COMPANION MODELING FOR INTEGRATED RENEWABLE RESOURCE MANAGEMENT: A NEW COLLABORATIVE APPROACH TO CREATE COMMON VALUES FOR SUSTAINABLE DEVELOPMENT

AUTHORS
Nipada Ruankaew
Department of Biology, Faculty of Science, Chulalongkorn University & CU-CIRAD ComMod Project, Chulalongkorn University, Bangkok, Thailand

Christophe Le Page
CIRAD, UPR GREEN, Montpellier, F-34398 France & CU-CIRAD ComMod Project, Chulalongkorn University, Bangkok, Thailand

Pongchai Dumrongrojwattana
Department of Biology, Faculty of Science, Chulalongkorn University & Paris X University, France.

Cécile Barnaud
CIRAD, UPR GREEN, Montpellier, F-34398 France & CU-CIRAD ComMod Project, Chulalongkorn University, Bangkok, Thailand

Nantana Gajaseni
Department of Biology, Faculty of Science, Chulalongkorn University & CU-CIRAD ComMod Project, Chulalongkorn University, Bangkok, Thailand

Annemarie van Paassen
Communication & Innovation Group, Wageningen University, Netherlands

Guy Trébuil
CIRAD, UPR GREEN, Montpellier, F-34398 France & CU-CIRAD ComMod Project, Chulalongkorn University, Bangkok, Thailand

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CORRESPONDING AUTHOR:
Nipada Ruankaew
Address: Department of Biology, Faculty of Science, Chulalongkorn University & CU-CIRAD ComMod Project, Chulalongkorn University, Bangkok, Thailand
Telephone: +66 22187537, Fax: +66 22185386, Email: Nipada.R@chula.ac.th

SUMMARY

Sustainable management of renewable resources is often complicated by diversity and dynamic nature of the ecological and socioeconomic systems involved. As these system dynamics and interactions are highly complex and frequently unpredictable, there is a need to opt for transdisciplinary research addressing adaptive and integrated renewable resource management. Companion Modeling (ComMod) is a multi-agent systems (MAS)-based approach relying on synergistic effects between Role-Playing Games (RPG) and Agent-Based Models (ABM) to facilitate information sharing, collective learning, and exchange of perceptions to support negotiation, facilitate collective decision-making, and to strengthen adaptive resource management capacity. Iterative and adaptive sequences of field work and modeling activities allow inclusive and interactive participation of stakeholders during design, implementation, calibration, and validation steps of the models, as well as joint use to explore possible future scenarios. ComMod was implemented in a study of a conflict between two ethnic communities and a newly proposed national park in Northern Thailand. Deforestation, biodiversity conservation, and livelihoods were key issues discussed during RPG sessions, and subsequently represented in an ABM simulator. Consequently, local stakeholders learned about agro-ecological and socioeconomic dynamics and gained an increased awareness of these key issues. Mutual understanding was improved, and the importance of collaborative discussion, essential to negotiation and decision-making, became obvious. Finally, this Northern Thailand experience has shown that collaborative interactions between researchers and local stakeholders mediated by ComMod tools were supportive of improved communication among the conflicting parties and joint learning for adaptive and integrated sustainable management of renewable resources.

INTRODUCTION

Sustainable management of renewable resources inevitably involves not only ecological dimensions but also social, economic, cultural, and political aspects of the use of resources. Successful management of the resources is, therefore, often complicated by diversity of the ecological and socioeconomic systems involved and their interactions, as well as the increasing number of stakeholders concerned by collective management of common-pool resources and environmental problems. In addition, dynamic nature of interactions among diverse factors at various levels and scales frequently leads to highly complex, non-linear, divergent processes and the emergence of new phenomena, which are often unpredictable (Liu, et al. 2007, Trébuil 2008, van Passen, et al. 2008). As changes are accelerating and uncertainty increases, there is a need to opt for trans-disciplinary research addressing truly adaptive and integrated renewable resource management (Berkes and Folke 1998, Holling 2001).

Companion Modeling (ComMod) is a multi-agent systems (MAS)-based approach which relies on synergistic effects between Role-Playing Games (RPG) and Agent-Based Models (ABM) to facilitate information sharing, collective learning, and the exchange of perceptions on a given concrete issue among researchers and other stakeholders. ComMod can be put in use to either better understand a complex issue or to support negotiation and collective decision-making among stakeholders facing a common renewable resource management problem (Bousquet, et al. 1999). Iterative and adaptive sequences of field work and modeling activities allow mutual and interactive participation of stakeholders during design, implementation, calibration,

and validation steps of the models, as well as their joint use to explore possible future scenarios.

