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Participatory simulation sessions to support collective decision: the case of water allocation between a Thai and a Hmong village in northern Thailand

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Abstract

Agricultural transformation, expansion of irrigated areas and recent land policy have increased the pressure on natural resources in northern Thai catchments. As a consequence, conflicts over collective management of natural resources and especially over water have been observed in recent years.

As a group of researchers working on participatory modeling we try to bridge simulation tools – as a means to explore complex human ecosystems – and participatory approaches – as tools to support collective decision making processes. However, the use of these simulation tools with local communities raises many questions related to technical, methodological and political aspects. In this paper, we try to respond to problems such as the perception and acceptance of the status of the simulation tool by the local communities, and we raise the issue of the impact of using such approaches in conflicting contexts.

The issue studied is the water allocation between two villages in a subcatchment of the Mae Sa watershed (Chiang Mai province); the first one being a highland Hmong village, mainly cultivating litchi and cut-flowers, the second one a lowland Thai village whose agriculture is characterized by continuous cropping of high-value irrigated cash crops. A multi-agent simulation model was developed to analyze the impact of different land use and water management options on water scarcity for the different water users. Three rounds of participatory simulation sessions were organized during which model improvements and scenarios to be tested for the next session were discussed with the stakeholders. The development and the use of the model thus evolved from one session to the other according to the participants' requests. This process enabled us to set an arena in which we could observe the relationships between the participants and the simulation tool and the interaction between the different stakeholders involved.

Our findings show that the understanding of the model as a virtual world and not as the reproduction of reality is difficult to convey to the stakeholders. The same applies to the vision of scenarios as a means to explore possible solutions. The progressive development and use of the model proposed here enabled to introduce these perspectives along the various sessions to finally reach a better understanding and acceptance of the model's status, limits and capabilities. Regarding the issue studied, the model shows that water scarcity is a serious problem in both villages during dry years. The most affected areas are the upstream parts of the subcatchment. When it comes to assessing the impact of scenarios on water scarcity in the two villages, the participants from the downstream village tend to focus mainly on their own village, whereas the

participants from the upstream village expressed concern about the impact on both villages. These findings contrast somewhat with the results from a participatory valuation process conducted by the Thai co-authors. They found that upstream villagers were less concerned about sharing water with their downstream peers.

Further investigations are required to assess the consequences of these different perceptions. This process needs to be handled with great care, though, since unveiling stakeholders' points of view under such a conflicting context in a public space can entail several risks, particularly when the relationship between stakeholder groups are characterized by power differentials.

Keywords: Participation, Simulation, Multi-Agent Systems, Negotiation support, Water allocation, Northern Thailand

1 Introduction

Agricultural transformation, expansion of irrigated areas in the lowland, increase in dry season irrigated agriculture, and recent institutional planning policy on land cover have increased the pressure over the management of natural resources in Northern Thailand catchments (Pinkaew, 1998; Neef et al., 2003; Walker, 2003; Nabangchang, 2005). In recent years conflicts over collective management of natural resources and, more particularly, over water have been observed in many catchments of the area (Prabudhanitisarn et al., 2002; Neef et al., 2004). In many cases the underlying issue involves, on the one hand, water scarcity - its extent varying from severe and regular lack of water during the whole dry season to occasional water insufficiency depending on climate years – and, on the other hand, sets of communities whose viewpoints and perspectives regarding water management differ.

As a response to these problems, groups of researchers have been working on participatory modeling which combines simulation tools – as a means to explore, explain and assess complex human ecosystems such as catchments – and participatory approaches – as tools to accompany and support collective decision making processes in a bottom-up approach (Costanza and Ruth, 1998; Promburom, 2004; Bousquet et al., 2005). Companion modeling – a type of participatory modeling focusing on the co-development of models together with local stakeholders – often uses a combination of Multi-Agent Systems (MAS) and Role-Playing Games (RPG) to achieve the above objectives (Barreteau et al., 2003). The use of RPG in this setting aims at opening the black-box of the MAS model for stakeholders to better understand and discuss its embedded assumptions hence facilitating the co-development of the model (Barreteau, 2003).

