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Exploring management strategies for community-based forests using multi-agent systems: A case study in Palawan, Philippines☆

Paolo C. Campo [a], Guillermo A. Mendoza [b,*], Philippe Guizol [c], Teodoro R. Villanueva [d], François Bousquet [e]

[a] Université de Paris X, Nanterre, Paris, France
[b] Department of Natural Resources and Environmental Sciences, University of Illinois, 1102 S. Goodwin Avenue, Urbana, IL 61801, USA
[c] Centre de Coopération Internationale en Recherche Agronomique pour le Développement, (CIRAD) and Center for International Forestry Research (CIFOR), Bogor, Indonesia
[d] University of the Philippines Los Baños, College of Forestry and Natural Resources, College, Laguna, Philippines
[e] Centre de Coopération Internationale en Recherche Agronomique pour le Développement, CIRAD-Baillarguet Campus, Montpellier, France

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ABSTRACT

This paper describes the experiences and lessons learned in applying a multi-agent systems (MAS) model to study the dynamics and complex interactions among stakeholders in the management of community-based forests. The MAS model is developed using the companion modelling (ComMod) approach, which allows for a collaborative development of the model between the stakeholders and researchers. This approach involves the development and application of role-playing games (RPGs) and computer simulation as learning tools and to validate the model. Inferences are drawn from the learning and negotiation processes that the stakeholders and researchers underwent in the collaborative development of the MAS model. These processes ultimately led to the development of a collaborative resource management plan. The approach and the MAS model were applied to a case study involving a community-based forest managed by three villages in the island of Palawan, Philippines.

1. Introduction

The Philippines has a long history of community forestry. Since the 1970's, a number of community-based forestry programs were implemented such as the forest occupancy management, communal tree farm, family approach to reforestation, timber production sharing agreements, industrial plantations and integrated social forestry. All of these programs ultimately led to the development of the more comprehensive community-based forest management (CBFM) program. In 1996, a Presidential Executive Order was enacted which institutionalized and mandated CBFM as the national forest management strategy with the goal of 'ensuring the sustainable management and development of the country's forest lands'.

There are at least three major institutional stakeholders formally involved in the CBFM program and its implementation, namely, the local communities, which are formally organized and constituted as Peoples Organization (PO), the Department of Environment and Natural Resources (DENR), and the Local Government Units (LGU). At the community level, CBFM is implemented through the PO's, which are entitled to certain incentives and privileges as stipulated in the community-based forest management agreements (CBFMA). Essentially, CBFMA serves as the primary tenurial instrument issued by DENR granting rights to PO's to occupy, possess, utilize, manage, and develop the forest lands and resources within the designated CBFMA area.

Through CBFM, partnerships among PO's, LGU's, private, and other stakeholders, including non-governmental organizations (NGO) are forged. Such partnerships are intended to strengthen the PO's capacity to develop, protect, and manage their resources. NGO's perform vital roles in providing various forms of assistance to CBFM participants. These include community organizing and training, establishment of livelihood projects, and technical support in actual forestry activities like plantation establishment and maintenance. Some NGOs also provide assistance in conducting monitoring and evaluation of CBFM activities as well as in linking POs with government and other service-providing institutions.

This paper describes the use of a simulation and analytical tool, called multi-agent system (MAS) to study the dynamics and

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* Corresponding author. Tel.: +1 217 333 9347; fax: +1 217 244 3219.
E-mail address: gamendoz@illinois.edu (G.A. Mendoza).

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complex interactions among stakeholders in the management of a CBFM area in Palawan, Philippines. The CBFM area covers three villages: San Rafael, Tanabag and Concepcion. In these villages, there are multiple stakeholders involved, each having their own and often competing interests, objectives and motives. This complex web of stakeholders also operates within a host of policies and regulations that are often not clear, sometimes confusing and conflicting, along with new management policies that often impose new access rules to resources that also threaten the livelihood of the community. This complex web of stakeholders and policy networks lend itself well to MAS (Bousquet and Le Page, 2004) analysis.

The purpose of the study was to create an environment that can facilitate the different stakeholders in communicating and negotiating their different interests, learning about the consequences of their strategies, and identifying areas of intervention. A number of applications of MAS have been reported in the literature, such as land use change (Castella et al., 2005, 2007; Castella and Verburg, 2007; Boissau and Castella, 2003; D'Aquino et al., 2003), irrigation and water management (Gurung et al., 2006; Barreteau et al., 2004a,b; Becu et al., 2003; Daré and Barreteau, 2003; Feuillette et al., 2003), negotiation (Barreteau, 2003; Barreteau et al., 2003a,b), forest management (Purnomo and Vanclay, 2003), and participatory natural resource management (Becu et al., 2003; Becu et al., 2008; D'Aquino et al., 2002; Bousquet et al., 2001; Rouchier et al., 2000; Antona et al., 1998).

