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Participatory modelling of fire prevention and urbanisation in southern France: from co-constructing to playing with the model

M. Etienne[a], M. Bourgeois[a], V. Souchère[b]

[a] *Ecodevelopment Unit, INRA, Site Agroparc, 84914 Avignon Cedex 9, France (etienne@avignon.inra.fr)*
[b] *UMR Sadapt, INRA, , BP1, 78850 Thiverval-Grignon, France (souchere@grignon.inra.fr)*

Abstract: In 2006, officers from the Nîmes Métropole urban community and from the Agriculture and Forestry Service decided to apply a participatory modelling process to sensitise the representatives of the community to fire prevention issues at the interface between natural areas and urban zones. The approach went through 3 phases. The first consisted of co-constructing, according to the ARDI method, a conceptual model of the current situation, in a group of technicians and local policy makers. The process was facilitated by a researcher used to the companion modelling approach and in charge of encouraging the participants to follow precisely the 4 steps of the participatory modelling process. The second phase was to implement the conceptual model into an agent-based model. The last was devoted to playing with the model during series of role-playing game (RPG) sessions set-up to stimulate discussions between the representatives of the community, urban developers and local policy makers. After a short description of the time schedule of the participatory process, the agent-based model and the corresponding RPG set up are briefly described. Specific skills developed during the co-construction stage and the way the model was progressively adopted by the participants are discussed. The function of the model during the role-playing game phase is analysed and its capacity to enhance discussions on the interactions between forest fire prevention, cropland abandonment and urban development is discussed. Particularly, the way players behave during the game and argue during the debriefing of the RPG session is described and the way the impacts of the participatory modelling exercise were evaluated is described.

Keywords: Participatory modelling, agent-based model, role-playing game, fire prevention, urban development, cropland abandonment.

1. INTRODUCTION

In 2006, officers from the Nîmes Métropole urban community and from the Agriculture and Forestry Service were looking for an effective tool to sensitise the representatives of the local villages to fire prevention issues at the interface between natural areas and urban zones. Fascinated by the approach previously developed for fire prevention in French Mediterranean forests (Etienne, 2003), they decided to try a participatory modelling approach. The approach based on the ARDI method (Etienne, 2006; Etienne et al., 2008) was applied by co-constructing an agent-based model in a group composed of technicians covering the main activities developed in the area, together with local policy makers. The process was facilitated by a researcher used to the companion modelling approach (Collectif Commod, 2006) and in charge of encouraging the participants to follow precisely the 4 steps of the participatory modelling process.

2. THE APPROACH

The principle of companion modelling (Collectif Commod, 2006) is based on a dynamic perception of the decision making process. Decision making is therefore considered as the result of interactions between individual stakeholders and groups advocating contrasting representations of the world and having different level of power in the negotiation process (Weber, 1995). When applied to decision support in natural resources management, it is supposed to facilitate a negotiation process aimed at transforming the interactions between ecological and socio-economic dynamics. Modelling is a crucial aspect of the approach because it is used as an efficient mean of building a shared (but not unique) representation of a complex situation, accounting for the dynamics of the system and simulating management scenarios.

What makes companion modelling original is the way the models are designed and used, and the involvement of the stakeholders in the modelling process. The main goal is to help practitioners, experts, or policy makers to elicit and share their points of view on a given complex question. Companion modelling promotes a reflexive use of models by setting up participatory workshops where stakeholders will learn collectively about a complex system by constructing, adapting, manipulating or observing a model (Collectif Commod, 2008). Generally, the approach goes through six to nine phases (Figure 1):

- sensitising: to convince stakeholders concerned by the same question that companion modelling can be an efficient way of starting collective thinking on that question
- co-conceiving: to jointly construct a shared representation of the question and the corresponding complex system
- monitoring: gathering available information and getting relevant new data on the system
- implementing: developing the computer model (commonly an agent-based model)
- validating: making stakeholders feel comfortable with the model
- visioning: playing with the model (role-playing game) or simulating scenarios
- feeding back: getting stakeholders not involved in the participatory process aware of what happened and what are the main outputs
- evaluating: measuring the impact of the participatory modelling approach on stakeholders practices and decision making
- training: getting participants self-sufficient on applying the approach on other topics