In this application to water allocation between two villages of different ethnicity in northern Thailand, we use stand-alone MAS models – without an RPG to facilitate stakeholders involvement in the process – and investigate the applicability and the difficulties encountered in such a setting. Moreover, the use of such a simulation tool with local communities raises many questions related to technical, methodological and political aspects. In this paper we focus on the latter two aspects (for considerations on technical aspects see Ramanath and Gilbert, 2004). We try to respond to problems such as the perception and acceptance of the status of the simulation tool by the local communities and raise the issue of the impact of using such approaches in conflicting contexts.

In the next section we briefly introduce the principles of Companion Modeling. The case study is then presented as well as the historical background of the water allocation issue between the villages. The MAS model developed to simulate the impact on water scarcity for the different stakeholders under different land use and water management scenario is then described. Next, we present the design of the application which involved three rounds of participatory simulation sessions. Results from each round are then described and discussed successively. For each of them we consider the difficulties faced regarding the use of the model with stakeholders on the one hand and the outcomes regarding the negotiation process on the other.

2 Companion Modeling: an iterative and continuous process

The Companion Modeling community[1] (ComMod) has developed an approach combining MAS technology and participatory approaches to assist local stakeholders in their decisions and evaluate sustainable management options. The scientific posture of ComMod seeks being open to any assumptions and beliefs of the system under study. MAS applications conducted in the ComMod approach are therefore stakeholder-driven. The approach considers as legitimate and takes into account points of views of the various stakeholders even though these could possibly be contradictory. In terms of objectives, two goals are pursued by the ComMod approach: understanding complex environments and support collective decision-making processes in complex situations (Barreteau et al., 2003; Bousquet et al., 2005).

In the context of understanding complex environments, modeling deals with the dialectic among the researcher, the model and the field. Computer simulation accompanies an iterative research process, which is specific to each situation. The continuous cycle “field work-> modeling -> simulation -> field work again, etc.” corresponds to this concept (Figure 1). This leads to accepting a diversity of models and methods, each contributing to a new kind of relationship between computer simulation, research activities, and the decision-making process of stakeholders.

In practice, this loop works as follows. A first analysis of the case study (field) allows developing a preliminary version of the computer model. Participatory simulation sessions are then organized with the different stakeholders involved. During these sessions, the model and its hypothesis are presented to the stakeholders and simulations are run and discussed. The discussions help the modeling team to review the model’s assumptions and to identify new modeling options and/or directions to focus on. A second version of the model is then developed and it is, once again, discussed with the stakeholders. This loop between field work, model development and participatory simulation sessions is undertaken as many times as required.

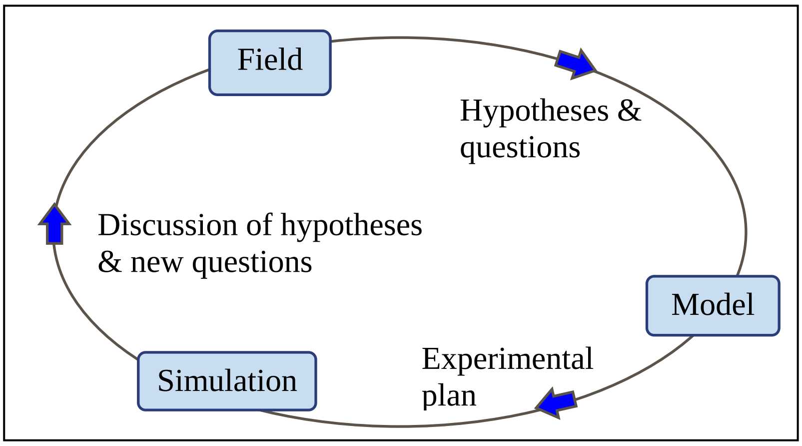

Figure 1: Companion Modeling approach involving stakeholders in model development

[1] http://commod.org

From the stakeholders' point of view, this process helps getting insights into the issues studied and facilitates discussions among stakeholders with different perspectives and interests. Because the model is a simulation tool, it may not only state the problem in a shared way[2], but it also allows exploring future scenarios. By testing various solutions to their problem through simulations, stakeholders are assisted in negotiation of competing interests and collective decision-making. Thus, the principle of the ComMod approach is the construction of a shared representation of the system under study. The model is a tool to make more explicit the various points of view and subjective criteria, to which the different stakeholders refer implicitly.