2. Methods

2.1. Multi-agent systems

As its name implies, MAS is a general approach that takes into account the presence of multiple agents (actors or stakeholders), each with unique views, perspectives and behavior (Ferber, 1999). Each agent or actor acts or reacts (or makes decisions) as he or she pursues his or her objectives rationally, or according to his or her own rules and behavioral patterns. Hence, a multi-agent system model (Fig. 1) represents a complex system involving the following components: (1) a space, called the environment; (2) objects that are situated in the environment; (3) a special type of object, called agents, that would represent the active entities in the system; (4) relations that link these objects, and consequently the agents, with their common environment; (5) a set of operations that could be performed by the agents to interact, transform or manipulate other objects in the environment; and (6) operators that represent the results when these operations are performed (Ferber, 1999 as cited by Bousquet and Le Page, 2004). In the context of community-based forest management, agents may include the stakeholders of the CBFM system, such as humans, animals, and government agencies, having their own limited perceptions and goals about the environment in which they operate. Given this limitation in knowledge and perception, as well as the differences in goals and perception, miscommunication, lack of coordination and even conflict can arise.

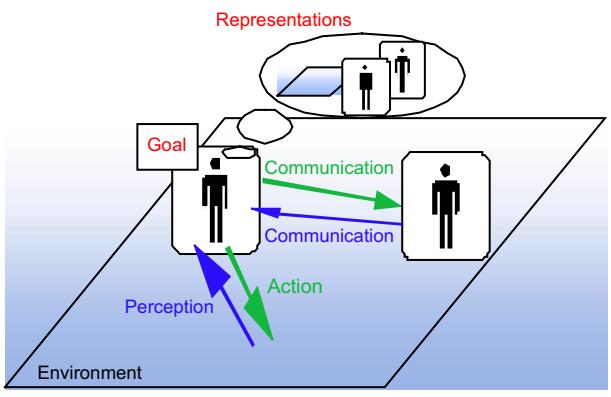

Fig. 1. Multi-agent system (Ferber, 1999 as cited by Bousquet and Le Page, 2004).

A MAS model may be realized in two ways: as a simulation and as a role-playing game (RPG). A MAS simulation is a computer-assisted implementation of the model with its components being represented as computer entities or objects. On the other hand, an RPG is an implementation of a MAS model using a game, with the players being the agents of the MAS model. The model is designed to mimic the actions, decisions, and interactions of the agents in the real world system. Although each type of implementation is independent of each other, these may be used complementarily, such as in companion modelling; an example of which is discussed in the next section.

2.2. The companion modelling approach

Companion modelling or ComMod (Barreteau et al., 2003a,b; Barnaud et al., 2006) is an approach in developing models of complex systems, such as a MAS model. In this approach, there is constant interaction between researchers and stakeholders in an iterative and potentially cyclical process (Fig. 2). The double arrow in Fig. 2 illustrates the interaction between and among the researchers and stakeholders. During the modelling process, it is conceivable that the model may undergo some modifications and, in some situations, the researcher-stakeholder interactions may even produce a significantly different model altogether. Stakeholders may realize the need to develop a new conceptual model whenever they: (1) do not feel that the model addresses their concerns; (2) do not think it is consistent with their goals; (3) want to address a more specific concern; or (4) have new questions about their system stemming from the learning and negotiation processes. In these cases, a new ComMod cycle begins.

The process of validating a model is a series of back-and-forth steps from the field (observed reality) to the model (represented reality), as shown in Fig. 3. The iterations take into account and properly represent the different perceptions of the stakeholders. In order to properly represent the various perceptions of the

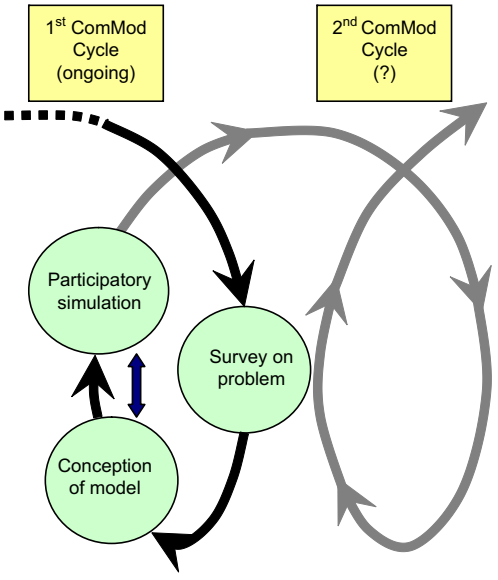

Fig. 2. Implementation of the ComMod approach in Palawan, Philippines (adapted from the Ecole ComMod Project Website: http://www.ecole-commod.sc.chula.ac.th).

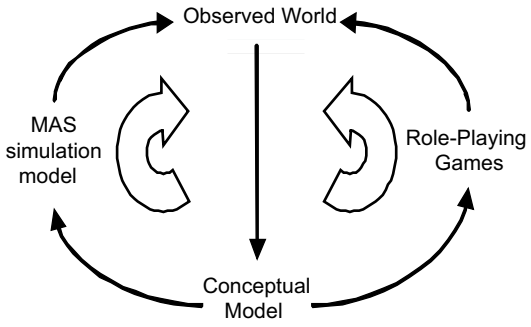

Fig. 3. The companion modelling approach (Barreteau et al., 2001).

stakeholders and build scenarios that reflect their interests and goals, the step-by-step approach of Etienne et al. (2003) may be used as a guide to ensure that all stakeholders' perceptions are included in the model. Through this approach, stakeholders are able to define: (1) the system according to their perception; (2) how to view this perception through spatial representation; (3) the indicators by which the model would be assessed and analyzed; and (4) the scenarios or management strategies the stakeholders would like to pursue or explore.