This article presents the theoretical and experimental aspects of Companion Modeling, followed by a case study which draws on a ComMod experiment conducted in northern Thailand. Results are then discussed as well as potentials for collaborative research and sustainable development of renewable resources.

METHODS

Companion Modeling

Companion Modeling (ComMod) is a multi-agent systems (MAS)-based approach, in which a collection of heterogeneous, autonomous entities or agents interact with each other and with their environment (Gilbert 2008). MAS models are thus adapted to describe dynamic and complex systems of renewable resource management and are able to capture emergent phenomena arising from interactions among diverse dimensions of resources and stakeholders in the systems (Janssen 2003). ComMod is accomplished by the combined use of Role-Playing Games (RPG) and Agent-Based Models (ABM), both of which are MAS-based tools (Barreteau 2003, Bousquet, et al. 2002)

ComMod has two major aims: to facilitate collective information sharing and learning; and to improve the coordination among stakeholders for negotiation and

decision making (Barreteau 2003, Bousquet, et al. 1999). It has been applied to explore renewable resource management issues in many places around the world, including several sites in Southeast Asia[1] (Bousquet, et al. 2005).

The modeling process of ComMod is divided into successive phases: (i) definition and characterization of problem, including stakeholder and institutional analysis, based on existing knowledge and specific surveys to fill the gaps; (ii) conversion of knowledge obtained to formal models through participation of stakeholders in the co-construction of such conceptual models; (iii) implementation of concrete models that can be run (simulators); and (iv) participatory simulations to explore various scenarios of possible solutions identified by stakeholders (Bousquet, et al. 2005). Iterative and adaptive sequences of field work and modeling activities allow inclusive and interactive participation of stakeholders throughout successive cycles of the ComMod process driven by stakeholders' needs. The approach considers that points of view of all local stakeholders on the issue to be examined are legitimate. Therefore, the collaborative modeling process welcomes the involvement of all concerned parties in problem definition, model design, implementation, calibration, and validation steps of RPG and/or ABM models (Dray, et al. 2006), as well as their subsequent use to explore diverse possible future scenarios of interest. Perceptions on various aspects of the common issue at stake are exchanged among local stakeholders and researchers with the aim of achieving an agreed-upon and shared representation of the problem to be mitigated collectively.

[1] also see www.commod.org, www.ecole-commod.sc.chula.ac.th, and www.cpwf25.sc.chula.ac.th for case studies

Based on initial conceptual models, RPG are MAS models implemented into playable games, usually with help of boards, maps, cards, papers, and are often computer-assisted. During RPG sessions, participants enact the actual use and management of renewable resources by playing various roles (sometimes their own roles) of resource users involved with the natural resource management issue in question. This experience allows the stakeholders to interact and examine complex systems they are part of in a non-threatening atmosphere, and usually triggers discussions among them about their common problems and possible solutions. To a certain extent, as the participants share existing common knowledge of the actual features of the problem at stake, the models can be rather simple and only critical interactions are focused on, for instance, improvement of management through negotiation and new rules (Barreteau, et al. 2003, Bousquet, et al. 2002).

Playing RPG also helps local stakeholders understand the structure and operation of the computer-based ABM model which will be used soon after to explore future scenarios of their choice, and gives them an opportunity to validate, criticize and improve it (Barnaud, et al. 2006). While the RPG tool is usually popular with local stakeholders, they tend to become complex and cumbersome as the number and diversity of stakeholders increase. In addition, RPG sessions are rather costly to organize in terms of time (half a day per gaming session with 10-20 players), as well as financial and human resources needed to prepare, moderate, observe and analyze the gaming sessions. Computer-based ABM simulations replaying the rules of the RPG are more manageable and time-efficient (Barnaud, et al. 2008b, Barreteau 2003, Barreteau, et al. 2001). Consequently, ComMod usually associate RPG with ABM simulators able to “play the game” in a time- and cost-efficient way, leaving plenty of

time for the stakeholders to debate the simulation results. Furthermore, the ABM tool facilitates the transfer of the RPG experience to larger groups of people (like the whole village population) and to decision or policy makers having limited time at higher levels in the social hierarchy