3 Water allocation in the Mae La Ngun catchment

The case study is located in the upstream part of the Mae Sa watershed (Chiang Mai province, Northern Thailand) and involves two villages in the Mae Sa valley. Muang Kham is a lowland Northern Thai village growing irrigated high-value cash crops all year long: sweet pepper using dripping irrigation, chrysanthemum and vegetables. Pha Nok Kok is an upland Hmong village cultivating litchi (partially irrigated during the dry season), gerbera cut-flowers (a biannual crop, harvested and irrigated all year) and vegetables mainly cultivated during rainy season. The two villages are located upstream-downstream from each other along the Mae La Ngun river. The area under study is thus the Mae La Ngun catchment with a size of 6.88 km^2. The modeling and aim of the participatory process is first to understand the upstream-downstream water sharing system between these two villages, and second to explore possible scenarios that would suit perspectives from both villages.

Water allocation between these two villages was already discussed in the past before we actually intervened in the negotiation process. In 1999 water was very scarce during the dry season. Villagers from Muang Kham complained that Pha Nok Kok farmers were using too much water (Neef et al., 2003). As causes for drought, farmers also mentioned the increasing use of water and the increasing number of water users. After discussions, villagers could find a provisional arrangement which was that vegetables in Pha Nok Kok village would not be irrigated – and thus not grown anymore – during the late dry season (February to May). Parallel to this and together with the development of sweet pepper, dripping irrigation was employed in Muang Kham (dripping irrigation is considered a water-saving irrigation system) and some farmers and/or investors also built private groundwater wells in the lowland to secure water availability (by building private groundwater wells they became independent from Pha Nok Kok water users). These developments contributed to resolving the issue. Still, occasionally, at the end of the dry season, water shortages occur. Even though it does not concern all farmers, the village headmen and/or representatives are still looking for a permanent and satisfying solution to this water allocation problem.

The objectives of the application were:

- <u>to explore the interactions</u> within the water resources system between the upstream and downstream villages;
- <u>to promote a common view</u> of water allocation and management options among the various stakeholders involved in the catchment;
- <u>to support negotiation and collective decision-making</u> among stakeholders, given that conflicts between the two villages have already occurred in the past years in relation to water shortages

[2] As all stakeholders are involved in the development of the model, the model reflects a compromised view of the situation.

for irrigation experienced by the downstream farmers at the end of the dry season (March, May).

To achieve the above objectives a MAS model was developed specifically for this case study. The aim of the model itself in the engaged participatory process was to serve as an intermediary object (Vinck, 1999) that would hold the heterogeneity of stakeholders' point of view and on the basis of which collective decisions can be drawn up.

4 A MAS model to simulate water scarcity for the different water users

The model is built on a Cormas platform which is tailored to MAS and natural resources management (Bousquet et al., 1998). Cormas provides a development framework for implementing the entities of the model. Three types of entities are considered: spatial (e.g. a plot, a hillside area supplying runoff water to downstream), social (e.g. farmers, water users) and passive entities (e.g. a pond, a crop). The models developed under this platform usually consist of two layers. The environment, which is spatial explicit in our case in this case, corresponds to the biophysical dynamic of the system. The second layer models the social dynamics, that is, the management of the resources and the activities undertaken by the agents of the model (the agents of the model correspond to the stakeholders of the system).

4.1 Biophysical component

The biophysical component consists of a hydrologic, a water balance and a crop model, all based on the CatchScape3 model that had been previously developed for a northern Thailand application by Becu et al. (2003). CatchScape3 model runs with a time step of 10 days. The hydrologic model is a semi-distributed one. Its transfer function uses a conceptual reservoir model for the deep drainage and a delay function for the runoff. The production function of the hydrologic model is embedded in the water balance model which provides deep drainage and runoff values at each step and for each plot. As the area modeled is discarded into a set of single plots, the water balance model is run for each plot, and results vary according to soil texture, sloop and depth characteristics of the plot and to the evapotranspiration of the land cover. The crop model uses the CropWat FAO model functions to calculate crop yields according to average crop yields in the study area, simulated water stress during the cropping period and a crop specific parameter reflecting its resistance to water stress. Both water balance and crop model are based on the Catchcrop model (Perez et al., 2002) that was developed for the Northern Thailand context and was calibrated for a number of commonly cultivated crops in the area and soils.