In using MAS models for ComMod, different tools, such as computer simulation and RPG, can be used as platforms for discussion. As previously mentioned, simulation and RPG could be used separately in the development of a MAS model, but together they can complement each other depending on the purpose of the MAS modelling exercise. An example of this complementary relationship is the case where RPG is used as a facilitation tool to explain the MAS model. A RPG played with the stakeholders is limited in the number of steps or iterations that can be played and in the number of interactions that can be represented. A simulation model could be used to support RPG – e.g. it can project the trend of the outcomes of the RPG if the game is continued for a longer period, or it can include more features and complex interactions that could not be represented in the RPG.

A integral aspect of this approach is its evaluation with a toolkit called ComMod evaluation protocol (CEP) (Perez and Aubert, 2007). This tool provides researchers involved in ComMod with the means to determine the impacts of the process and link these impacts to the steps taken in the process. The results of the evaluation could then be used to improve future implementations of the approach, as well as to improve the evaluation process using the toolkit.

In ComMod, the process of building the model is of paramount importance in order to ensure that the stakeholders feel some ownership of the model and therefore consider the model to be relevant to their local context (Bousquet et al., 2007). Moreover, because of its iterative and participative nature, stakeholders are more likely to accept the results of the modelling process. Ultimately, the goal of the ComMod approach is a collective understanding of the complex system among the stakeholders, which could help motivate them to discuss and negotiate resource management schemes together in a more equitable manner.

3. The case study

The case study is a component of a project, called "leveling playing field (LPF): fair partnership for local development to improve the forest sustainability in Southeast Asia", managed by the Center for International Forestry Research (CIFOR) and Centre de Coopération Internationale en Recherche Agronomique pour le Développement (CIRAD), in partnership with the University of the Philippines at Los Baños. The LPF project developed approaches and tools to promote good governance by facilitating local stakeholders to take collective decisions and to negotiate with other actors towards fair agreement about natural resources management. It involved capacity building, visioning, institutional strengthening and small-scale business development for local communities.

The LPF study site in the Philippines is located in Puerto Princesa, Palawan (Fig. 4). The site is in three villages (*barangays*), namely San Rafael, Tanabag and Concepcion, which have three types of landscapes: coastal areas, lowland areas for farming, and an upland areas covered with forests.

About 90% of the families belong to migrant communities and the rest are indigenous people, called Bataks. The total population is about 3600. Each village has its own local leader and council members. The Bataks have their own chieftain as well. The livelihood activities of the migrants are fishing, farming (vegetable, corn and rice), copra production, charcoal-making, roof shingles-making, collection of non-timber forest products (NTFPs) including honey, rattan and almaciga resin, catching milkfish fries, livestock-raising, ornamental and flower plants gardening and trade (buy-and-sell). Some of the people are also involved with swidden farming. The Bataks engage in collection of NTFPs, swidden farming, hunting and raising livestock. Migrants are usually involved in more than one livelihood activity at any one time (Devanadera et al., 2005). Government organizations (GOs) and non-government organizations (NGOs) exert influence in the exploitation of natural resources,

Large portions of two community-based forestry management agreements, as shown in Fig. 4 are within the boundaries of the three villages. One CBFMA was granted to the migrants with an area of 5000 ha, while the other was granted to the Bataks with an area of 1750 ha. A cooperative manages each area.

4. The ComMod process in Palawan, Philippines

4.1. Initialization of the modelling process

Each implementation of ComMod is unique because the process is influenced by the stakeholders involved. In the case of Palawan, the stakeholders were chosen based on the stakeholder identification and analysis study of the LPF project (Devanadera et al., 2005). Many of these stakeholders are decision-makers in their respective organizations, which included members of the village councils. The ComMod process in Palawan began with a collective learning experience among the stakeholders through a series of workshops to introduce the concept of MAS and present aspects of the study that relate to the involvement of stakeholders. The workshop was also an excellent opportunity to gain the communities' acceptance and approval of the MAS modelling and ComMod processes. The introductory workshops were conducted four times, each lasting for 1 day, and done with different groups of stakeholder (18 from GOs, five from NGOs, 22 migrants and 12 Bataks). Aside from a brief presentation about MAS, the stakeholders were shown a prototype simulation model, and were introduced to a generic RPG called *CherIng*.[1] In this game, players compete for a hypothetical resource called *Ing* in an artificial landscape. The game is played with scenarios wherein the participants are given the option to interact with each other under different conditions. With the scenarios, the players have the opportunity to compare the impacts of strategies and negotiations resulting from their interactions using visualization tools as shown in Fig. 5. The results

[1] CherIng is a game conceived by Michel Etienne – an agronomist and plant ecologist from the National Institute for Agronomic Research (INRA) in Avignon, France.

