Simulating irrigation co-ordination in a virtual basin with joint use of Role Playing Games and Agent Based Modelling

Olivier Barreteau, Géraldine Abrami, Saléha Chennit, Patrice Garin

A. Richard, P. Caron, J.Y. Jamin, T. Ruf (éditeurs scientifiques), 2006. Coordinations hydrauliques et justices sociales. Actes du séminaire, novembre 2004, Montpellier, France. Cirad, Montpellier France, Colloques

Simulating irrigation co-ordination in a virtual basin with joint use of Role Playing Games and Agent Based Modelling

Olivier BARRETEAU*, Géraldine ABRAMI*, Saléha CHENNIT*, Patrice GARIN*

*Cemagref IRMO, BP 5095, 34196 Montpellier Cedex, France

Résumé — Simulation de la gestion concertée de l'irrigation dans un bassin versant virtuel avec des jeux de rôles et des systèmes multi-agents. Cette communication présente une association spécifique d'un jeu de rôles et d'un système multi-agent, dont l'objectif est d'accroître l'implication des usagers dans les processus de décision relatifs à la gestion de l'eau. Les jeux de rôles et les simulations sur un bassin versant générique sont un moyen d'instaurer une distance dans la discussion avec les intérêts privés des parties prenantes. Nous décrivons ici un outil, PIEPLUE, conçu comme une forme hybride de jeu de rôles et de simulateur multi-agent informatique. Cet outil représente des agriculteurs virtuels dans un bassin versant virtuel utilisant de l'eau pour irriguer des cultures variées. Ces agriculteurs font des choix individuels concernant leurs assolements et leurs pratiques d'irrigation. A la fin de chaque campagne simulée, les joueurs peuvent adapter leurs règles collectives de partage de l'eau. Cette communication présente les résultats d'un premier test avec l'institution portant la mise en œuvre du SAGE de la Drôme dans le Sud de la France.

Abstract — Simulating irrigation co-ordination in a virtual basin with joint use of Role Playing Games and Agent Based Modelling. This communication is presenting a specific association of Role Playing Game and Agent Based Modelling aiming at increasing the empowerment of final users in the collective decision processes for water management issues. Role Playing Games and simulations on a generic basin are a way to bring distance with private interests in dialogue processes. We describe here a tool, PIEPLUE, designed as a hybrid of a Role Playing Game and a Computer Based Agent Based Model. This tool represents virtual farmers in a virtual river basin using water to irrigate various crops. These farmers choose individual organizational patterns concerning crops choice and water use choices. At the end of simulated cropping season, players may adapt the collective rules for sharing water. This communication is presenting the results of a first test with the river basin institution of the Drome River Valley in the South of France.

Introduction

Dialogue support for territory planning or natural resources management is increasingly using Agent Based Modelling (ABM) and Simulations or Role Playing Games (RPG) or both categories of tools jointly (Bousquet *et al.,* 2002). They recognize their ability to simulate and handle complexity.

Public participation is increasingly involved in collective decision processes at the local scale, even though the level of participation on Arnstein's ladder (Arnstein, 1969) is barely specified nor is specified the stage in the decision process. In Europe, the Water Framework Directive contents a specific article on that point. In Africa, NGOs have attempted to involve stakeholders or citizens in collective decisions or implementation of their outputs. It is now promoted by International Institutions. However what is meant by participation is varying and implementation of participation, whatever it is intended to be, is facing many pitfalls, notably due to the complexity of societies supposed to be involved in these participatory processes (Eversole, 2003). In many cases implementation of participation may be stuck due to internal conflicts or disagreements among involved people, it may even foster conflicts through underlying these disagreements. NIMBY effect is a classical format of such dead ends met by participatory processes due to a too strong involvement of private interests: stakeholders agree to have collective rules to deal with multiple uses needs of natural resources provided their own interests are not affected by them.

We propose thus to use the capacities of Agent Based Models and Role Playing Games to work on complexity as well as to induce distance with immediate private interests to test them as tools to support participatory decision making. This comes in the trend of several works using these tools for natural resources management issues (D'Aquino, Le Page, Bousquet, Bah, 2003; Etienne, Le Page and Cohen, 2003; Hare, Pahl-Wostl, 2003). The tool developed, Pieplue, is specifically aiming at overcoming issues of zero-sum game kind of interactions among farmers in sharing of water, towards win-win situations. It has been developed to fit an on-going dialogue process in South-East of France: the Drôme River basin development plan, and its negotiation of water sharing rules among irrigating farmers. Played by farmers already involved in such collective decision processes for sharing water, it is meant to lead them to discuss cropping pattern choices at the same time as sharing water rules. Changes induced in the decision processes are however fostering institutional reluctance, which make the implementation of tests difficult.

This communication presents the rationale and the characteristics of this tool and then the outputs of one test session organized by out field partner, the basin institution. This test session is paving the way for improvements of the tool but also raising questions concerning its potential uses.

