Participatory design and use of a simplified landscape in a simulation model for mitigating land use conflict in Northern Thailand highlands*

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ABSTRACT

Landscape modelling integrating spatial information in Geographic Information Systems has been widely used to represent knowledge and support decision-making in the field of natural resource management. However, creating suitable visual representations of the landscape and its dynamics to stimulate the participation of diverse stakeholders in co-management of the land is still needed. This paper focuses on the design and implementation of a virtual landscape based on iconic representation used with herders and foresters, which both of them have contrasted perceptions on forest regeneration, to observe vegetation dynamics and emerging landscape features depending on different cattle and forest management strategies. This spatial interface was used during computer-assisted Role-Playing Game sessions as part of a Companion Modelling process aiming at facilitating learning and support decision making among the concerned stakeholders in an upper watershed of northern Thailand.

Before designing the spatial interface used in the model, an historical analysis of land use and land cover changes based on remote-sensed data was carried out, as well as a field survey on the impact of cattle grazing on vegetation dynamics. Then, the first set of vegetation states and their dynamics were produced and were validated with herders and foresters later. Thereafter, the simplified landscape representing landscape heterogeneity was constructed and used in two gaming and simulation field workshops. The different patterns of landscape emerged from herders' and foresters' decisions and interactions stimulated them to think about how to manage agro-ecosystems. Both of them agreed to implement a pilot plot of *Brachiaria ruziziensis* pasture in reality after finish the second workshop. This process proved to be instrumental in facilitating communication among the parties in conflict and increasing their motivation to improve the current situation. However, the use of such virtual landscape in gaming sessions proved to be time consuming and the managed area as well as the number of players was limited. Therefore, to get rid of these constraints, a fully autonomous Agent-Based Model making use of the same kind of simplified virtual landscape will be developed and used with local stakeholders to run possible future scenarios of change in a more time efficient and inclusive way.

Key words: Simplified landscape, Visual representation, Model interface, Companion modelling, Role-Playing Game, Agent-Based Model, Northern Thailand.

* Presented at International conference titled "Emergence in Geographical Space: Concepts, Methods and Models", Paris, France, 23-25 November 2009

INTRODUCTION

Collaborative landscape modelling and visualization

In the field of natural resource management, participatory or collaborative modelling and simulation becomes more and more common. Collaborative modelling allows different types of stakeholders to exchange their perceptions and viewpoints about the landscape and its evolution, and can create shared understandings and representations of the land system they manage collectively (Renger *et al.*, 2008). Very often the modelling and simulation tools use visualization features allowing stakeholders to discuss the landscape architecture and its dynamics. Frequently, modelling and simulation platforms dedicated to complex land use planning tasks are combined with GIS-tools. But the role of traditional GIS-based participation tools is limited to providing the information to the users and visualization of the spatial problems combined with some simple tools for communication and participation. "Simply making GIS available on the Internet does not constitute an effective participatory decision support solution.... The GIS-based tool itself cannot encourage higher public participation in spatial planning since GIS and spatial data are expensive and require substantial investment in learning how to use them" (Krek 2005 cited by Horlitz 2007). Such approach cannot constitute an effective participatory decision support solution (Kerk, 2005), especially when indigenous people having received little formal education are involved in the process (Lewis and Sheppard, 2006).

Landscape visualization needs to support the identification, communication and understanding of the important components and behaviour of the modelled phenomena (Kornhauser *et al.*, 2009). The visual representations in the model could be more or less abstract or realistic depending on the objectives of the model and its use (Burton and Obel, 1995; Lange, 2001). But it is important that the relevant features of reality regarding the issue at stake are clearly displayed, but also allow the participants to distance themselves from the real life in order to be creative when envisioning alternative options for landscape management (Dionnet *et al.*, 2008). In participatory modelling and simulation processes, effective visuals presenting information should be clear and understandable by all types of potential users for models to have a chance to be usable and effectively used to support dialogue and decision-making. But, as Horlitz (2007) said it is a tightrope walk between the demand for transparency (avoidance of black box effect) on one hand and the need to reduce complexity on the other.