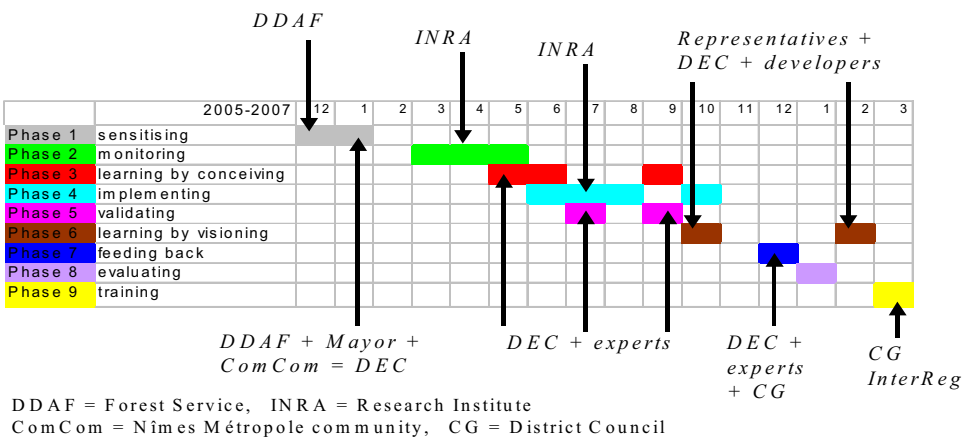

Figure 1: Time schedule and stakeholders involved in the companion modelling process of the Nîmes Métropole study case

In the Nîmes Métropole case study, participatory workshops were focused on phases 3, 5 and 6. But phase 2 was also used to gather and share spatial information on forest and urban dynamics, and knowledge of the main practices of local stakeholders (farmers, developers and foresters). Phase 3 was devoted, on the one hand, to elaborating and validating a virtual spatial representation of 3 contiguous villages taken to represent a typical organisation and structure of the northern fringe of Nîmes city; and, on the other

hand, to co-construct, a conceptual model representing the current functioning of the territory and the most likely trends in the next 15 years. Phase 6 was focused on learning by playing with the model during a series of role-playing game (RPG) sessions set up to stimulate discussion between the representatives of the 14 villages, urban developers and local policy makers.

3. CO-CONSTRUCTING A MODEL WITH STAKEHOLDERS

As mentioned in Figure 1 (DEC group), the core group leading the participatory process was composed of a mayor (vice-chairman of Nîmes Métropole), the officer in charge of environmental issues at Nîmes Métropole, the officer in charge of fire prevention at the Agriculture and Forestry Service and a researcher used to the companion modelling approach. At this stage, the core group paid special attention to the convocation of the working group, particularly on 4 aspects: choice of the participants, venues, scheduling of the workshops, mode of invitation (Etienne et al., 2008). The first point was discussed at length because the richness and relevance of the representations elicited during the co-construction exercise depend on the representativeness of the participants. Two options were considered: to work with real stakeholders or with experts from the extension services. The first of these was finally discarded due to the difficulty of selecting farmers to represent each dominant agricultural activity. Instead we chose officers from the extension services (agriculture, forestry, hunting, urban planning) who were thought to already have an overall view of the dominant practices of the main stakeholders. For the three other points, the workshops took place at Nîmes Métropole office, every 3 weeks, and participants were invited by the Nîmes Métropole officer to discuss the following question: how to reduce forest fire hazard at the urban fringe ?
The co-construction of an agreed representation of the question followed the ARDI method (Etienne et al., 2008), but a preliminary workshop was organized in order to define the environment and spatial scale to support the co-construction. According to the land use typology of the 14 villages surrounding Nîmes city (Bourgeois, 2006), 3 archetypes were defined and a virtual map gathering these 3 archetypes was proposed by the core group and designed on a GIS as a contiguous territory. This map was then modified and validated by the working group. After that, three participatory modelling workshops were organized in order to answer the 4 following questions:
Who are the main stakeholders involved in or with a duty to play a decisive part in fire prevention on this territory ? What are the principal resources of the territory and the key information needed to guarantee a sustainable fire prevention ? What are the main processes that drive huge changes in resource dynamics ? How does each stakeholder use the resources and modify the processes?