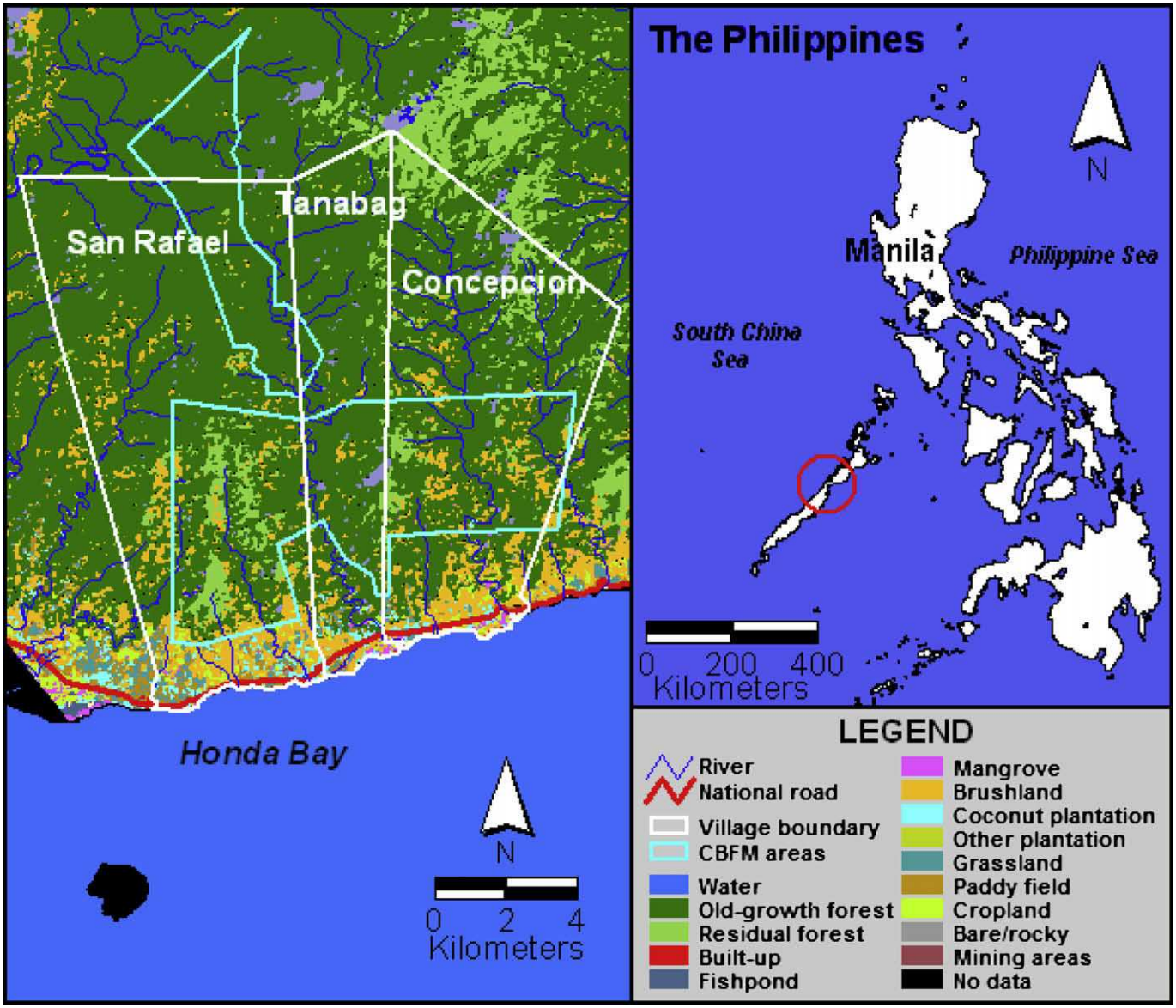

Fig. 4. Location of study site.

of the game scenarios and the experiences of the participants are discussed after the game. Subsequently, the participants in the introductory workshops discussed the value of the generic RPG and whether it would be beneficial to build a similar game that represents their real world situation. The participants gave their consent and assurance of active participation in the process. Afterwards, the theme of the first ComMod cycle was identified based on a discussion of what they would like the model to show or represent. It was apparent that the participants were very interested in understanding the dynamics of the natural resources under the pressure of various livelihood activities and the impact of formal rules for resource access and use to their livelihood and natural resources. Consequently, this was made to be the theme of the first ComMod cycle and a MAS conceptual model was constructed thereafter.

4.2. MAS conceptual modelling

Preliminary data and information about the system under study, such as demographic and socioeconomic data, as well as the list of major stakeholders and the stakeholder analysis, were acquired from the LPF baseline studies (Devanadera et al., 2005). Based on these baseline studies, a rough conceptual model was formulated. To improve the conceptual model, needed supporting data and information were identified and gathered. Individual interviews with community members were conducted to determine how the community, i.e. the resource users, perceived themselves in relation to their natural resources. Focus group discussions with a total of 122 participants were conducted with the community to reconstruct the step-by-step process of each of the main livelihood activities of the community, identify the decisions made in a livelihood activity, and the criteria used to make those decisions, and the interactions that occur within the livelihood activities. Seasonal calendars, locations where the resources are gathered, the cost and the potential returns of the community's livelihood activities were also identified. These data and information were used as inputs to the conceptual model. We used the universal modelling language (UML) to systematically organize the different elements of the system model. UML is a standardized specification language for