For the application to the Mae La Ngun catchment, GIS data available at the Uplands Program such as land use, soil types, contour lines and stream network were processed and imported as attributes of the plots that formed the basic unit of the spatial interface of the model (each plot has an area of 2 rai - 0.32 hectare). This resulted in a spatially explicit representation of the catchment (Figure 2). Moreover, the DEM (digital elevation model) of the catchment was processed to discard it into sub-catchments that are used by the hydrologic model to calculate water discharge at each of the node of the river network (a node stands for the outlet of sub-catchment). Hence, at each step the model first calculates – according to the current rainfall – the run off and deep drainage of the plots of the most upstream sub-catchment. The values for each plot are summed up and then transferred to the next node located directly downstream. The water discharge of this second node will then be the sum of what it received from the above node and the runoff and deep drainage transfer from its own sub-catchment. This sequence – called an arc-link structure – is repeated until the last node of the area which corresponds to the outlet of the whole catchment.

The input rainfall data used are from the Uplands Program weather station of Mae Sa Mai located a few kilometers east from the area. Three hydrologic years are used: 2001-2002 to

2004-2005. The parameters of the transfer function – the most sensitive one of the hydrologic model – were calibrated by comparing the simulated water discharge at the catchment outlet and gauged outlet discharge from neighboring catchments (no discharge measurements were available for the Mae La Ngun catchment).

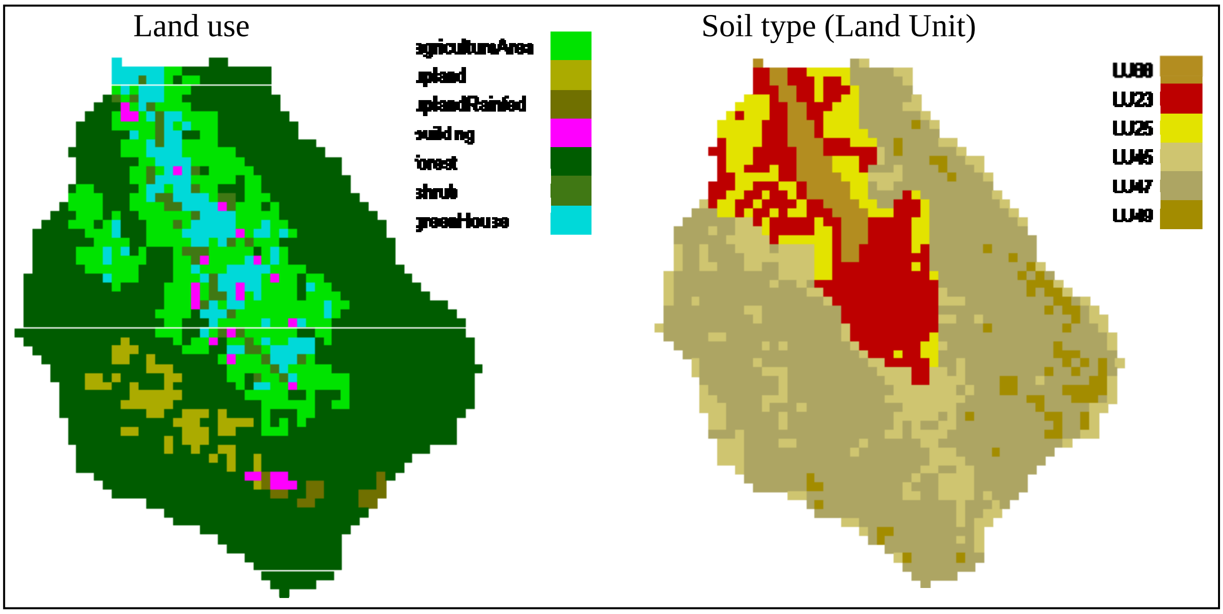

Figure 2: Spatial interface of the model – view of land use and soil type of each plot

The arc-link structure described above also manages the allocation of water to the plots according to the demand at each step. If the demand for one node can be met (each plot is associated to the node which is directly upstream from its location), the corresponding volume of water is transferred to the plots. If the node water discharge is insufficient, some percentage of the demand will be allocated, resulting then in water deficit for the plots. The water demand is managed by the social component thereafter described.