ABM and RPG to enhance stakeholder involvement

"Member States shall encourage the active involvement of all interested parties in the implementation of this Directive, in particular in the production, review and updating of the River Basin Management Plans" (Water Framework Directive, art. 14, EU, 23-10-2000).

Institution in charge of water management, at whatever level of organisation they are, basin institutions, local delegations of concerned departments of State, counties, municipalities, are all sharing such objective of concerted water management, such as written down in the European Water Framework Directive. Their concern is however dealing with making operational the concept of participation (Richard, 2000). We develop in this section the needs for methods and tools to implement participation.

Models, be them computer based, as drawings, maps or parables have always been used to support the design of public policies (Saunders-Newton and Scott, 2001). Since more than a half century, advises to policy makers have focused on these tools, with an increasing use of science and mainly computer science, in order to rationalize the decision processes. This is also especially true for participatory management, when a diversity of viewpoints is involved. This section is also presenting Role Playing Games jointly used with computer Agent Based-Models as tools to fulfill the needs for implementing participation.

Need for specific tools

The call for more involvement of stakeholders is specific in the case of the Water Framework Directive quoted above, but is met in many other places, from grassroots organizations to international institutions. There is a current consensus that stakeholders should be involved in water management processes. Why? To which extent? At which stage of the process? There is neither consensus on these issues nor making them explicit. Rationale might be to acknowledge a fundamental right of citizen to be involved the decision processes they are concerned by or a mean to convince them of a decision already taken. It might also be a legal constraint or a way to share the burden of responsibility and to prevent further criticisms in a context of uncertainty and complexity.

A classical scope of extent of participation has been first described in a scale going from information to co-decision through consultation by (Arnstein, 1969). The issue of the stage of the process has been less tackled. In a comparison of development of tools to support participatory water management across Europe, it appeared that some participatory processes are aiming at making stakeholders choose among a few predefined solutions while others are aiming at making stakeholders elaborate common objectives or issues at stake in their area. However the definition of the issues on which dialogue should take place or the definition of the set of solutions among which the choice is open is providing power to those who are entitled to do that (Marengo and Pasquali, 2003). Thus the actual empowerment of stakeholders through participation will differ slightly according to the stage of the decision process.

In the following we focus on the support to participatory collective decision making as a pragmatic mean to reach decisions which are implemented, at the level of co-decision and covering all stages from elaboration of scenarios to choice of scenarios. This means an important collective empowerment of stakeholders involved in the process.

One common pitfall in this context is that the power formerly attributed to the administration or any other "top" institutions is taken over by other local social hierarchies. If the purpose of implementing participation is to increase democracy, there is then no guarantee that the new empowered stakeholders have a more democratic legitimacy than former "top" institutions. Emergence of new leading groups or reinforcement of local leaderships is increased by a lack of organisational training of stakeholders involved, even more with so-called rapid approaches (Platteau and Gaspart, 2003).

According to pre-existing social relations within the group of stakeholders involved, collective decision processes may lead to more conflicts than they are supposed to sort out (Parent and Gallupe, 2001). The evolution of a participatory process is thus rather uncertain and dependent on the nature of the relations among the group as well as on the job and personal characteristics of the facilitator of the process. Any approach of supporting facilitation should thus provide possibility of tuning the tools and methodology of using them to the local characteristics.

Availability of information (Glendinning, Mahapatra and Mitchell, 2001) is a key feature to profit by this redistribution of power in decision making. However there is no equality in access to information. Social networks in which stakeholders are involved are means to get this information or to control its diffusion. Level of education, involvement in a local NGO, size and revenue of farm are reported to increase acquaintances with extension services, and thus the amount of information available for one stakeholder. Therefore providing explicit and legitimate information is a key feature of any method to support participatory collective decision making. By "legitimate information", it is meant accepted as a representation of reality and accepted to be disseminated.

There is thus a need to improve methods to implement participatory management to reach genuine participation, without any de facto hijacking by some stakeholders due to their social status or specific social networks.

Water management issues are a specific aspect of renewable resources management issues. Use of water by any actor has consequences for other actors in the same river basin in at least one of various fields: flow level, quality or access to the river banks. These interactions may be limited to shared interests: winegrowers of Languedoc-Roussillon for example are interested in a collective image of environmentally friendly cropping patterns, they are thus interested by impact of other winegrowers impact on water quality.

A specific characteristic to these situations of shared resources and interests are named NIMBY: "Not In My BackYard". Individuals have strong expectations towards the community so that there is providance and good management of common goods such as water resource, but to the extent that their own interests are not affected. Actors taking part in collective decision processes would be first motivated by egoist reasons. The setting of new railway or a dam is a frequent case of this phenomenon. With the implementation of public participation as required by the EU Water Framework Directive, such behavioural patterns might be exacerbated if too particular interests are put to the front of the debate.

However this viewpoint on actors potentially involved in participatory processes should be tempered: these actors are most often associations or NGOs and constitute institutions for raising awareness and for education on environmental issues, they feel also concerned by agreement on general principles, such as on the relations between public decisions and environmental issues (Lafaye and Thévenot, 1993). In cases of civil engineering design with strong public protest and de facto involvement, such as the new railway "TGV Méditerranée" in the South East of France, some NGOs and citizen associations have been able to address very generic issues, discussing objectives of designing this new railway: they happened to intervene in a re-definition of the issue (Lolive, 1997). It is actually an issue of putting the right question in the debate.