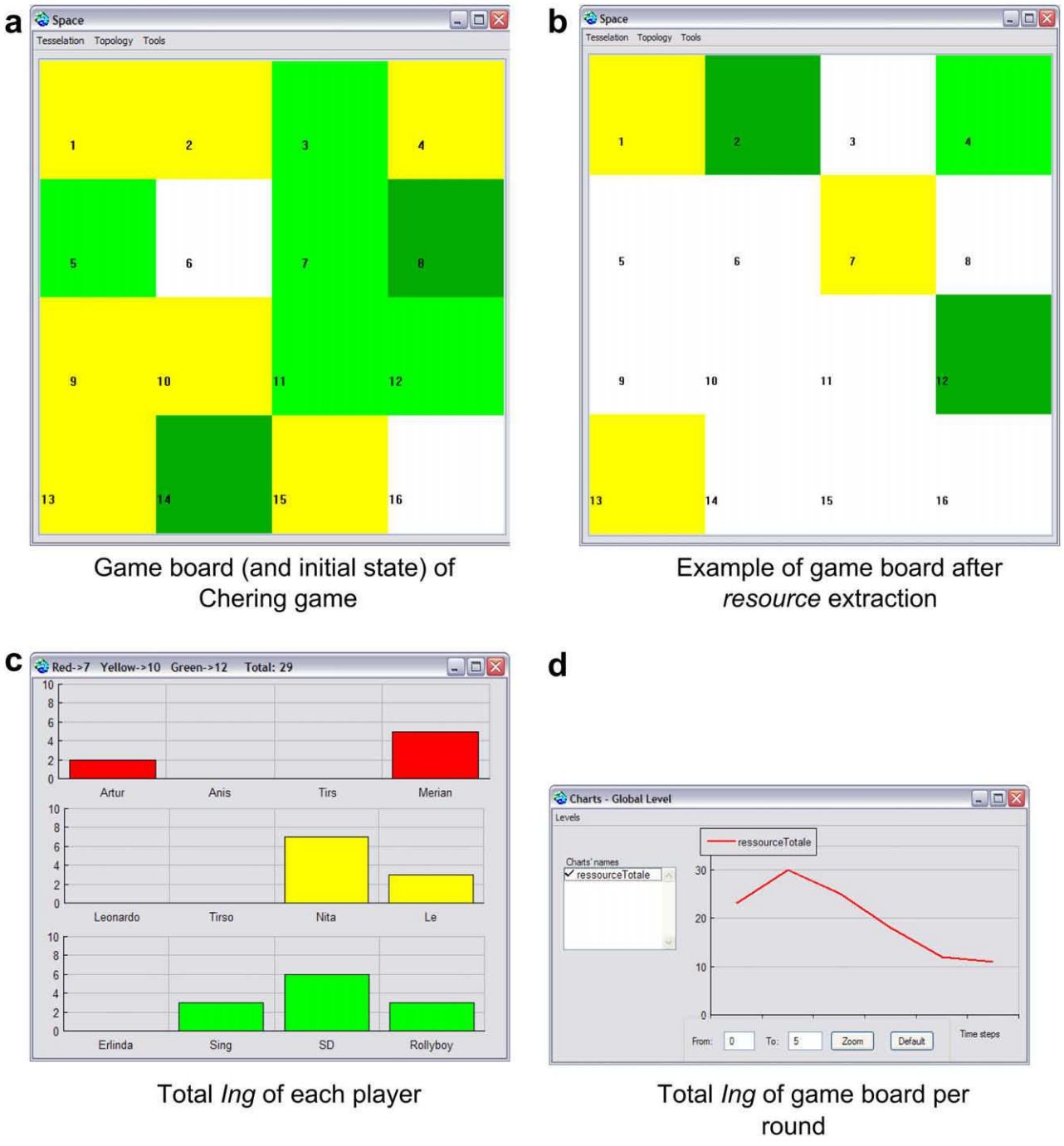

Fig. 5. *CherIng* game visualization tools.

object modelling that includes a graphical notation used to create an abstract model of a complex. UML diagrams were drawn to visualize the MAS model and describe the static and dynamic characteristics of the CBFM system. Fig. 6, a simplified UML class diagram, describes the various entities or objects of the CBFM system, the interrelationships of these entities, and the operations an entity undertakes or experiences. The type of agents identified in the study are: (a) the *Villager,* which is further classified into two types – *Migrant* and *IP* (indigenous person); (b) the organizations or groups the villagers have formed, i.e. *People's Organizations*, or *PO*'s; (c) *VillageCouncil*; (d) *HouseHold*; (e) *Village*; and (f) *MediatingInstitutions*, i.e. *government organizations* and *non-government organizations.* The environment, which is composed of *cells* or units of land, has components both on land and in the sea. A *Cell* contains different types of resources depending on its cover. Other entities of the model are the *ManagementUnit* and W*eather*, a global entity used to represent weather that affects all the other entities of the model. Each entity may have different attributes or characteristics as well as operations or functions. For example, a *Villager* has the following as attributes income, age, gender and functions such as: it can *raiseAnimals*, *collectNTFP*, *hunt*, and carry out other livelihood activities. A *MediatingInstitution* may be able to conduct training, and provide livelihood materials and education for the PO. The lines connecting the entities represent the relationship between these entities. For example, both the *PO* and *MediatingInstitution* are managing the *ManagementUnits*. The operations or actions of an