4.2 Social component

Three classes of agents, corresponding to each type of water users of the catchment, are modeled: farmers from both villages, a drinking water company located at the center of the Muang Kham village area, and the Pha Nok Kok village household water consumption diverting water from a stream next to the village.

Agent-farmers' behavior consists in planting, irrigating and harvesting. Agents' decision for the type of crop to plant and for irrigation are made so to reproduce the cropping pattern and irrigation schedule observed in the area in 2003. Data used are from a set of surveys conducted by the Uplands Program and its Thai counterparts. Three different farm cropping patterns for Muang Kham and one for Pha Nok Kok were identified and integrated into the model as different sub-classes of agent-farmers. At the beginning of the simulation, starting at the rainy season, agent-farmers thus plant a first type of crop according to their farm type. After a number of steps depending on the crop's cultivation period, agent-farmers harvest the crop and choose the next crop to be planted. The irrigation decision works with a similar mechanism: agent-farmers have an irrigation schedule for each type of crop and apply it at each step. Yet, the action of the agents here consists in setting an amount of water demand for each plots and the actual amount of water allocated is managed by the biophysical component as seen above.

The drinking water company agent behavior only consists of pumping underground water at each step. The water demand varies from 1 to 6m^3 per step (source: interview of the company in January 2005). However, the allocated water depends on the water availability of the underground reservoir as calculated by the deep drainage transfer process of the hydrologic model. The Pha Nok Kok household water consumption agent demands 240m^3 per step (60 liters per day and person; source: Uplands Program survey in Mae Sa Mai). The actual allocation depends on the water discharge of the node corresponding to the stream diverted.

4.3 Simulation of water shortages

Figure 3 shows the location of the five types of water use considered in the model and for which water lack results are simulated. Muang Kham cropping area is split into an upstream and a downstream part in order to reflect the direct influence of Pha Nok Kok water use on Muang Kham upstream plots.

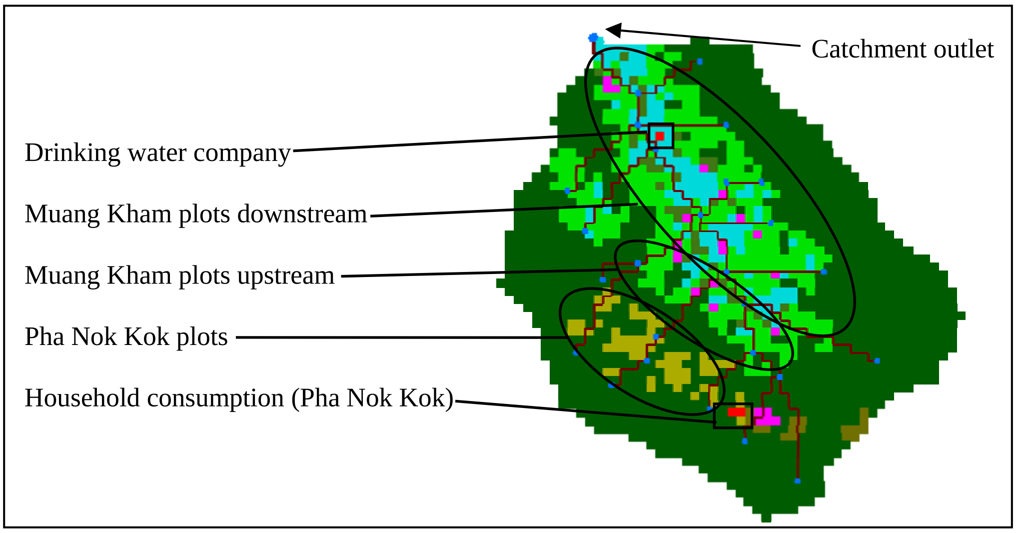

Figure 3: Location on the spatial interface of the simulated water lack results

Simulations start on 1st April (time step is 10 days) but only the results from the dry season are considered (from November to March or April depending on duration of the dry season). Table 1 first shows the number of days a severe water shortage occurred during that period for the different water users. For the different agricultural areas, a severe lack of water occurs during a time step when most plots could not be irrigated as much as the agent-farmer owning the plot demanded. For the company and the household consumption this is the case when less then half of the demand could be allocated. The second column shows the average percentage of water demand that could be allocated by the biophysical component during the periods of water lack. The yield depletion is the yield actually obtained compared to the maximum potential yield defined as a parameter of the biophysical model.