Complementary to RPG, ABM Simulations are computer simulations *integrating* information and indigenous knowledge gathered from RPG sessions, therefore providing common representations of the complex dynamics of the systems. As they are based on MAS structure, agents and environment in the ABM are created to represent actual resources and users along with rules and context of the real system. Gradually built during the whole ComMod process, these simulations are mainly used to simulate relevant scenarios selected by the stakeholders to help them explore alternatives in resource management. In particular, they are able to see and discuss their possible specific effects on the resource, normally through the observation of relevant ecological indicators agreed upon during previous sessions. Additionally, stakeholders are also able to examine specific effects of simulated scenarios on the concerned parties, for example, with social and/or economic indicators showing benefits and disadvantages (Barnaud, et al. 2008a, Etienne, et al. 2003).

More often than not, RPG followed by participatory ABM simulation sessions lead to improved knowledge and dialogue through co-learning. In addition, new aspects, key questions or entirely different problems frequently emerge from interactions and discussions among participating stakeholders that could be examined through similar modeling and simulation activities during field workshops in a new ComMod cycle. The iterative ComMod cycles provide an adaptive approach for the exploration of

rapidly evolving renewable resource management issues. For example, ComMod researchers have successfully used collaborative ABM simulations with illiterate Akha ethnic highlanders to explore rules of credit allocation among different types of households in perennial cash cropping in northern Thailand (Barnaud, et al. 2008a)

As a new collaborative research and modeling approach, ComMod can be used in two contexts: to understand the functioning of a complex social-ecosystem by stimulating dialogue and collective learning; and to facilitate negotiation and decision making; therefore, strengthening the capacity of local stakeholders for adaptive resource management. The two contexts are complementary and not mutually exclusive, as the first objective needs to be fulfilled before proceeding to the latter. For the most part, several ComMod exercises have achieved the first objective, i.e., to gain greater understanding of complex natural resource management systems (Barnaud, et al. 2008b, Dumrongrojwatthana, et al. 2008, Dung, et al. 2008, Mathevet, et al. 2003, Naivinit, et al. 2008). However, a few case studies have reached the second objective, i.e., to support collective negotiation and decision making process (Barnaud, et al. 2008a, D'Aquino, et al. 2003, Gurung, et al. 2006, Promburom and Bousquet 2008), and therefore have contributed towards adaptive and integrated management of renewable resources.

Case study on management of an upper watershed in Northern Thailand

A case study of ComMod approach in dealing with integrated renewable resource management in Northern Thailand is presented here. This case study combined RPG and ABM simulation experiments to raise stakeholders awareness and understanding

of effects of the establishment of a new national park on local farming activities in the upper watershed of Nan Province, Northern Thailand (Barnaud, et al. 2008b). Ban Nam Ki and Ban Nam Paeng villages are two ethnic Mien (or Yao) communities located along the border of the new Nanthaburi National Park (NNP) in western Tha Wang Pha District, Nan Province. Their livelihoods until the 1970s have depended upon shifting cultivation-type agriculture of maize, upland rice, and opium poppy. In the late 1970s, government's interventions have forced them to replace opium poppy cultivation with extensive cash cropping, while commercial logging concessions led to significant deforestation. To combat the serious decline of forest cover in this headwaters area, farmland was delimited by the Royal Forest Department (RFD). Subsequently, the Mien villagers had to replace shifting cultivation with permanent cultivation of annual (mainly maize for animal feed) and perennial (mainly litchi orchards) commercial crops. Therefore, subsistence livelihoods were replaced with new and far more unequal socioeconomic situations in which villagers depended upon outside markets, both for inputs and outputs.

As a result of these transformations, the most resource-poor villagers were seriously in debt, and had to supplement their income with collection of non-timber forest products (NTFPs), as well as seeking off-farm employment in urban areas. In 1996, a new national park has been proposed in the area, although it has not yet been officially declared at the time of the study (2006). Park boundaries were not clearly defined, leading to the Mien villagers' confusion and frustration over losing already limited farmland. Moreover, specific forest management rules and regulations were not known, especially regarding the rights of the villagers to continue gathering NTFPs, which are important sources of income for the most economically vulnerable

households. A rising conflict between the two villages and the national park was becoming evident. Lack of communication between the stakeholders involved did not help in mitigating the conflict, and was leading to widespread mistrust and misunderstanding prevalent among the stakeholders. The conflict over utilization of forest resources in the study area encompassed both ecological and social dimensions, resulting in intricate and dynamic situations. Forest cover of the watersheds, water availability, and biodiversity conservation were issues as important as villagers' livelihoods dependent upon farming and forest products.