To design such effective landscape representations, Kornhauser et al. (2009) stressed the importance of "cognitive design and aesthetics aspects". Cognitively efficient model visualizations help model users to detect rapidly important features on the model interface. But this is not easy to do when the case includes heterogeneous stakeholders (such as researchers, farmers, technicians, development workers, administrative officers) using different types of knowledge (scientific, empirical, expert, institutional, etc.) and experiences to frame and produce their own perceptions of the land and its dynamics. A suitable way to do it could be to co-design the landscape features with the main concerned stakeholders to discuss and select the important features linked to the issue at stake to appear, their spatial arrangement and possible evolutions during a simulation. The aesthetic aspects of the visualization are also important to take into account as the visuals have to appeal to their users to highlight key messages and to increase memorization. This is particularly important when iterative gaming and simulation activities are used in order to facilitate the participatory comparison of successive versions of the same model (especially when they need to be validated by diverse users) or/and to carry out comparative analyses of results from different simulated scenarios. The visual features should also stimulate communication among the participants in a collaborative modelling process and stimulate the emergence of new ideas and possible solutions to the problem under study through interactive exchanges and the creation of users own results (Horlitz 2007). And Sheppard (2001) underlined the need for researchers to monitor and evaluate the practical use and influence of landscape visualizations with users.

Therefore, how to create suitable visual representations of the landscape and its dynamics to stimulate the participation of diverse stakeholders in co-management of the land? We attempted to answer this question in a case study focusing on the co-construction and joint use of evolving simulation tools to facilitate the mitigation of a land use conflict between herders and foresters in Northern Thailand. This paper presents the Companion Modelling process implemented to co-design and use a simplified landscape in participatory simulations to stimulate communication and exchange of contrasted perceptions between the two main parties in conflict, to facilitate negotiation, and support collective decision-making toward the emergence of a co-management of the land.

The Companion Modelling approach (ComMod)

ComMod belongs to the family of trans-disciplinary participatory modelling approaches (Barreteau, 2003). Its main objectives are to develop simulation models integrating diverse stakeholders' points of view (including researchers' ones) to better understand the system under study, and to facilitate collective learning, coordination and negotiation processes supporting the adaptive co-management of renewable resources (Bousquet and Trébuil, 2005a; Trébuil, 2008).

The main tools used in ComMod processes are agent-based simulation models, most of the time a combination of Role-Playing Games (RPG) and computer Agent-Based Models (ABM), e.g. Castella *et al.* (2005), Barnaud *et al.* (2007), Barnaud et al. (2008), and more case studies are available at www.commod.org. The use of the multiple synergies between these two complementary types of simulation tools is a characteristic of the ComMod approach (Bousquet and Trébuil, 2005b).

Natural resource management context at study site

Following the implementation of a first ComMod process in this district in 2005-6, the management of the new Nanthaburi National Park (NNP) requested to set up a similar process focusing on the management of the forest-farmland interface at Doi Tiew village. This is a Hmong settlement bordering the park area where reforestation activities managed by the Nam Khang Headwater Research and Development Unit (NKU), another government agency, are also taking place. A land use conflict has been involving different types of local herders and these two forest management agencies.

The two parties in conflict have contrasted perceptions of interactions between forest regeneration, cattle grazing and reforestation. Herders consider that cattle grazing accelerate forest regeneration, while foresters say that cattle grazing damage tree seedlings and saplings, and cause human-made forest fire in the dry season. Before this ComMod intervention, there was no dialogue to mitigate the rising social tensions on land use. We decided to test our hypothesis in this context: Is it possible to facilitate exchanges of contrasted perceptions, improve communication and understanding, and negotiate a co-management action plan through the co-construction of a simplified virtual landscape and its joint use in interactive gaming and simulation activities?