One objective for any tool supposed to facilitate these approaches is to make generic issues addressed during the dialogue process, in order that it does not become pure defence of particular interests.

Joint use of Role Playing Games and Agent Based Models

ABM and RPG have both been developed for group decision or dialogue issues in separate trends (Barreteau, 2003). RPG, including notably policy exercises, are historically the first ones. They have been used to understand these collective decision processes as well as to train stakeholders involved in them or to bring support within them. From an analysis viewpoint, they make misunderstandings emerge through splitting the decision process among several decision centres (Schelling, 1961). They constitute tools close to the experiments economists do. They are very good tools to empower stakeholders in the decision processes and to facilitate sharing of information (Tsuchiya, 1998). However they are rather heavy to design and repetitions of experiments with a control of parameters are at least difficult (Piveteau, 1995).

More recently ABM have been used to simulate complex systems, with the idea of using them not only to represent collective decision processes, but also to support them. This second standpoint aims at broadening the field of information available to the participants (Benbasat and Lim, 2000): providing stakeholders with the potential consequences of various choices involved in an on-going group decision process reportedly mobilizes them more actively in the process (Driessen, Glasbergen and Verdaas, 2001). Here the objective of the ABM is to represent the stakes at the center of the collective decision process so as to lead stakeholders to better formulate the problems or to give them a tool to share viewpoints. However as they are usually embedded within a computer tool, they are always perceived by stakeholders as black boxes, which is raising issues of their legitimacy and acceptability.

Formally ABM and RPG have the same architecture: autonomous entities situated in an environment and interacting dynamically. This helped to overcome both limits: RPG might be used as a translation of an ABM more explicit to stakeholders, ABM can be used to repeat and simulate game sessions (Barreteau, Bousquet and Attonaty, 2001). This has lead to a large series of joint use of ABM and RPG in these last years (Boissau and Castella, 2003; D'Aquino *et al.,* 2003; Etienne, 2003; Etienne *et al.,* 2003; Hare and Pahl-Wostl, 2003). Most of them use a companion modelling approach[1] (Bousquet *et al.,* 2002) which aims at involving more stakeholders in the modelling process itself. Several categories of joint uses might be identified, presented in table I, according to relations between conceptual models on one hand and to organization of joint use on the other hand. The two main interests of using ABM rather than other kind of modelling also jointly used with RPG (Duijn, Immers, Waaldijk and Stoelhorst, 2003; Meadows and Meadows, 1993) are: the possibility of implementing the same conceptual model in various formats and the continuity among entities in RPG and ABM.

Table I. Categories of joint use of models and games**.**

	Different underlying conceptual model	Same underlying conceptual model
Model and game used in parallel processing	-Mutual support in use -Variety of time scales	-Association of virtual and real players
Model and game used sequentially		-Mutual support in design and assessment (co-design, validation, benchmarking)

[1] This approach has been written down in a charter, consultable at the following website: http://cormas.cirad.fr/en/reseaux/ComMod/index.htm

RPG and ABM, jointly or not, are used notably for renewable resources management issues. RPG are always associated to at least a simple model to represent the dynamic of the resource. In the field of irrigation management, several RPG have been developed to train people to manage these complex issues and to learn their potential consequences (Burton, 1994; Smith, 1989; Steenhuis *et al.,* 1989).

Creating a distance and involving complexity

A first feature of these tools making them fit the initial requirement is their ability to deal with complexity. A reason early mentioned of using games for policy issues research as well as education is their ability to generate complexity (Schelling, 1961). Multi-Agent Systems have also been developed to work on complex issues (Ferber, 1995). In both cases the key feature to endorse complex issues is the distribution of decision centres, either in computer agents or in players.

Role Playing Game design and facilitation is craft. Moreover, even for very closed games, constraining players as robots, there is always a remaining space of freedom in which players can interpret in various ways their role. This helps to fit the requirement of contingency, through adaptation of the tool by the players themselves.

Use of computer simulations allows informing stakeholders on potential consequences of their collective behavioural patterns. The gaming side is providing stakeholders a better knowledge on what is inside these tools, increasing thus their legitimacy (Dare William's, Boutet Annabelle, Barreteau Olivier and Ferrand Nils, 2004).

Finally ABM and even more RPG are very simplified representations of the world. Even if some elements of the real world are still present, they constitute thought support tools, on which private consequences cannot be identified, leading to focus on generic issues leaving away each one’s backyard. Gaming atmosphere is moreover providing some distance with real issues, providing possibilities to explore scenarios which are not socially acceptable, leaving a door open on refusing the consequences of simulations.

We explore below this second option in a specific case study dealing with irrigation in the South-East of France.