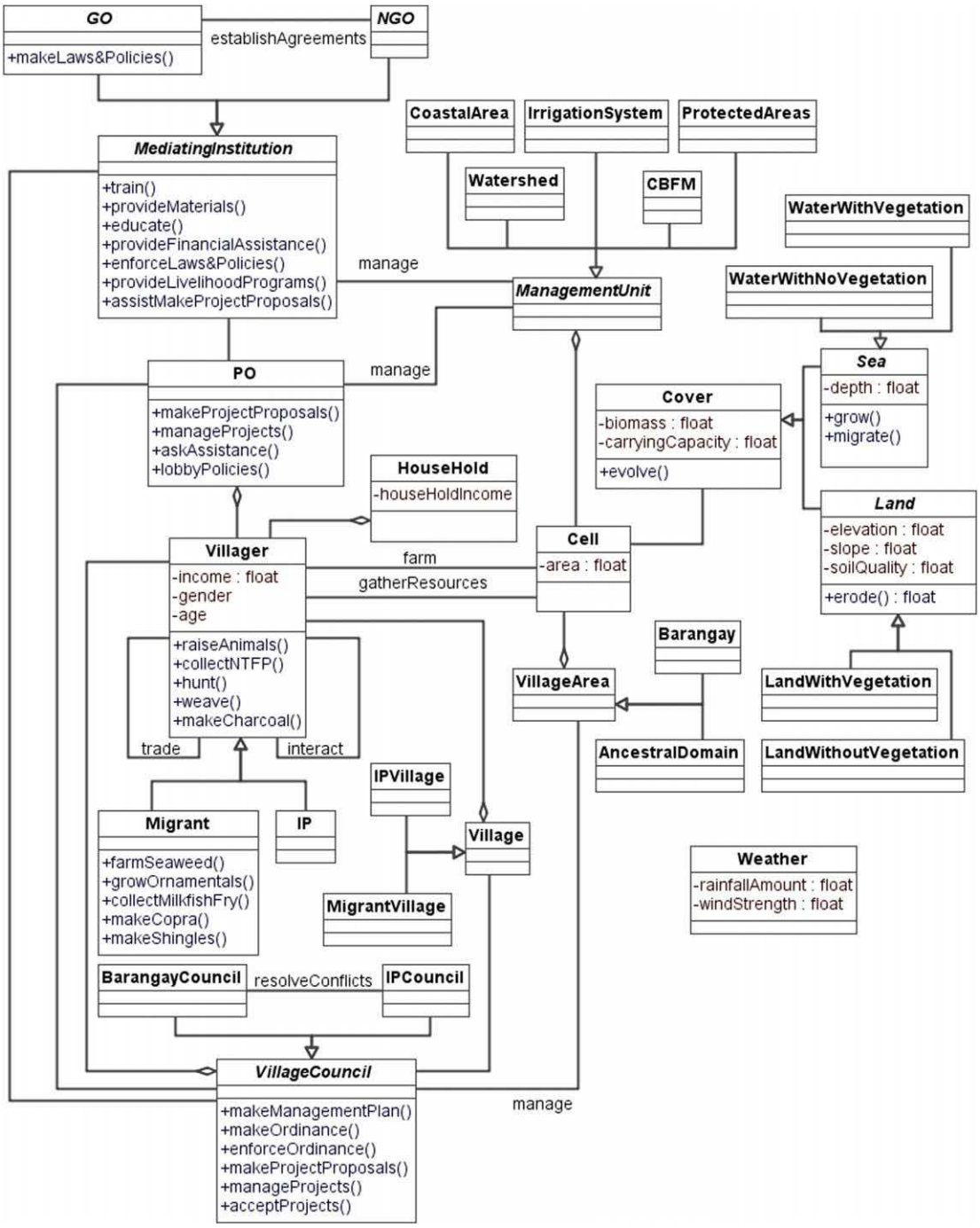

Fig. 6. Entities of the MAS model and their interrelationships.

agent depend on its goals. For example, a *Villager* would have a goal of generating income, thus most of its actions are related to livelihood activities. On the other hand, a *MediatingInstitution* would be interested in protecting the environment, thus it has actions that are meant for this purpose such as enforcing environmental laws and policies and educating the *PO*. Lines with triangular arrowheads are used to describe subclasses or subtypes of an entity. For example *GO* and *NGO* are subclasses of *MediatingInstitution* and this is shown as arrows coming from the subclasses *GO* and *NGO* leading to the class *MediatingInstitution*. Lines with diamond ends are used to describe membership of groups, e.g. a *PO* is composed of *Villager* and *ManagementUnit* is composed of *Cell*. From the MAS conceptual model, a role-playing game, referred to as RPG1, was developed and played with the stakeholders to validate the conceptual model, and at the same time immerse the stakeholders into a collective learning process.

4.3. Role-playing game: model presentation, validation and experience

RPG1, which was inspired by the *CherIng* prototype game used in the introductory workshops, was based on the simplified MAS conceptual model, which focused on the livelihood activities of the local communities and their impacts on the natural resources.

Game rules were formulated based on the researchers' understanding of the system and game materials, such as a game board and player's income cards were constructed. The game was presented and played in a series of workshops, four sessions in total, and attended by 36 migrants and 12 Bataks. In the game, the participants or players were asked to take their roles as they would normally do in real life situations: making decisions, taking actions, reacting to situations as they unfold, and doing whatever actions or patterns of behaviors they would otherwise do in their current situations. This activity, in part, serves as a form of legitimizing the RPG1 process and also validating the conceptual MAS model. As with any other model that is being validated, some of the aspects of the game had to be changed based on the feedback from the participants. Monetary payoffs of some livelihood activities were revised and a livelihood activity was replaced with another. Additional data were collected through individual interviews with players and non-players. These revisions were reflected in the MAS model and, consequently, the RPG as well. The revised RPG1, i.e. RPG2, was introduced to the stakeholders for another round of validation through another series of workshops.