Following the presentation of the successive methodological steps, alternating field and laboratory activities, the results from the iterative process will be presented in four sections, i) The production of a visual representation with stakeholders, ii) The simplified landscape used a first participatory workshop, iii) Its flexibility and modification based on stakeholders' requests, and iv) Their feedback after using this tool. The discussion will deal look at the strong points of such an approach but also its limitations before to present the next steps of this ComMod process linked to the future use of simplified landscapes.

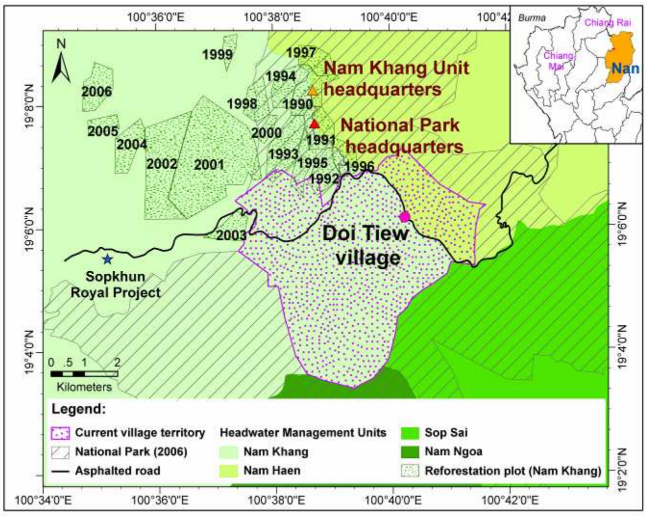

Figure1. Location of study site in the remote highland area in Tha Wang Pha District of Nan province, Northern Thailand.

METHODOLOGY

The successive methodological sequences of activities implemented in this case study are displayed in Figure 2.

Preliminary diagnosis

We started this ComMod process by studying the origin of the conflict, its actors, the resources involved, and the key interactions between them through land use change analysis at the village territory scale, farm surveys (main types of herders and their practices) and an ecological field survey to understand the impact of cattle grazing on vegetation dynamics. From this latest activity, a set of pictograms corresponding to the main vegetation types was produced as part of a conceptual model of vegetation dynamics based on researchers' understanding. These pictograms could be use to represent various successions of vegetation states depending on natural processes or human or animal-made actions.

Co-design of a shared representation of vegetation dynamics

The results from the set of diagnostic activities were assembled in a first conceptual model used to allow stakeholders to share their perceptions in sensitizing activities with two groups of stakeholders (4 foresters and 5 herders) meeting separately due to the initial absence of trust between them. They were asked to comment and improve the range of vegetation states (i.e. what states were missing or needed to be removed?). In a second stage, they use these pictograms to build successions of vegetation states depending on different activities. At this stage, the research team obtained two different diagrams representing vegetation dynamics, with minor differences in transition duration (in years) from one state to another, and merged them into a new one to be discussed in a first participatory simulation workshop.

Design of a simplified landscape and its dynamics

A heterogeneous transect was selected in the 2003 land use map produced during the LUCC analysis. The proportions of the main land cover types were calculated and their correspondence with the pictograms verified. It was simplified into a grid made of assembled pictograms representing the key features of the landscape heterogeneity and gradients. We assumed that the local users would be able to relate this landscape to real circumstances (such as the forage biomass corresponding to each pictogram) based on their empirical experience. This simplified landscape was converted into an environment file in COmmon-pool Resources and Multi-Agent Systems (CORMAS) simulation platform (Le Page and Bommel, 2005). The vegetation dynamics were driven by the state transition diagram produced in the previous activity.