Pieplue: an hybrid tool associating a RPG and an ABM

The Drome River Valley Case Study

A SAGE (Local Water Management Plan) has been signed up for the Drôme River Valley (Major tributary of Rhone river in the South-East of France) at the end of 1997 by the Prefect (State representative) building upon an agreement among representatives of local elected bodies, water users representatives and state representatives. It tackles among others the issue of minimum flows to be observed in downstream part, where main use is irrigation, through an agreement among stakeholders on a minimum threshold for downstream flow of 2.4 m^3/s all the year long. We have then been involved in the facilitation of the dialogue among the farming sector on how reaching collectively this objective through a collective mastering of irrigation uptakes. A set of collective rules has already been agreed upon early 2003, but not yet tested due to the exceptional drought of year 2003 (water flow at the upstream part of the irrigated area has been naturally below the minimum level for most of the normal irrigation season). This set of collective rules is based upon the use of complementary resources coming from outside of the river basin and the definition of allocation rules among farmers. The RPG and ABM presented below aim at providing an interactive setting for future possible revisions of the agreement.

Farmers are the major consumers of water for irrigation, which is mainly that of corn fields: irrigation is the main reason for water pumping, with 80 % of the irrigated fields (3000 ha) being on the downstream part of the river. Total pumping capacity for downstream part is 2 m^3/s. Farmers are partially organized within three irrigation systems managed by users’ associations: three-quarters of the irrigated area falls within one of these three irrigation systems, and 85 % of farmers belong to at least one of these three associations. Remaining irrigated areas are irrigated through wells in the alluvial aquifer. The whole context is evolving with:
– occurrence of droughts, causing individual expectations for critically dry years to evolve;

– political stakes, such as local elections, which cause new scenarios to appear and others to become taboo;
– national and European agricultural policy, which cause interests in specific crops demanding more or less on water to evolve.

Co-ordination of RPG and ABM

Dealing with dialogue support for collective decision processes for irrigation management issues raised the need to tackle a large sample of time scales: from the day when hydraulic balance and water level in the river is computed or observed and the practical decisions for cropping and irrigating are made up, to years when irrigation investments are made. The interactive setting presented here, named PIEPLUE, is constituted by a couple of an ABM and a RPG. It has to be able to deal with:
– a short time scale, typically the day, as the time for the farmer to choose the plot to irrigate;
– a medium time scale corresponding to the evolution of priorities among crops, typically the month, for the farmers to update their irrigation patterns;
– a long time scale, typically the year, for cropping pattern choices and collective discussion on rules to share water.

The short time scale is simulated by the ABM according to the choices made at the two other time scales. These medium and long time scales are simulated in the game, benefiting from the simulation results of the first one.

The RPG constitutes the basis of the interactive setting. As for many games using computer tools, the ABM is embedded in the RPG. All players take on roles of farmers. Two game facilitators are required, one for the gaming part and one to use the ABM. It builds upon a sequence of several stages summed up in figure 1. In the initialisation stage players are allocated 6 fields each characterized by a soil water capacity (superficial, medium or deep) as well as two water supply facilities characterized by a location (an individual well or an outlet on a collective irrigation network) and capacity. These allocations are provided randomly by the computer to each player individually. Each player receives also an objective to help in taking on their role. The basic setting involves two collective networks, one with a pumping station at the upstream part of the irrigated area and the other at the downstream part. It might be reduced to only one if not enough players are available. The collective irrigation networks are initiated with the choice of a president among players holding an outlet in it, and with the definition of water pricing for outlet holders.

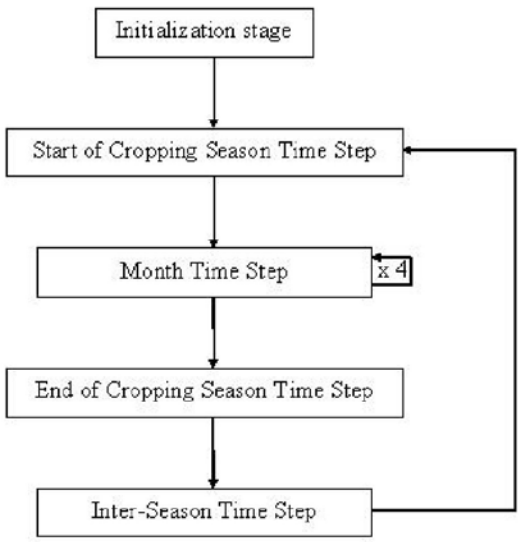

Figure 1. organization of a RPG session.

During the start of cropping season time step, players choose their cropping pattern based on an affectation of a crop for each field among {wheat, maize, tomato, garlic}.

Then they choose an irrigation pattern for each month time step. This step is repeated four times considering that irrigation season is lasting four months in that area (June, July, August and September). Players fill in for each of these time steps a form specifying a weekly irrigation pattern for their both water sources as shown on table 2. These forms are then entered as parameters for the ABM by a game facilitator on specific computer interfaces.

Table II. table to be filled in by each player at each month time step for each water source.