In 2006, the ComMod approach was put to use to improve communication among the conflicting parties. The challenge was to facilitate communication between villagers and the national park administrators, in order to improve their understanding of the complex issue of forest resource management and to lead to a new set of rules regulating the exploitation of NTFPs by poor local people. The ComMod exercise combined modeling activities in the laboratory, namely the design of two successive RPG and of an ABM simulator, with a series of field workshops, including RPG gaming sessions and subsequent interviews, in the two villages. The first set of workshops was followed by presentation of the ABM simulator and stakeholders' feedback from field workshops to NNP officers. A final joint workshop was implemented with the participation of farmers from both villages, as well as RFD and NNP officers (Figure 1).

During the initial diagnosis based on secondary data analysis, landscape analysis and individual interviews of local farmers in early 2006, the research team was able to identify a key renewable resource management problem, i.e., the possible conflict

between the NNP and the two villages over forest utilization in the midst of newly proposed national park demarcation; and the main stakeholders involved. This preliminary diagnostic-analysis showed how crucial NTFPs gathering (in particular Arenga palm fruits) was to the economic survival of the most resource-poor farming households. Therefore the ComMod activities focused on the effects of forest and biodiversity conservation on villagers' livelihoods.

During the ComMod process, the interaction between deforestation, biodiversity conservation, and villagers' livelihoods were first represented in a RPG and discussed just after the gaming sessions in both plenary debates and individual interviews with the players in order to improve its features and rules and to make its relationship with actual circumstances even more explicit. Later these interactions were represented in an ABM simulator similar to this game that was used to communicate the villagers' point of view on the issue at stake to the RFD and NNP officials and to convince them to join in the exchange process (Figure 2).

The first round of participatory workshops based on RPG sessions, subsequent group discussions and individual interviews were held in June 2006 with selected farmers from the two villages representing the socioeconomic diversity of households. Twelve farmers from each village played separately with a board representing farm areas and forests, making decisions to allocate land, labour, money and resources to grow and harvest crops as well as to gather NTFPs (Figure 2a). Players needed to make decisions to allocate labor force and money, choose crop types and land area, and to collect NTFPs from the community forest. After each round of play, players were presented with their crop yields and incomes gained. Subsequent discussions led to

changes in game rules and possible scenarios to explore; in this case, with and without presence of a national park and its imposed regulation of forest use.

The gaming sessions, plenary debate and individual interviews with the players enriched the research team understanding of the forest-farmland interactions under study. The key issues and important interactions were later represented in a simple ABM simulator similar to the RPG (Figure 2b). This simulator was able to replay the gaming sessions *in silico* and was used to provide feedback from the gaming sessions played by a dozen of farmers to the whole village populations. It was also used to communicate the villagers' point of view to the forestry officials and national park rangers before the second round of RPG sessions held in December 2006, during which villagers from both villages, RFD foresters and national park rangers participated.

As part of the ComMod approach, group discussions and individual interviews were routinely conducted with the participants immediately after each of the RPG or ABM simulation sessions to gather what they learned and received from the ComMod experience, as well as their suggestions on how to improve the on-going modeling process. Normally, the questions asked and discussed include changes in perceptions, levels of understanding, and behavior of the stakeholders towards the issues of resource management which was the focus of the ComMod sessions.

In June 2007, an external evaluation of this Northern Thailand ComMod case study was conducted based on a framework to document and assess experiences of the

process designers and local participants[2]. The external evaluation, conducted through interviews, aimed to assess the actual implementation and diverse effects of this ComMod process on its participants, both immediate and long-term (van Passen and Patamadit 2008). Combining the routine evaluation and monitoring steps inherent to ComMod approach with the additional evaluation by external experts has provided an innovative framework to systematic assessment of this case study.

RESULTS AND DISCUSSION

The outcome of the ComMod process implemented in remote villages with people having received limited or no formal education showed that villagers, and researchers alike, gained a better understanding of the forest resource and farmers' livelihood issues and increased awareness of these issues among the villagers. 85% of the participants said that the game increased their awareness of the national park issues (Barnaud, et al. 2008b). Rules of forest usage emerged as a more significant problem than the actual national park boundary itself.