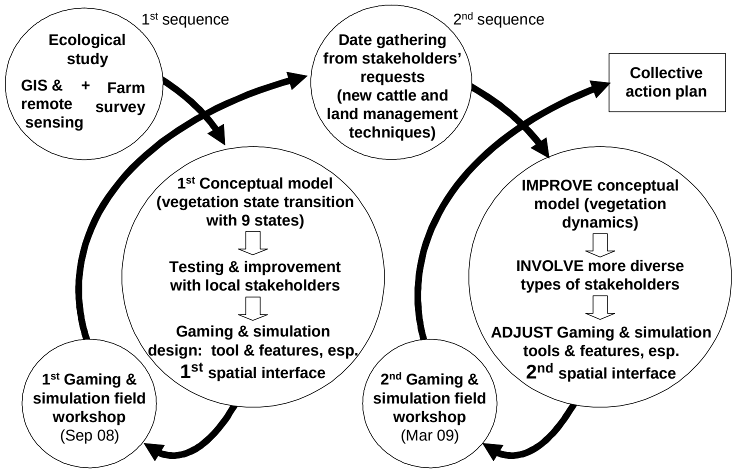

Figure 2. Successive sequences on participatory design and used of simplified landscape.

Two gaming and simulation field workshops

Two successive field workshops were conducted and used this simplified landscape as the main interface of a simulation tool called computer-assisted Role-Playing Game (cRPG). The characteristics of these key events are described in Table 1, while Figure 3 displays how this simplified landscape was used in gaming sessions. Individual interviews were conducted with the players after each workshop to record their comments on the simplified landscape and suggestions to improve it, as well as to clarify their actions during the gaming and simulation sessions.

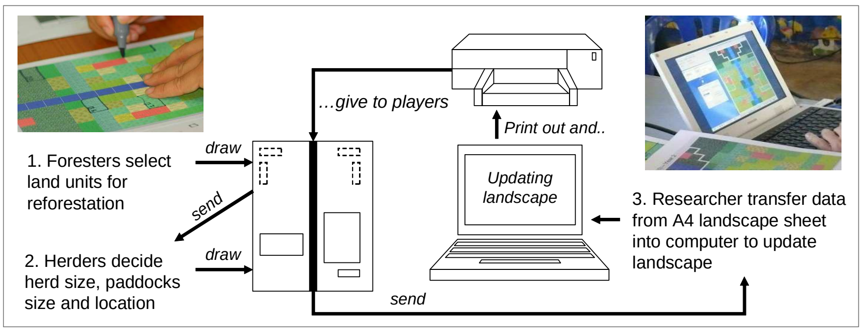

Figure 3. Key steps on the use of simplified landscape through gaming and simulation sessions with local stakeholders. They can exchange and negotiate to manage cattle and reforestation in front of this platform.

Table 1. Details of simulated scenarios using simplified landscape through computer-assisted Role-Playing Game in the 2 field workshops.

Activity	Gaming and simulation (G&S) sessions		
	First workshop (Day 1)	First workshop (Day 2)	Second workshop
Date	- 23 September 2008	- 24 September 2008	- 10 March 2009
Types of partici-pants (number)	- Herders (14) - Researchers (4) - Assistants (7)	- NKU foresters (3) - Herders (8) - Researchers (3) - Assistants (7)	- NKU foresters (3) - NKU foresters (3) - Herders (8) - Livestock Development Officer (1) - Researchers (3) - Assistants (7)
Objectives	- To investigate herders' decision-making process and interactions regarding cattle rearing and forest regeneration. - To prepare the herders to participate in G&S sessions with foresters by giving them more time to understand the G&S tool, especially the simplified landscape and its dynamics	- To present day 1 results to foresters and show how the cRPG works to foresters. - To demonstrate how the computer ABM works without entering players' decision on cattle raising and reforestation. - To stimulate communication, collective learning and sharing of knowledge and perceptions between herders and foresters.	- To investigate the foresters' and herders' decision-making processes regarding the new cattle and land management techniques. - To facilitate collective action plan setting up among local stakeholders.
Scenarios (number of rounds simulated) & activity	- S1 (3 rounds): 2 groups of herders manage cattle without reforestation plots. - S2 (1 round): 2 groups of herders manage cattle with reforestation plots of different ages (2, 3, 5, 10, 20 and 25 year old) initialized in the landscape sheet by researchers.	- S3 (10 time steps): demonstration of vegetation dynamics with reforestation plots and without cattle in landscape. - S4 (4 rounds): herders and foresters manage a common landscape, negotiation is allowed, and different age of reforestation plots (0, 2, 5 and 10 years old) initialized in the landscape sheet by foresters.	- S5 (3 rounds): Herders manage cattle individually. - S6 (4 rounds): Herders manage cattle collectively. - Negotiation is allowed during the G&S sessions.