	Field 1	Field 2	Field 3	Field 4	Field 5	Field 6
Monday						
Tuesday						
Wednesday						
Thursday						
Friday						
Saturday						
Sunday						

Players can base their choice on the irrigation pattern of previous month time step which is provided together with information on the evolution of private and public indicators during the previous month time step. They have also information on the way they are affected by collective rules in case of water shortage.

Private information concerns systematically the evolution of state of crops according to soil-water availability as shown in figure 2. It is printed out and given privately to players for their own fields. Other private information is available and provided to players on request: water consumption for each of their water source by day, irrigation amount by field and by day.

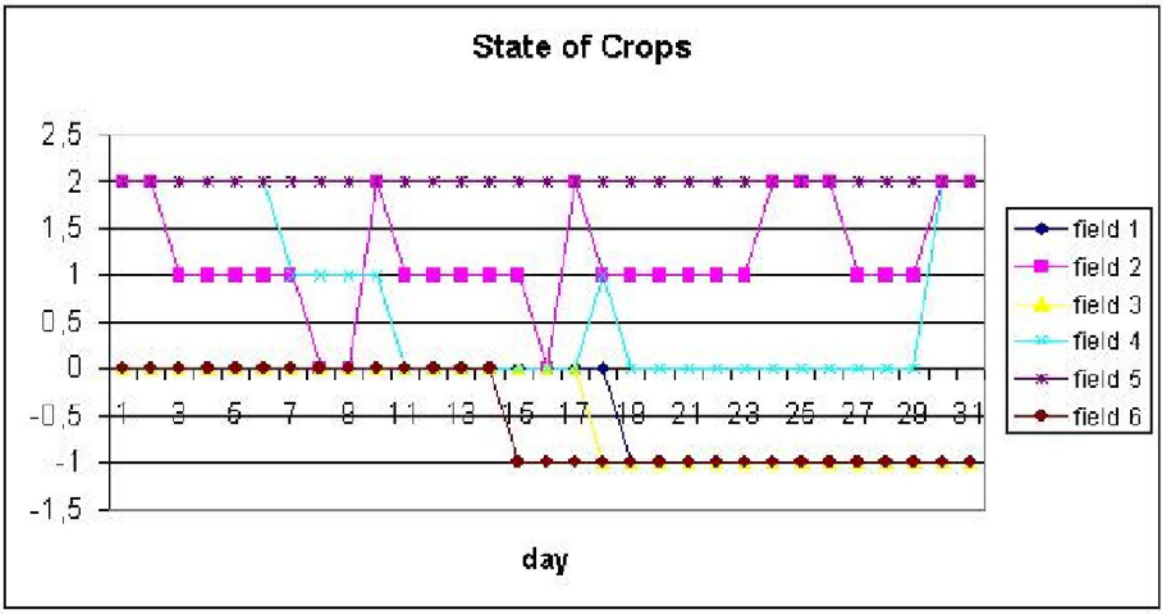

Figure 2. evolution of state of crops during a month for all fields of a player (2 stands for "good", 1 stands for "thirsty", 0 stands for "very thirsty", - 1 stands for the absence of crop usually due to harvest alrady passed).

Public information is projected directly from the computer. It concerns notably the series of downstream flow which appears on a computer interface as presented in figure 3 and is projected systematically. Other indicators are computed and might be projected on request from players: climatic data on previous month (rain and Potential Evapo-Transpiration), evolution of crisis level, upstream flow.

