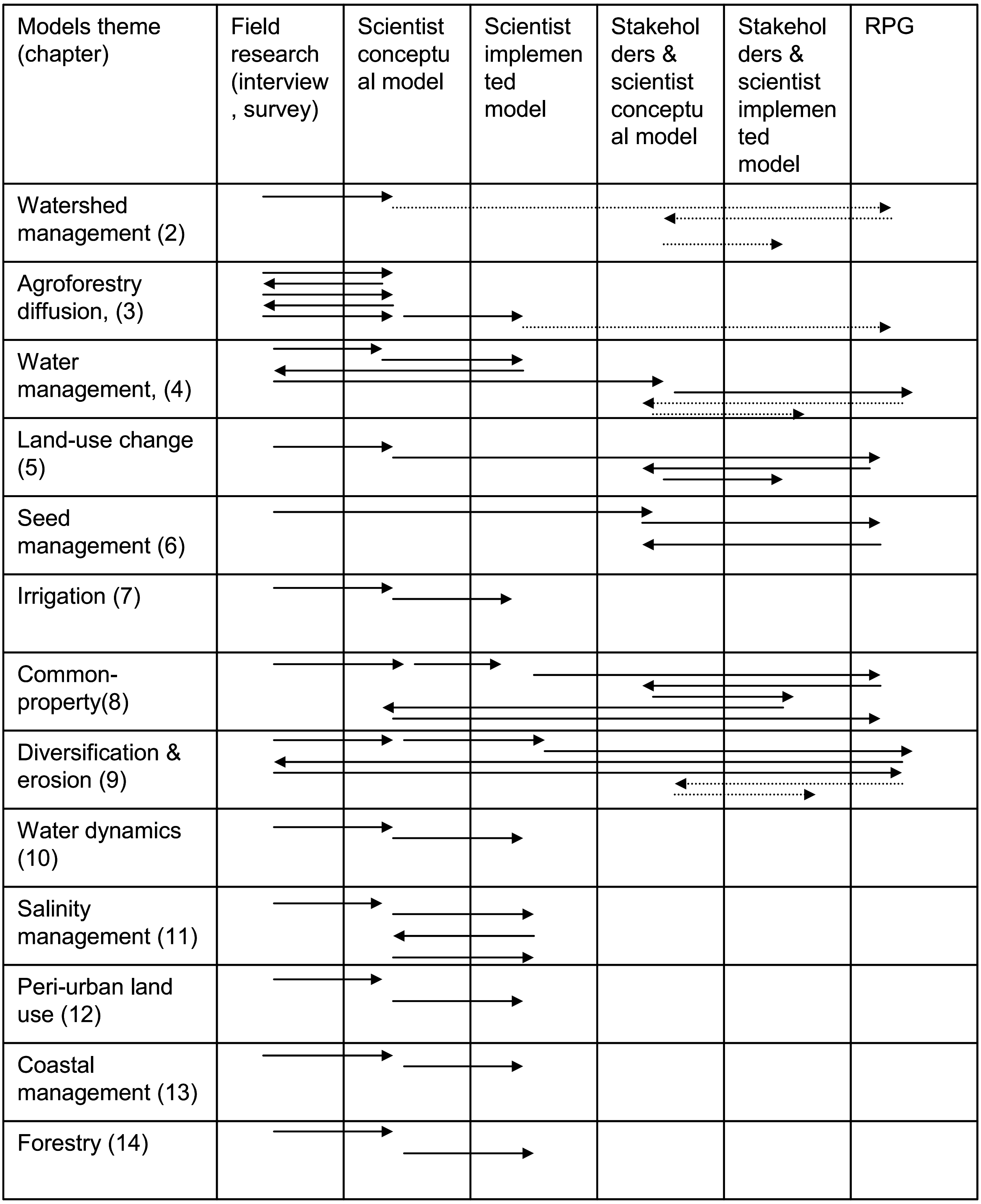


Figure 6. The different methodological pathways and stage of advancement of the contributions presented in this book. Broken arrows represent activities not presented in this book.

All case studies were initiated from a real world key question identified in the field and the problems to be investigated were generally chosen for their relevance to users & decision makers with whom the authors work, or else for a methodology development purpose. We classified these contributions into four groups.

The first one deals with the model conceptualization stage based on an observed reality.

- ☞ P. Promburom and co-authors present their case study on watershed management in northern Thailand and a first conceptual model which corresponds to the analysis of actors and processes to be taken into account for the simulation of land use dynamics at the watershed level. Further steps of his work such as the development and use of role-playing games (RPG) were also published during the edition of this book .
- ☞ D. Macandog et al. illustrate the iterative process leading to the design of different conceptual models for the study of the diffusion of agroforestry systems in Mindanao, The Philippines.
- ☞ N. Bécu et al.'s contribution deals with the methodological problem of eliciting and modeling stakeholders' representations in a northern Thailand watershed and the authors propose a method for that purpose.

The second group of papers describes applications characterized by an association between models and role-playing games.