RESULTS

Co-design of vegetation types and their dynamics

Based on knowledge acquired from the preliminary diagnostic activities, researchers proposed nine pictograms of the main vegetation states. But during the sensitizing activities, the herders asked to add another one called "*Chromolaena* mixed with *Impera*ta fallow." For herders, a given amount of forage availability was associated to each of these pictograms. The herders and the foresters were able to manipulate these pictograms to represent vegetation successions and to assemble a vegetation dynamics diagrams subsequently merged into the one shown in figure 4.

Simplified landscape used in the first workshop

The set of pictograms was used to build the simplified landscape shown in figure 5. Each cell corresponded to 3.2 ha in reality and this interface was large enough to be used by 10-12 herders (managing a total of approximately 100 heads of cattle) and several foresters for displaying their land management decisions and practices in simulation gaming sessions based on the cRPG tool.

A symmetric landscape was used to allow the display of the land use choices made by two (left and right) groups of players acting in parallel. This facilitated the comparison of landscape patterns resulting from the different land management strategies adopted by each group, such as individual vs. more collective herd management.

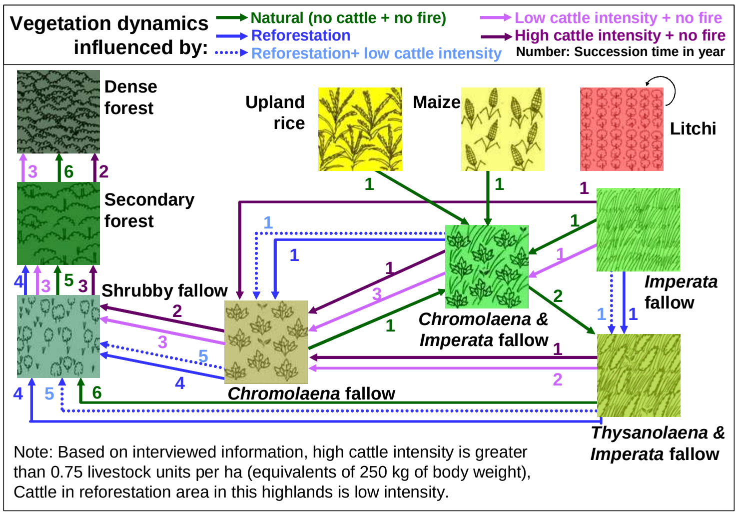

Figure 4. Vegetation states and state transition diagram used to implement the agent-based model.

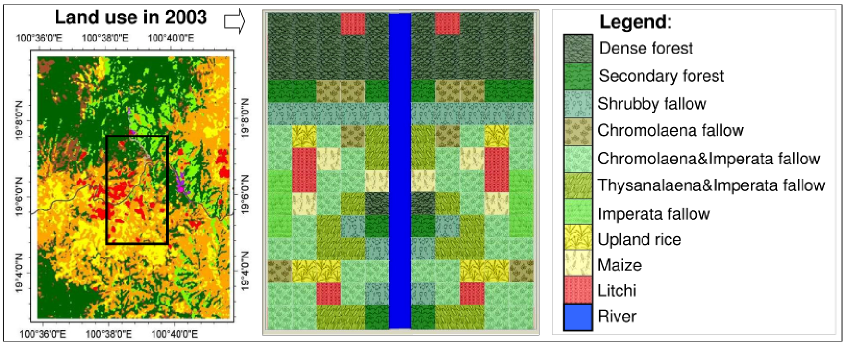

Figure 5. The simplified landscape representing key vegetation types and their positions used as the main interface of the simulation tool in the first field workshop.