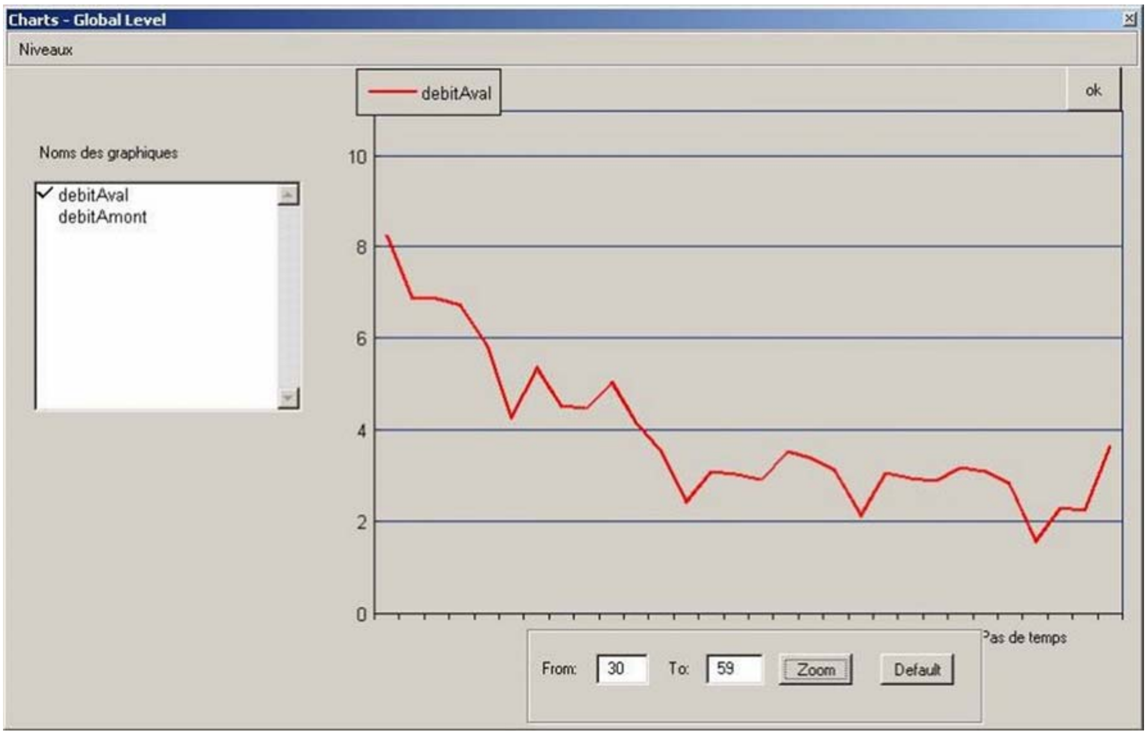

Figure 3. evolution of downstream flow during a month time step. Y-axis is downstream flow in m^3/s, X-axis is time in days**.**

All these indicators are computed in-between two time steps by the computer ABM. The ABM has the same architecture as the RPG:
– agents are farmers (with one instance of farmer for each player, water user associations (one for each collective irrigated network), and one local water commission (implementing the collective rules and played in the RPG by the RPG facilitator);
– objects are the fields, the crops, the outlets, the pumps (collective or individual) and the river.

The ABM is implementing the irrigation patterns provided by each player at the day time step. The resulting downstream water flow is then daily compared to the objective and the collective rules implemented, generating possibly crisis and decrease of water pumping. Expenses for each cropping activity as well as incomes from yield are also computed, updating cash level of each player.

At the end of the cropping season, each player is privately provided with his own results: yield for each crop and current cash level. Current collective rules are then reminded and a discussion time is open to possibly modify these collective rules for a new cropping season.

Modularity in use of Pieplue

Two test sessions

Two test sessions have already been undertaken, one with scientists in the field of irrigation water management, and another one with employees of the Communauté de Communes du Val de Drôme, association of communes in charge of the implementation of the SAGE. The first one was aimed at calibrating the game and validating the relevance of the ABM simulations from an expert point of view. It led notably to propose new indicators and provide more information to players. It also led to provide the evolution of indicators along the whole month instead of the mere current state at the beginning of the month. The objective of all these modifications is to give more keys to players to possibly analyse and better understand the reasons of current state of their field. A water shortage may for example be due to the implementation of collective rules reducing water uses or to too little supply of water through irrigation.

The second test session was held with the institution in charge of the SAGE implementation and thus of the facilitation of collective decision processes which are induced by the SAGE. The objective was that this institution has a good knowledge of PIEPLUE before any test with real farmers and that they take part in its design upon the basis of this first prototype. In this second test session players were a little bit lost by the amount of rules to be learned at the beginning. These difficulties of understanding were notably due to the participation in the game of employees of the CCVD not familiar with irrigation issues to reach a minimum number of players. The supply of the series of indicators was useful to help players understand these rules during the play of the first cropping season. Players could understand the relations between their choices and their results. However these explanations were time consuming and only one cropping season could be played, which did not allow testing the capacity of PIEPLUE to foster the generation of new collective rules.

Repetition of tasks has been well accepted in these PIEPLUE tests, since they were associated with direct simulation of consequences of various actions made by each player. These simulations, and notably private information provided to players did generate comparisons between neighbours in the interactive session. However whole duration is still too long and has to be improved, or time dedicated to explanations has to be reduced through a progressive learning of the game.

Discussion: uses of Pieplue

The second test, with the institution in charge of SAGE, led to a rich discussion on the possibilities of uses of Pieplue. Whereas it has been designed as a collective decision support tool, participants in close relation with farming sector (extension services from local water institution or water users association) have rather identified an interest as a professional training tool, beside any real decision making processes. These players have acknowledged the power of this tool to make farmers understand that dialogue is an important pattern for water management. This understanding should lead them then to design water management scenarios with other parameters than pumping rights only. They did not feel a potential for collective decision support in an operational context however. They argued that there are already negotiations taking place among the farming sector, without this kind of interactive session. The biases, such as hijacking of the decision process by a few leaders of the farming sector, observed in such real negotiation patterns is not relevant to them since there aim is to provide advice to the farming sector and to lead them to good practices. They ask thus for more control input on scenarios of simulations played during game sessions so that lessons learnt from the game could be those they want to reach: representation of climatic diversity and a proposal of a few cropping patterns to players in order to reach contrasted outputs. However such use would require a deeper validation of the model because it assumes less knowledge and less experiment from players and thus less capacity to sort out game outputs. With this category of tool and players, it is easy to go from training to manipulating.