- ☞ N. Suphanchaimart et al. present a case study on land-use change in north-eastern Thailand. An interdisciplinary group of researchers conceptualized a model which was used to build a RPG. Once played with stakeholders, the conceptual model was updated and a simple MAS model was created to simulate and discuss scenarios with the stakeholders
- ☞ C. Vejpas et al. organized a similar process on the topic of rice seed management in lower northeast Thailand, but with the participation of government agencies in the model conceptualization phase The process led to the creation of two complementary role-playing games played at different (village and provincial) scales.
- ☞ T. Raj Gurung et al. prepared a RPG on the problem of sharing irrigation water between two villages at rice transplanting in a Bhutanese watershed. This game was played two times in a negotiation process. Two villages are in conflict for the use of water and the ComMod process was used to bring people together and discuss the issues at stake. The RPG is presented in this volume while, later on, a MAS model was also produced .
- ☞ S. Boissau presents his experience on alternating the use of MAS and RPG to collectively assess the driving forces of land use changes in the uplands of Northern Vietnam. After a first MAS model was built, a RPG was conceived and played several times. Simple MAS models were used to simulate scenarios with stakeholders . Then this author worked on simpler and more generic models and developed new RPG to be associated with to these new models.

The third group of papers presents MAS models with an emphasis on technical aspects or on simulation results.

- ☞ G. Trébuil et al. developed a case study to understand the interaction between soil degradation and agricultural diversification in a highland watershed of northern Thailand. The initial phase of the modeling process was based on several years of onfarm research. The first model developed was a MAS loosely linked to a GIS to assemble the scientist' knowledge on erosion processes and crop allocation in this mountainous area. Later on, this model was used to conceive a RPG which was played twice with stakeholders and led to the construction of a second, simpler, MAS model simulating the RPG. In this volume, more details are given on the technical aspects of the initial scientist model while information on the subsequent RPG can be found elsewhere .

☞ G. Lacombe & W. Naivinit present a MAS model which simulates water dynamics at the sub-watershed level in lower northeast Thailand. Its objective is to study how stakeholders cope with the highly variable hydrological pattern in this rainfed region. The model is described and preliminary simulations are run to assess different farmer strategies regarding the use of stored water resources for irrigating rice nurseries.

☞ L. Dung et al. produced two models dealing with the issue of water management in the lower part of the Mekong delta in southern Vietnam. The water management and the associated geographical zoning of fresh and brackish water led to a conflict among different users. These models were developed to examine the issue of economic differentiation among households. The first one is based on realistic maps and simulates the actual behavior of farmers and its consequences on economic differentiation. The second one is a more abstract version which focuses on the dynamics of change by using the consumat theoretical model .

☞ SK. Morshed Anwar and F. Borne worked on a model of land-use changes in a peri-urban area of Bangkok. They focused on the identification and assessment of spatial criteria allowing the comparison between spatial simulation outputs and GIS maps.

☞ P. Campo presents a model for simulating the coastal management of an island in The Philippines. His model integrates GIS maps and interactions between stakeholders and policies.

☞ H. Purnomo and P. Guizol developed a simulation model focusing on the spatial configuration of land leading to a better co-existence between smallholders and industrial tree plantations in Indonesia.

The fourth and last group of papers deals with different learning issues.

☞ C. Le Page and P. Bommel present a methodology for the conception of MAS models in the field of INRM. They mainly focus on the use of the Unified Modeling Language (UML) for model conceptualization and on the CORMAS platform for simulations. Most of the contributions in this book refer to this first chapter.

☞ I. Patamadit and F. Bousquet analyzes the relevance of the ComMod approach in the Thai cultural context. They tackle this question by exploring the cultural aspects which support the use of this approach as well as those other aspects making it inadequate.

☞ G. Trébuil and F. Bousquet propose a critical evaluation of the learning process of their Asian partners who attended a series of short courses and workshops on multi-agent systems, social sciences and INRM organized with the support of the Asia It&C project between October 2001 and April 2004.

The discussions held during the Suan Bua technical workshop in October 2003 which led to the preparation of this volume are also reported at the end of this volume.

Because of the recent development of all these case studies, no in-depth ex-post evaluation of the effects and impact of using the ComMod approach with stakeholders has been made yet. In fact, a specific methodology to assess these effects and impact is needed. It will have to take into account the definition of the research objectives, the quality of the approach, the characterization of the initial state, the agreed upon monitoring & evaluation indicators of the system resilience, and, last but not the least, will define how to assess the improvement in the stakeholders capacity for collective learning.

On another front, further methodological development of the ComMod approach is under way to better deal with the modeling of stakeholders' perceptions and spatial representations. The possibility to upscale the use of this approach will also be investigated in the near future, particularly by looking at the way it could be used to facilitate communication among heterogeneous agents, groups and institutions/organizations at higher levels. Based on the ex-post analysis of past case studies, the characterization of the contexts in which ComMod can be efficiently used and how it should be used will also be documented.

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Suggested citation:

Bousquet F, Trébuil G, Hardy B, editors. 2005. Companion modelling and multi-agent systems for integrated natural resource management in Asia. Los Baños (Philippines): International Rice Research Institute & Cirad. Introduction, 1-20.