Modifications made following the first workshop

This simplified landscape had to be modified according to the players' requests along the ComMod process, particularly to allow the simulation of possible future scenarios of interest to them (Figure 6). For example, the herders decided to test the introduction of artificial pastures in the landscape to compensate for the expansion of the forest cove. Consequently, a new pictogram "Ruzi pasture" was added to represent their preferred forage species (*Brachiaria ruziziensis*). Reforestation plots of different ages proposed by foresters were also inserted in the simplified landscape. The size of a cell was also changed from 3.2 ha to 1.6 ha due to fewer numbers of herders (from 12 to 6). And a seasonal time step (dry and wet seasons) replaced the yearly one used in the first workshop in order to represent the use of the seasonal paddock rotation technique in the subsequent one, another new technique the herders wanted to test.

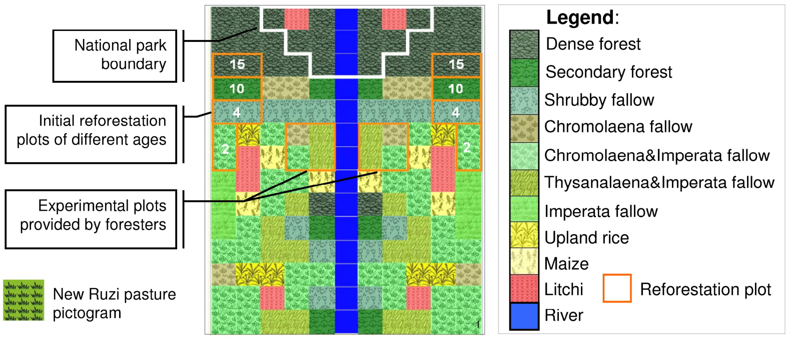

Figure 6. Improved spatial interface for the second workshop.

The use of this simplified landscape in two field workshops

We found that, although it could be seen as complex by an outsider, this simplified landscape representing the local forest-farm land interface was not difficult to understand by the stakeholders as most of its features were familiar to them in actual circumstances. They could easily realize that the upper part corresponded to the conservation area managed by the NNP because of the domination of the dense forest pictograms. Most of the players could remember quickly the meaning of these pictograms and their use to display patterns of landscape. Those who did not understand central Thai language asked further explanations to their neighbours. Exchange of perceptions, shared learning, and improved coordination between herders and foresters was achieved through the joint use of this common virtual landscape.

In the first workshop, herders and foresters were able to manage this landscape according to their actual experiences (Figure 7). Herders used the game to introduce their idea about land management to foresters by showing their cattle raising strategies. One group of herders pooled a small herd and used the paddock rotation technique by alternating grazing between the upper and lower parts of the virtual landscape. Another group raised cattle individually. After four rounds (corresponding to four years) different landscapes emerged from these contrasted management strategies. On their side, foresters faced more difficulties to find new cells unoccupied by herders for reforestation and they had to start negotiation with the herders in a productive discussion and exchange of viewpoints on landscape management.

In the second workshop, both herders and foresters could manage their herds and reforestation plots although the size of the landscape was reduced. We found that herders interested in Ruzi pasture more than paddock rotation technique, and interested to use forester's plot in landscape. By different mode of communication to manage cattle, herders learned that the collective management allowed more extensive establishment of Ruzi pastures (Figure 8). The proceedings of this second round of gaming sessions led to the negotiation of a co-management action plan between the two parties. Central to this plan is the decision to set up a 10 ha pilot plot of Ruzi pasture in 2010 on land provided by the NKU foresters and with the technical assistance from the District Livestock Development officer who joined in the ComMod process at this stage.