This viewpoint on potential use of Pieplue as a training tool is heading in the same way as the one proposed by institutional stakeholders in a participatory modelling experiment for water management: although they took part in model design, river basin managers/facilitators think it should be a training tool made to bring a specific message while modelling scientists think of a discussion support tool (Boutet, 2003). In both cases the aim of representative of extension services or river basin facilitator do want to make water users' practices evolve towards new practices considered as the good ones, from their view point, different from the viewpoints of these water users. While setting of Pieplue is considering farmers as actors to be involved in the decision process, the expectation of institutional stakeholders is to consider them as final users, needing to be convinced to adopt good practices. Rationale of involvement of these final users in interactive sessions is to lead them to take "better decisions", defined beside of them and according to an objective which goes beyond their own sphere. There is no purpose of involvement in the decision process itself, which would imply that there would be no expected decision a priori.

Validation of interactive setting such as Pieplue is thus a real concern: either go straight from the laboratory to target population, or go through intermediary test with players with enough knowledge of the context to play as if they were from the target population.

Second option is raising the issue of the choice of these sets of players for test. If they have enough knowledge of the context of the real players they are likely to be concerned by the way they will play the game, and make it evolve towards the kind of game they would like the target population play.

First option is facing the risk of having some samples of the target population, or even through diffusion the whole target population, being lost to purposeful uses of the game because they have played with a version under construction. This is however what has been done by Patrick D'Aquino in Senegal with another interactive gaming tool, selfCormas (D'Aquino *et al.,* 2003). He started by organising game sessions at farmers level, then technicians of extension services in a second stage and the leaders of the institution in charge of extension in a third stage. At each level the game was perceived as an interesting but too complicated and not suitable for actors of the level "above".

The interactive setting proposed by D'aquino is however simpler than Pieplue: his aim is to make players first design the game according to their own representation of their territory. Pieplue is more complicated and requires some calibration in the parameters but also in timing. This timing calibration, to have game sessions lasts not more than 3 hours, has to be done by players with player with knowledge of farming activity, because it impacts on duration of play.

Discussion and conclusion

The development of PIEPLUE is still on-going following a Companion Modelling approach (Bousquet *et al.,* 2002), which implements a succession of versions confronted to the field at various levels. Here we go from experts external to the field closer and closer to actors more directly involved in the use of water resource.

However the use as dialogue support could not yet be tested as it is planned to: through the comparison of propositions in the game with the possibility to implement them in real world. But it has been considered generic enough to be used as a training tool. Therefore the requirements proposed in the first section are eventually met:

The tool is still open to new rules, even though it is constraining the topic of discussions. There must have been a prior agreement on the fact that sticking to cropping pattern and management of irrigation patterns are suitable and sufficient to deal with water sharing issues among farmers;

There is empowerment of stakeholders who happen to play in the game. However it raises the issue of the power they eventually gain regarding those who do not participate. Since the game cannot be played by more than a dozen of players, it has to be repeated so that this technical feature is not inducing more changes in power relations than those generated by the implementation of any participatory process. Protocol for these repetitions and synthesis of conclusion of sessions are still to be designed.

In this case study relations among the farming sector are not too difficult. Playing randomly attributed roles lead also players not to involve actual relational issues among them, for example between individual and collective water uses, since they are not personally responsible of their played behavioural patterns.

These randomly attributed roles and the generic spatial support not sticking to any part of the basin leads to tackle rather generic issues, it is impossible to assess trough the game the particular consequence to any body of the proposed rules.

Acknowledgements

We are grateful to CCVD (Communauté de Communes du Val de Drôme) for the quality of interactions in the case study and the French Ministry of the Environment's program called "Concertation et décision en environnement" (dialog and decisions on the environment) for financing this research. We also wish to thank our colleagues from Cirad and INRA for the rich discussions on companion modelling and use of Role Playing Games.

Bibliography

ARNSTEINRNSTEIN S., 1969. A ladder of citizen participation, Journal of the American Planning. Association, 35 (4) 216-224.

BARRETEAU O., 2003. The joint use of role-playing games and models regarding negotiation processes: characterization of associations. Journal of Artificial Societies and Social Simulations, 6 (2), http://jasss.soc.surrey.ac.uk/6/2/3.html.

BARRETEAU O., BOUSQUET F., ATTONAT J.-M., 2001. Role-playing games for opening the black box of multi-agent systems: method and teachings of its application to Senegal River Valley irrigated systems. Journal of artificial societies and social simulations, 4 (2) http://jasss.soc.surrey.ac.uk/4/2/5.html, http://jasss.soc.surrey.ac.uk/4/2/5.html.

BENBASAT I., LIM, J. 2000. Information technology support for debiasing group judgments: an empirical evaluation. Organizational behavior and human decision processes, 83 (1) : 167-183.

BOISSAU S., CASTELLA J.-C., 2003. Constructing a common representation of local institutions and land-use systems through simulation gaming and multiagent modeling in rural areas of northern vietnam: The samba-week methodology. Simulation and gaming, 34 : 342-357.