The results from the first RPG sessions led to the construction of a hybrid ABM simulator, which represents the resources, stakeholders and rules of resource utilization. After presentation of the ABM simulator, NNP officers better understood the collaborative modelling process and its objectives and accepted to participate in the second participatory workshop with the farmers from the two villages. As a result,

[2] The external evaluation was part of a large-scale evaluation of some 30 ComMod processses in various continents carried out under the Agriculture and Sustainable Development (ADD) Program of the ANR, France.

it was agreed that mutual understanding through better communication was needed, and a common platform was necessary for mediation and negotiation of the forest resource management issues in the area. This achievement was seen as a first step towards a more adaptive and sustainable management of forest resources in this area.

However, the chief of the NNP did not join the workshop, and, as the National Park law is highly top-down regulated, only informal local agreements can be reached and the villagers remain vulnerable to the looming change in forest utilization rules. Another problem was that a few households of forest encroachers from the Ban Nam Ki village, the most concerned one by the issue being examined, refused to participate in any of the ComMod activities. This underline the need for more sentisizing activities prior to the implementation of field workshops to try to limit this somewhat self-exclusion of key players, as their important participation is required so that they have a chance to see the recommendations made at the end of the ComMod process being implemented and enforced at the village level.

The external evaluation revealed that the ComMod approach was useful to local villagers for individual learning about consequences of the proposed regulation by the new national park. Researchers gained a better understanding of the agro-ecological situation and of the interactions among local stakeholders. Likewise, NNP officers gained an increased awareness of the villagers' circumstances and points of view, and acknowledged the need for better communication and coordination mechanisms with the villagers. Specifically, the villagers learned about agro-ecological dynamics and socioeconomic equity issues. Several of them increased their social networks used to communicate about the new national park issue and realized the importance of mutual

discussion at the village level essential to satisfactory negotiation and decision making processes involving powerful government agencies. Most importantly, the ComMod process increased mutual understanding among villagers and between them and NNP officers (van Passen and Patamadit 2008).

In general, the ComMod approach proved to be strong and practical in the representation and demonstration of stakeholders' behavior and interests and dynamics between stakeholders and resources. The RPG proved to be an effective tool to reveal individual and collective behavior that are not easily identified with less interactive tools, such as individual interviews, especially when social tension among stakeholders exists (Barnaud, et al. 2008b). However, some stakeholders expressed concerns that the complexity and diversity of issues during sessions could overwhelm the participants; this suggests a limitation to include more diverse types of conflicts and stakeholders in one session and the need to design and implement such ComMod processed by focusing on a well-defined practical resource management problem faced by the potential participants. Sessions need to be structured to get focused discussions, and unravel issues one by one, according to the priorities (van Passen, et al. 2008).

ComMod was also shown to be useful in multi-level communication. In the present case study, the iterative sessions of RPG sessions and ABM simulator have acquainted local farmers and national park officers, who are used to top-down administration, with the possibility of bottom-up decision making and scenario-enhanced negotiation. Specifically, the RPG was successfully used with small groups of local stakeholders and the accompanying ABM simulator was subsequently used to

provide feedback to the whole village community as well as familiarize the national park officers before their participation in the second RPG sessions. This synergistic interaction between the RPG sessions and ABM simulators has therefore provided an original achievement in up-scaling ComMod to include a diverse and hierarchical structure of stakeholders involved in collective management of renewable resources.

CONCLUSION

The overall outcome of this Northern Thailand experience has shown that collaborative interactions between researchers and local stakeholders mediated by ComMod tools were supportive of joint learning to create common values among various stakeholders and to improve adaptive and integrated management, which can lead to sustainable development of renewable resources. However, challenges and obstacles to up-scaling ComMod still need to be explored, especially the need for a supportive policy environment to facilitate the implementation of collective action plans emerging from such collaborative modeling processes for sustainable and integrated management of renewable resources.

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Figure 1. Iterative companion modeling process alternating field and laboratory activities implemented in 2006 in Nan Province, Northern Thailand (RPG = role-playing game, ABM = agent-based model).