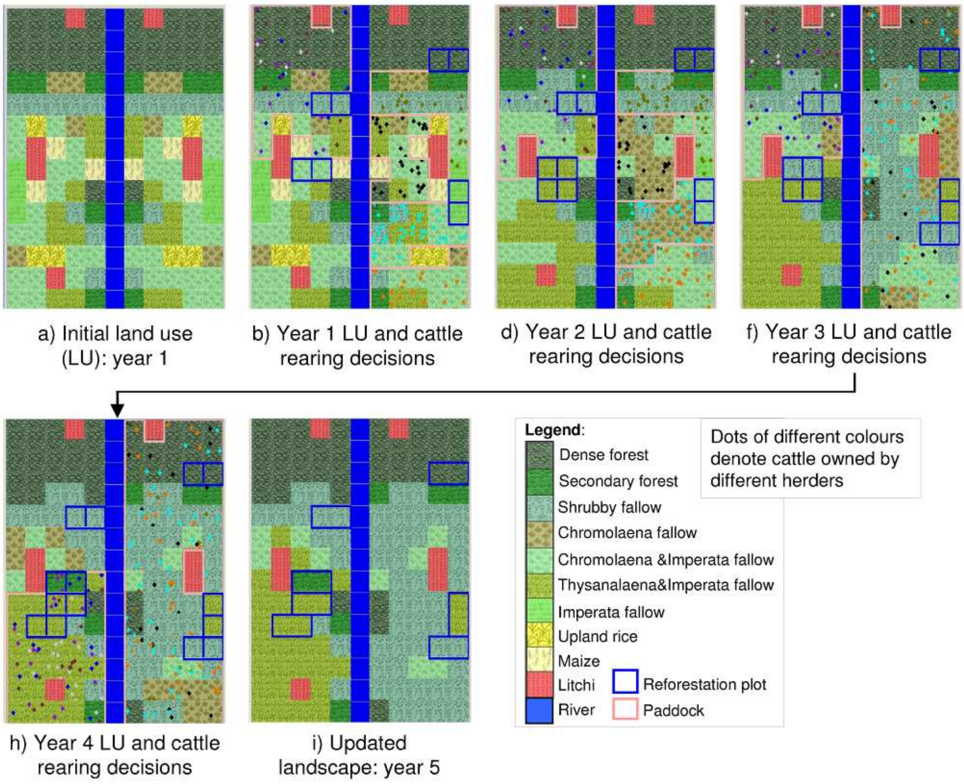

Figure 7. Landscape dynamics emerged from herders' and foresters' strategies in first workshop. In front of the landscape sheet, they discussed and requested to test new cattle and land management scenarios.

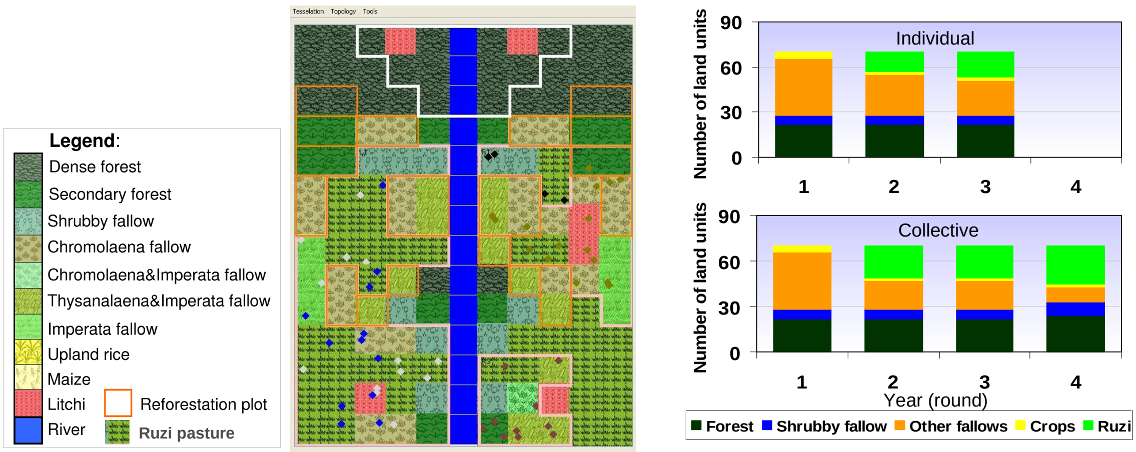

Figure 8. Examples of players' decisions (see legend in Figure 6) on the simplified landscape after modification (right) and increasing proportion of Ruzi pasture in scenario with collective management of cattle (left).