Table 1: Simulated water shortage indicators during first and second year of the baseline scenario

	Year 1 - rainy year			Year 2 - moderate dry year		
	(1)	(2)	(3)	(1)	(2)	(3)
MK downstream	0	-	11%	10	46%	15%
MK upstream	40	20%	15%	70	26%	31%
PNK	60	26%	19%	80	24%	32%
HH water (PNK)	50			70		
Water company	0			0		

(1) Number of days of severe water shortages; (2) % of water demand that could not be allocated; (3) Yield depletion - % of max. potential yield

Results show that the lack of water for Pha Nok Kok and the upstream part of Muang Kham is in the same range. The downstream part of Muang Kham is rarely short of water. These results are in accordance with a study in the same area by Sangkapitux et al. (2006) which found that water security in upstream communities was significantly lower than downstream water security, which contradicts the common view of upstream people having better access to water resources as compared to downstream residents.

The trend is the same in each of the three years of simulation, but the drier the year, the greater the lack of water. Household water consumption in Pha Nok Kok shows the same trend, however in this case, water shortages occur later in the dry season. The water company never lacks water even during the third and driest year. Yield depletion is, especially during dry years, in the same range of values for Pha Nok Kok and the upstream part of Muang Kham.

For the first participatory simulation session, only the first water shortage indicator was presented; the latter two were presented during the next sessions. During those sessions, participants suggested scenarios which results are summarized in Table 2.

Table 2: Number of days of severe water shortages in year 2 (moderate/dry) for different scenarios

	Baseline	(1) More sweet pepper in MK	(2) More gerbera in PNK	(3) Reservoir in PNK
Muang Kham (upstream)	70	0	90	60
Pha Nok Kok	80	80	90	30

Simulation results of scenario 1 and 2 show that an increase of sweet pepper production in Muang Kham would decrease water shortage for the lowland village, while a shift to gerbera in Pha Nok Kok would increase water shortage for both villages. The construction of a water reservoir in Pha Nok Kok in scenario 3 (storage capacity of 8,000 m^3) results in a substantial decrease of water scarcity in the highland village, and in a slight decrease in the lowland village. In this scenario, the reservoir is used by Pha Nok Kok farmers to store water during the rainy season and irrigate during the dry season. The benefit for the lowland village is due to the lesser water withdrawal on streamflow of the agent-farmers from Pha Nok Kok during the dry season.

5 Results from three rounds of participatory simulation sessions

Three rounds of participatory simulation sessions were organized at regular intervals (every three months) either in the villages or at the office of the local Tambon (sub-district) Administrative Organization (TAO). Each time, a new version of the model (based on the previous meeting's conclusions) was presented and discussed with the stakeholders. The participants were a sample of farmers from the two villages, the village headmen, the representatives of the TAO and the manager of the drinking water company. The numbers of participants varied from 6 to 15 persons.

5.1 Setting of a session

For each session, one or two observers in addition to the moderators were recording participants' reactions and discussions in order to assess the model use and the negotiation process. After an introduction, the model's interfaces – displayed on a large screen using an LCD projector – were explained and one or two scenarios were then simulated one time step after the other to show the gradual changes of cropping patterns and water availability throughout the three years of simulation.

Model results at each step were presented on two different interfaces. The spatial interface was showing a view of the current cropping pattern using a color code for each crop (far right in Figure 4). The second interface was showing the results for each water user during the current step. Instead of charts we used three types of smiles, corresponding to severe, medium or slight water shortage (right in Figure 4). At the end of each year of simulation, results were summarized on a board and participants were assessing the results of the year for each different type of water use (left in Figure 4).