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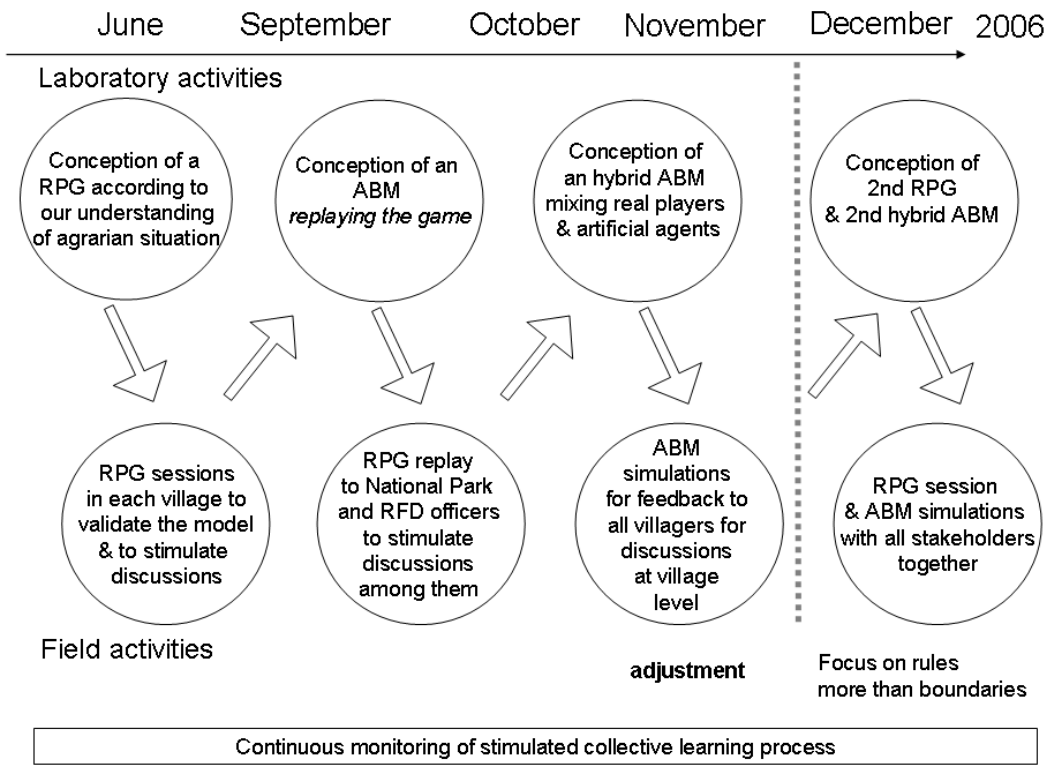
Figure 2. Similarity of features between the main gaming board (a) used in the role-playing game and the interface of the agent-based simulator (b) used in the ComMod study of forest utilization conflict in Nan Province, Northern Thailand.



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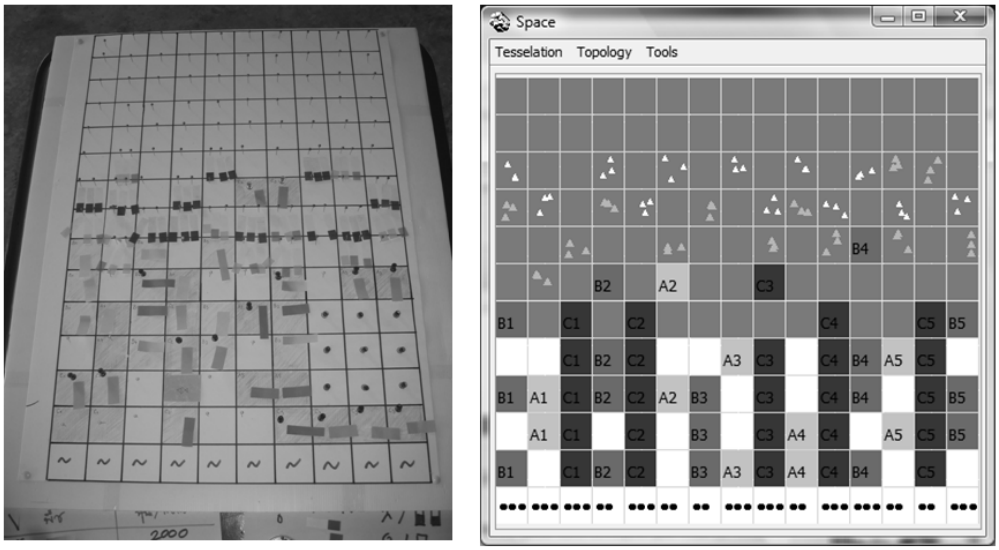

Figure 2. Similarity of features between the main gaming board (a) used in RPG and the interface of ABM hybrid simulator (b) used in the ComMod study of forest utilization conflict in Nan Province, Northern Thailand.