DISCUSSION

Strong points of the co-design and use of this simplified landscape

Transparency and trust between researchers and users: By allowing the modification of the initial researcher representation of the landscape based on the stakeholders perceptions and requests, such iterative modelling and simulating collaborative process lead to the use of more transparent tools and to stronger relationships between the research team and more engaged local model users.

Easy to perceive: A key advantage of such simple accessible models lies in the fact that not only plain information making sense to the users is offered but also the consequences of their different decisions (e.g., land and cattle management options here) are made visible along the modelling process (Horlitz, 2007). The visualization of the results of each group of players' decisions on the land cover on the symmetric landscape and their comparison allowed the users to observe and comment on the changing patterns resulting from individual or collective management strategies. This also stimulated their reflections on how to better adapt to an expanding forest cove and improve their forest-farmland management strategies.

Flexibility of the tool: this is a crucial characteristic in collaborative modelling and we have seen that new types of vegetative cover, scales and time step could be adopted along the modelling process.

Support collective learning and participation level in gaming and simulation sessions: such sessions created a suitable atmosphere to facilitate share learning (Wilson *et al.*, 2009). In simulations, the users could test their proposed scenarios in a non-threatening context and learn by observing the evolution of landscape patterns resulting from own and other stakeholders' behaviour and decision-making. These two workshops were enough to allow the conflicting parties to design a first agreed upon concrete action plan, may be a first step toward the adoption of a more negotiated and decentralized management of the land in this area.

Support concrete decision-making without having to use a more realistic landscape representation: Some studies showed that models for decision-support need a relatively high degree of realism than the ones used for learning (Dionnet *et al.*, 2008). But in this case, we found that a more realistic visual representation was not necessary to accommodate the insertion of the new cattle raising techniques requested by the herders. Only the nature of the scenarios simulated and explored in the first and second workshops evolved toward more realistic ones.

Limitations

The "human interface": one needs to recognize the key role played by the "human interface" i.e. the process facilitator helping people to make use of the tools and models, tailoring them to their changing needs along the learning by modelling and simulating process (Castella, 2009; Horlitz, 2007). But as soon as the second round of gaming sessions, the first batch of players was able to train the newcomers in their own words and in a time efficient way for them to quickly understand the meaning of the pictograms and their use in landscape heterogeneity.

Need for a more user friendly tool: the use of this virtual landscape still relies on the computer to update vegetation states and produce the refreshed landscape after each round of play. This is quite slow and still need to be improved as "processing speed and interactivity are determining factors for success if the model is used in participatory and exploratory exercises involving stakeholders" (Engelen, 2000 cited in Horlitz, 2007).

CONCLUSION

This case study showed that such 2D simplified landscape could be used to examine a complex landscape management problem with stakeholders characterized by very limited background of formal education. And this without having to resort to more sophisticated types of geographical information such as 3D elevation or more realistic display of land cover. The co-design and validation of simplified landscape by the end users are important steps to create transparency and mutual understanding between researcher and local stakeholders. Interactive and evolving use of such simplified landscapes through simulations based on stakeholders' interest is an efficient way for sharing different perceptions, stimulate communication between conflicting parties, and supporting collective decision-making.

In the next steps, a fully autonomous ABM making use of the same kind of simplified virtual landscape will be developed and used for out-scaling this pilot study with more local stakeholders in a more time efficient and inclusive way. This ABM could also be used with other types of stakeholders, such as administrators or policy-makers having limited time to understand replays of long gaming and simulation sessions organized with villagers, and with different ethnic groups living near similar conservation areas and facing the same kind of land use conflict.

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