During and after the simulations, three topics were discussed: (1) the relevance of the model's assumptions (e.g. cropping patterns, irrigation schedule); (2) the main findings from the model's simulations following discussions regarding the water allocation issue; and (3) possible model improvements and further scenarios to be tested for the next session.

Figure 4: Model interfaces (right), results board and participant assessing results (left)

Following, we present the results of each of the three rounds organized. Each time, we discuss the findings related to using the model with local stakeholders and the outcomes regarding the negotiation process between the different water users.

5.2 First round

The session took place at the TAO office together with representatives of all water users and of the TAO. During this session, only the baseline scenario was presented and discussed (three years of simulation: a rainy, a moderate dry and a dry year).

Participants' understanding of the model's interfaces varied. Remarks from some of them showed that they could follow, understand, and interpret the simulation results. Other participants had difficulties to orientate themselves and to locate their fields on the map and to understand the changes from one step to another. During this session participants had difficulties in making a difference between the model as an abstraction of reality and reality itself. This finding linked to the status of the model is also observed in other participatory modeling applications with local stakeholders. This problem can be countered by the use of role-playing games as a simplified version of the computer model which helps clarifying the status and purpose of the model (Barreteau, 2003).

Based on the simulation results, participants and especially farmers from both villages changed their point of view and realized that water scarcity affects both villages in the same way. After sharing this common perspective, they explained to each other how they currently deal with the problem of water scarcity. However, when it came to defining scenarios for potential improvement, the discussion became unease and stopped before any scenarios or solutions could be identified. We believe that the existing tensions between the Hmong and the Thai communities that can be observed in Northern Thailand may have impeded on the discussion. These tensions are related to usual upstream-downstream interrelations and power differentials as well as to environmental considerations and land use and ownership disagreements. Most typical are stereotypes of Hmong people cutting the forest on land which they do not own resulting in negative impacts on the environment (Renard, 1994; Walker, 2003). For the second round, separate meetings were therefore organized in the two communities, however, at the expense of impeding direct discussion between the communities.

5.3 Second round

For the second round, scenarios were first identified through individual interviews. One session was then organized in Muang Kham village during which scenario 1 was presented, and two sessions took place in Pha Nok Kok village for scenarios 2 and 3 (Table 2). Participants were farmers from the village and the representatives of the TAO for this village. For Muang Kham session, the manager of the drinking water company also participated.

We first observed that participants understood better the model's interfaces, results and status as they became more familiar with the model. This became evident when one participant of the second session in Pha Nok Kok explained to the others at the beginning of the meeting how the model was functioning and the meaning of the model's interfaces. The simulation of scenarios from the baseline helped clarifying the status and purpose of the model as participants could actually see that it aims at exploring "virtual" solutions.

In this setting, in which participants from each village were within their own peer group, farmers where more inclined to discuss scenarios (the one presented and others mentioned during the meeting), their implications for the different water users and their feasibility in real life situation. This was even more obvious with the highland villagers with whom a second session was arranged, presenting scenario 3. Moreover, the meetings showed that when it comes to assessing impacts of scenario on water scarcity, the participants from the two communities showed different reactions. According to our observations the downstream villagers focused mainly on the positive or negative results for their own village. On the other hand, participants from the upstream village expressed concerns on the impact on both villages (their own village and the downstream village). Similarly, the participants' assessments of the water scarcity in the baseline scenario (the result board summarizing the results at the end of each year of simulation) are different in both villages. For the same level of water shortage occurring in the lowland village, Muang Kham farmers gave the score "acceptable", while Pha Nok Kok farmers rated it as "not satisfactory".

These dissenting points of view regarding water allocation between both villages contrast somewhat with the results from a participatory valuation process conducted by the Thai co-authors. They found that upstream villagers were less concerned about sharing water with their downstream peers. When villagers in Pha Nok Kok were asked to rank the different values attached to water, the value "sharing water with the downstream community" came only in fifth place in a pair-wise ranking exercise, while in Muang Kham "sharing water with the upstream community" came in third place[3]. These results are in accordance with group-based water resource valuation in eight upstream and downstream villages in the upper Mae Sa watershed.