BOUSQUET F., BARRETEAU O., D'AQUINO P., ETIENNE M., BOISSAU S., AUBERT S., LE PAGE C., BABIN D., CASTELLA J.-C., 2002. Multi-agent systems and role games: an approach for ecosystem co-management. In M. Janssen (Ed.). Complexity and Ecosystem Management: The Theory and Practice of Multi-agent Approaches (pp. 248-285). Edward Elgar Publishers.

BOUTET A., 2003. Phylou dans tous ses états. Analyse de la co-construction d'un outil d'accompagnement dans la gestion locale de l'eau. Cemagref Report N° WP 2003-01, n° 1080.

BURTON M.A., 1994. The irrigation management game : a role playing exercises for training in irrigation management. Irrigation and Drainage Systems, 7 : 305-318.

D'AQUINO P., LE PAGE C., BOUSQUET F., BAH A., 2003. Using Self-Designed Role-Playing Games and a Multi-Agent System to Empower a Local Decision-Making Process for Land Use Management: The SelfCormas Experiment in Senegal. Journal of Artificial Societies and Social Simulations, 6 (3), http://jasss.soc.surrey.ac.uk/6/3/5.html.

DARE W., BOUTET A., BARRETEAU O., FERRAND N., 2004. Le point de vue des sociologues sur l'usage de méthodes de modélisation d'accompagnement pour la gestion collective de l'eau. XVII^{e} Congrès international des sociologues de langue française. L'individu social : autres réalités, autre sociologie ? Tours.

DRIESSEN P.P.J., GLASBERGEN P., VERDAAS C., 2001. Interactive policy making - a model of management for public works. European Journal of Operational Research, 128 : 322-337.

DUIJN M., IMMERS L.H., WAALDIJK F.A., STOELHORST H.J., 2003. Gaming Approach Route 26: a combination of computer simulation, design tools and social interaction. Journal of Artificial Societies and Social Simulations, 6 (3), http://jasss.soc.surrey.ac.uk/6/3/7.html.

ETIENNE M., 2003. SYLVOPAST a multiple target role-playing game to assess negotiation processes in sylvopastoral management planning. Journal of Artificial Societies and Social Simulations, 6 (2), http://jasss.soc.surrey.ac.uk/6/2/5.html.

ETIENNE M., LE PAGE C., COHEN M., 2003. A step by step approach to build up land management scenarios based on multiple viewpoints on multi-agent systems simulations. Journal of Artificial Societies and Social Simulations, 6 (2), http://jasss.soc.surrey.ac.uk/6/2/2.html.

EVERSOLE R., 2003. Managing the Pitfalls of Participatory Development: Some Insight from Australia. World development, 31 (5) : 781-795.

FERBER J., 1995. Les systèmes multi-agents, vers une intelligence collective. InterEditions.

GLENDINNING A., MAHAPATRA A., MITCHELL C.P., 2001. Modes of communication and effectiveness of agroforestry extension in Eastern India. Human ecology, 29 (3) : 283-305.

HARE M.P., PAHL-WOSTL C., 2003. Stakeholder categorisation in participatory integrated assessment processes. Integrated Assessment, 3 (1) : 50-62.

LAFAYE C., THEVENOT L., 1993. Une justification écologique ? Conflits dans l'aménagement de la nature. Revue française de sociologie, 34 (4) : 495-524.

LOLIVE J., 1997. La montée en généralité pour sortir du Nimby. La mobilisation associative contre le TGV Mditerranée. Politix (39) : 109-130.

MARENGO L., PASQUALI C., 2003. How to construct and share a meaning for social interactions ?, Conventions et Institutions : approfondissements théoriques et contributions au débat politique. Paris.

MEADOWS D., MEADOWS D., 1993. Fish Banks news, Fish Banks limited and Laboratory for Interactive Learning. University of New Hampshire: Durham, NH, USA.

PARENT M., GALLUPE R. B., 2001. The role of leadership in Group Support Systems failure. Group Decision and Negotiation, 10 : 405-422.

PIVETEAU V., 1995. Prospective et territoire : apports d'une réflexion sur le jeu. Cemagref éditions.

PLATTEAU J.-P., GASPART F., 2003. The risk of resource misappropriation in community driven development. World development, 31 (10) : 1687-103.

RICHARD A., 2000. Analyse comparée de l'acceptabilité des SAGE et contrats de milieu. Cemagref/ Ecole Polytechnique, Palaiseau, Montpellier.

SAUNDERS-NEWTON D., SCOTT H., 2001. But the computer said! Credible uses of computational modeling in public sector decision making. Social Science Computer Review, 19 (1) : 47-65.

SCHELLING T. C., 1961. Experimental games and bargaining theory. World politics, 14 (1) : 47-68.

SMITH L. E. D., 1989. The Wye College Irrigation Game. Irrigation and Drainage Systems, 3 : 255-264.

STEENHUIS T. S., OAKS R. L., JOHNSON R., SIKKENS R., E.J., V. V., (1989). Irrigation rehab: a computer aided learning tool for system rehabilitation. Irrigation and Drainage Systems, 3 : 241-253.

TSUCHIYA S., 1998. Simulation/gaming as an essential enabler of organizational change. Simulation and gaming, 29 (4) : 400-408.