4.4. RPG2 and scenario-building

The revalidation of the MAS model using the RPG2 was done in another series of workshops. This time, the game was played not only with the community (participated in by 26 migrants and 14 Bataks) but also with government organizations (GO) and NGO representatives, with 19 and five participants respectively. The participants from GOs, NGOs, migrants and Bataks played in separate sessions. The GO and NGO participants in this situation played the role of resource appropriators, different from their usual roles, and thus revealed insights on their perceptions of the local communities' behaviors in resource extraction and livelihood. In addition to validation, the concept of scenarios was reintroduced to the participants by changing the rules of the game, similar to that of the *CherIng* game. More specifically, rules on resource access were changed to simulate the implementation of new laws for resource access. This was used as an example to prepare the stakeholders for the next step of the process, which was scenario-building. Scenarios or "what if" situations about the CBFM system were developed collectively with active and direct participation of all stakeholders. This step was designed to draw out the concerns of the stakeholders about their resources. At the end of the workshop sessions, the participants, having validated the model and attesting to its value in planning processes, endorsed its use in future management planning activities for the CBFM and other resource management systems.

4.5. Resource management planning and negotiation

A MAS simulation model, which included options to simulate the scenarios that were identified earlier by the stakeholders, was developed and presented to the stakeholders representing the local government units, NGO's and the local community in a natural resource management planning workshop. Because the stakeholders have different perceptions and interests, these perceptions were represented using indicators that were identified by the stakeholders themselves during the scenario-building process. These different worldviews were modelled using graphical representations such as maps or charts, which were then used to examine the differences in the perceptions. The scenario-building results served as the basis for discussion in the collective planning of the resource management strategies of the three villages. At the end of the workshop, resource management strategies for each of the villages were collectively developed, unanimously agreed upon and with commitments from the stakeholders to their implementation.

4.6. Evaluation

The evaluation of the ComMod process in Palawan, conducted 8 months after the last ComMod activity, made use of the ComMod evaluation protocol. Executed by an external evaluator, the evaluation was to determine the impacts of the ComMod process on the stakeholders and link these impacts to the steps of the process. The evaluation results (Perez and Aubert, 2007) were used to corroborate the observations and findings made by the LPF-ComMod researchers, such as those that are presented in this paper.

5. Key outcomes and lessons learned

After the introductory MAS workshop, the participants welcomed the idea of building a MAS model to represent their CBFM system. They were interested and engaged in the simulation because they have a number of concerns that they wanted MAS modelling to address, e.g. effects of livelihood activities vis-à-vis resource availability. Thus, the RPG was seen as an effective tool in communicating information regarding natural resource management, and it also served as a convenient platform to better explain, or demonstrate, ideas and concepts through games rather than oral presentations. Using different scenarios in the game, the RPG created an environment that simulated or mimicked negotiation processes that are likely to happen in real situations. Equally important, the game also offered a forum for the collective or collaborative development of management strategies. There was perceptible excitement and obvious signs of 'learning' among the participants as they interacted, discussed and debated resource management issues. For example, some players began experimenting and testing strategies for their livelihood choices within the game. It was encouraging to observe that some of them seem to have started implementing what they have learned and the strategies they devised.

The combined and integrated use of RPG and simulation in the modeling process offered an environment for all stakeholders to participate in a setting where they perceived themselves to have equal power or opportunity. The MAS model served as a mediation tool where management strategies or actions conceived individually or by a few stakeholders can be evaluated collectively and objectively by a larger group. Ideas, proposed actions, and strategies were evaluated based on their 'merits' according to the results from the MAS model, and not so much on the personal power, influence, or persuasive capabilities of stakeholders. Positive feedbacks from this experiential and experimental learning activity were received. For instance, NGOs, requested that they be given more in-depth training to enable them how to conduct similar MAS and RPG activities because they would like to apply the model to other areas. Also, as the RPGs (i.e. *CherIng*, RPG1 and RPG2) were played at different times with different participants, different perceptions and priorities of the stakeholders were revealed. The data-gathering activities for the MAS modelling process, on the other hand, gave additional insights on how the stakeholders interact within their group and with the other stakeholders. This also revealed that many of the migrants from the community perceive themselves as resource users rather than having a specific livelihood.

The RPGs and the subsequent discussion were an eye-opener to the stakeholders because they provided a comparative look at the three *barangays*, as well as between migrants and the Bataks with respect to their livelihood activities and attitudes. Until the time of RPGs, some of these aspects remained hidden because they could

not be drawn out during the interviews and focus group discussions, or because they could not be revealed simply by asking questions. The following insights were deduced from the observations during the RPG sessions as well as the discussion among participants about RPG and its results:

(1) At the beginning, it was assumed that the three *barangays* were sharing the same space for resource use. It was expected that there were similarities as well as differences in their livelihood activities. Although this was obvious for the case of the Bataks because they are limited to the forest area, it was much more difficult to identify the similarities and differences in the choice of livelihood activities of the migrants. The RPG process revealed a different and clearer picture in terms of which *barangays* are more involved in a particular activity based on the choices they made during the game as well as from the discussions that followed.
(2) The income from just one livelihood activity is not enough to sustain the everyday cost of living in the community. Given this situation, the migrants are often engaged in more than one livelihood activity, many of which are outside the CBFM area. However, the profitability of some of the livelihood activities outside the CBFM, such as fishing and vegetable gardening, given the right capital, training, and equipment, will actually depend on the participants' experiences. For example, in the RPGs played with the participants in the three *barangays*, most of those who tried to engage in fishing, but with little or no fishing experience in real life, did poorly. When asked if this result is realistic, they replied affirmatively. However, some players, who are experienced fishermen in real life and have invested resources in their equipment, especially on their boats, were profiting from fishing during the game. They were asked if indeed such profits were attainable in reality. They replied that based on their experiences, it is indeed possible.
(3) During the RPG, it was observed that Bataks will do the same livelihood activity at one time. In the ensuing discussion, it was explained to the researchers that the Bataks will do one kind of activity for a period of time depending on the season or demand and as agreed upon by the Batak community. For example, if it is the season for honey, all those who are physically able will gather honey. If there is demand for rattan, all of them will gather rattan.
(4) During the discussion about the RPG, the Bataks were asked about their strategies during the game, such as when the community is engaged in a particular activity, and if the payoffs they were getting in the game were accurate. They explained that, for some of the commodities, these are gathered only if there is demand from the traders (migrants). In terms of pricing, it is the traders who dictate the price. Therefore, for the case of the Bataks, they rely heavily on the trading activity of the migrants for their livelihood. Most, if not all, of their commodities are sold to the migrants from within the three *barangays*. The Bataks seldom sell their commodities in the main city due to high transportation costs.
(5) Initially, buy-and-sell activity was not seen as directly connected with resource exploitation; thus they were not identified in the focus group discussions and were not included in the RPG. During the discussion of the RPG, however, the participants pointed out that these activities should be included in the game because there are considerable numbers of people in each of the three *barangays* who are engaged in this type of activity. Closer analysis reveals that because of the number of people involved in this kind of activity, in addition to the fact that the livelihood activities of the Bataks are demand-driven, these activities may determine the rate and intensity at which resources are gathered within and outside the boundaries of the *barangays*. A more precise study about the buy-and-sell activities of the community is needed to gain a better understanding of the dynamics of this livelihood.

The insights, observations, and lessons learned from the RPG and MAS modelling processes were communicated to a community working group, which was organized by the stakeholders under the initiative and facilitation of the LPF staff. Data gathered from the focus group discussions and the different aspects of the livelihood activities in the villages, including costs and income generated from performing a livelihood activity, and the insights generated from the RPG's and MAS simulations were used by the working group in devising plans for future livelihood activities and new opportunities.

One limitation of the method used in this study is dependence upon technology and equipment not readily available in communities. Discussions between the LPF (e.g. researchers) staff, some government offices and NGOs are now exploring ways to translate the RPG into something quite crude; one that does not require elaborate set up, needing only minimal use of technology, equipment and electricity. Such a crude tool could be used in remote areas where these items are lacking. The stakeholders appreciated the lessons they learned from the MAS model, and the RPG processes used in making the model. They recommended adoption of both tools to the *Barangay* Development Council – the decision-making body of a community composed of community leaders and representatives – as a decision-making tool in its resource management planning activities. They also suggested that, to further promote the use of the model and the tools, an RPG session should be conducted with the members of the BDC so that they will also experience and appreciate the value of the model in their planning process.

6. Conclusions

This paper reported on the results of a study aimed at exploring different management strategies using a MAS model developed through companion modelling (or ComMod) for a CBFM site of three villages. The modelling process exposed the stakeholders to learning experiences that are not typically found in other methods such as in most social surveys and interviews. The creative ways of facilitation adopted in the study during a series of workshops involving RPG and simulation allowed the researchers to present the model in a more acceptable and agreeable manner and, to a certain extent,, in some cases even entertaining. This in part created an informal and comfortable environment and helped maintain the interests of the stakeholders and keep them engaged in the process. The use of RPG also enabled the researchers to observe stakeholders and draw the stakeholders' motives and attitudes towards decision-making under a controlled environment. The stakeholders' direct and active participation in the modelling process gave more credibility to the model and its artefacts; consequently, the stakeholders had more confidence in adopting the results (e.g. management strategies) from the process. Knowledge and information gathered from the stakeholders were shared back to the stakeholders and used in the learning processes through RPGs. The results of the RPG and computer simulation and its implications were subsequently used to support the process of negotiations and in developing management strategies. Invariably, outcomes generated from negotiations had a greater chance of acceptance. Collective learning situations also built and strengthened the relationships between stakeholders as they shared knowledge, expertise, and experiences. For instance, the models were used more effectively in discussing policies that were

perceived by plantation developers as disincentives to plantation development and management. Perhaps the most significant result from the study is the appreciation generated from the stakeholders in terms of the value and applicability of the tools and models presented to them. ComMod provided an excellent tool that stakeholders, who are mostly unfamiliar with models, or are not used to thinking about 'systems', could use to address the concerns, objectives, and goals in managing their CBFM area. RPG offered a good platform for the stakeholders to mimic their actions, reactions, and decisions under an egalitarian environment, thereby providing equal opportunity for all stakeholders to participate. RPGs also allowed stakeholders to have a more direct experience in testing strategies because they are immersed in a 'realistic' situation giving them a more pragmatic approach in making plans and decisions. Finally, MAS simulations enabled scientists and stakeholders to work together in developing and testing management strategies.

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