[3] Water values considered in the group-based valuation were (1) use as drinking water, (2) household use, (3) agricultural use (irrigation), (4) ecological value, (5) religious/spiritual value, (6) cultural practices,

5.4 Third round

This last session took place at the TAO office and representatives of all water users were invited once again for a collective meeting. However, Pha Nok Kok farmers did not join the meeting, with the exception of one villager who works as a receptionist at the TAO. Reasons for their not attending are unclear and we assume in the following that it was on purpose and related to the issue discussed and to their position in the negotiation process.

Concerning using the model with local stakeholders, we observed that participants continued to acquaint themselves with the model and even started to impropriate it. This was already noticed during the previous session at Pha Nok Kok village, when the model's assumptions and simulation results related to the use of a water reservoir were put under scrutiny and sometimes denied by the farmers. In this session, participants also discussed the type of indicators used for showing the simulation results and modifications as to the way of calculating them to better suit participants' idea were identified. Still, once again, we had to deal with new participants who were seeing the model for the first time and needed further explanations to understand it.

The presentation of scenario 3 during this session – the scenario of implementing a water reservoir in Pha Nok Kok – engendered many comments from the participants. Most relevant is a discussion on who should be the users of such a reservoir. The option that only Pha Nok Kok farmers would use it – as implemented in scenario 3 – was somewhat rejected; yet those farmers were not present to state their opinion. Some participants also argued that the location of the reservoir as shown in the scenario was not appropriate and that it should be located more to the downstream part.

These strong statements lead us to question ourselves on the impact of using such an approach in a conflicting context. As mentioned previously, power differentials exist between the two communities. As Hmong farmers do not own title deed, their plots being located in the Doi Suthep-Pui National Park, they put their right to use the land at risk in this negotiation process. Indeed, if the process engaged with the model comes to the conclusion that highland farmers are responsible for water scarcity in the catchment, there is the risk that their legitimacy to use the land could be reconsidered. On the other hand, Muang Kham farmers are well established in the area, both regarding land ownership and their relationship with government agencies and the local administration. Therefore, highland villagers have more to loose in this process then their lowland counterparts, which is underscored by the fact that the negotiation that took place in 1999 between the two communities already resulted in cultivation restrictions for Pha Nok Kok. This situation could explain why the Hmong farmers did not join the last session at the TAO office. It could also explain why they feel so concerned about the scenarios' impact on the downstream village, as it is actually not in their interest that the model shows a negative impact on the downstream village.

6 Conclusion

Results from this application show that using participatory simulations with local stakeholders implies several methodological difficulties. As compared to other Companion Modeling applications combining multi-agent simulations and role-playing games (RGP), such as in Bousquet et al. (2005), we had to face a misinterpretation of the model status by the involved

(7) bequest value, (8) sharing with upstream/downstream communities, (9) drinking water for domestic animals, (10) fire protection, and (11) source of food (fish and other aquatic animals).

stakeholders at the beginning of the process. In contrast, using RPG as a communication means between the model and reality improves stakeholders' understanding and involvement as they can directly influence the experiment through the actions they perform in the game (Barreteau, 2003). The same occurs for the model's appropriation by the stakeholders which took some time in our application and which have not yet been fully achieved. When models are developed on the basis of RPG, stakeholders see a direct link between the model and what they had played previously. The other methodological difficulty that we faced is that the farmers attending the participatory simulations sessions were not the same in each round. New participants were coming and others did not join all rounds depending on their time availability. In these villages farmers have high opportunity costs of time and are therefore not always ready to attend long workshops like the ones often organized in Companion Modeling applications. We thus had to explain the model again at each session; still, it is likely that the dialogue between stakeholders was altered by the fact that participants were not the same. These constraints can be partly overcome by triangulation of methods, i.e. by cross-checking information obtained in the MAS meetings with data gathered in formal farm household surveys, role plays, informal talks and focus group interviews (such as the water resource valuation study conducted by the Thai co-authors).

Another major conclusion is that Companion Modeling can have important socio-political implications when implemented in a conflicting context. Disclosing stakeholders' potentially dissenting points of view in a public space can then entail serious risks for some actors, particularly when the relationship between stakeholder groups is characterized by social tensions and power differentials. This calls for a long-term approach of joint learning and action in which trust between the various stakeholders (including the researchers) can gradually built up.

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