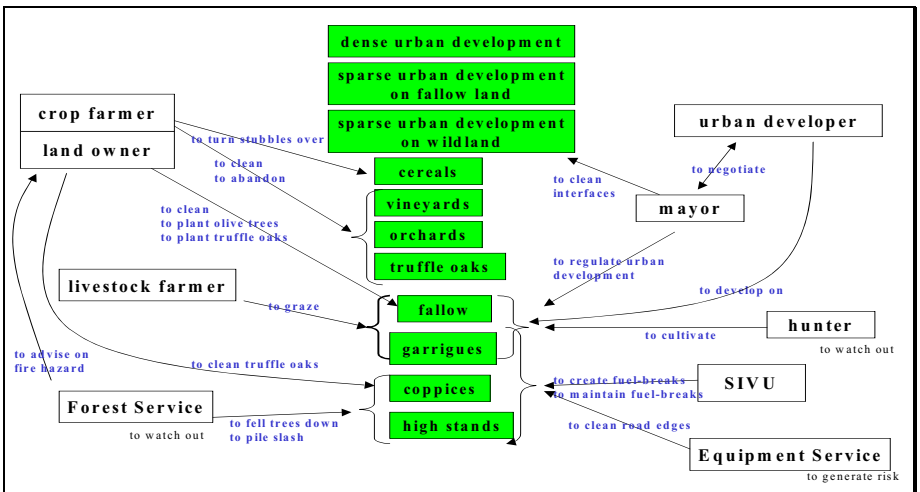

Figure 2: Interaction diagram co-constructed by the working group

This first participatory process led to a conceptual model of the current situation expressed by a diagram representing the key interactions between stakeholders and resources in relation to current trends in urban development and fire hazards (Figure 2).

4. THE AGENT-BASED MODEL

The co-constructed conceptual model was implemented by the research team into an agent-based model. The environment is modelled by way of a cellular automaton representing 3 virtual neighbouring villages covering the most common types of urban density and forest/cropland ratio measured around Nîmes city. The spatial grid is made of 83 x 69 cells, each of 1 ha. The vegetation viewpoint (Figure 3) provides 18 land use types with 7 types of croplands, 4 types of urban development and 7 types of native vegetation. This environment changes according to 3 ecological processes: fallow encroachment on abandoned croplands, natural regeneration after wildfires, natural succession from open garrigues towards Holm oak coppices or Aleppo pine woodlands.

Four agents play an active role in the model: urban developers, mayors, farmers and the local Forest Service. The developers propose to establish new developments near to current urban areas but with different levels of standing and price according to the past land use of the land: olive grove, fallow, garrigue or pine forest. To promote their project, they have to negotiate a building permit provided by the mayors according to their urbanising strategy (increasing the density of the present urban area, extending development on flat lands or on the hills). This strategy is defined in the local urban plan (PLU) that fixes for 10 years the areas where development will be permitted. When revising the PLU, new roads are planned giving access to new areas for development. Farmers take care of the crops mainly located in the flat lands and decide on key maintenance practices such as weeding the vineyards or ploughing the stubbles. When their crops are facing an economic crisis, they receive CAP subsidies to uproot vineyards or abandon cereal cropping on fields located near to urban areas. Finally, the Forest Service is gradually creating a strategic fuel-break perpendicular to the main wind direction and connected to well-maintained crop fields.

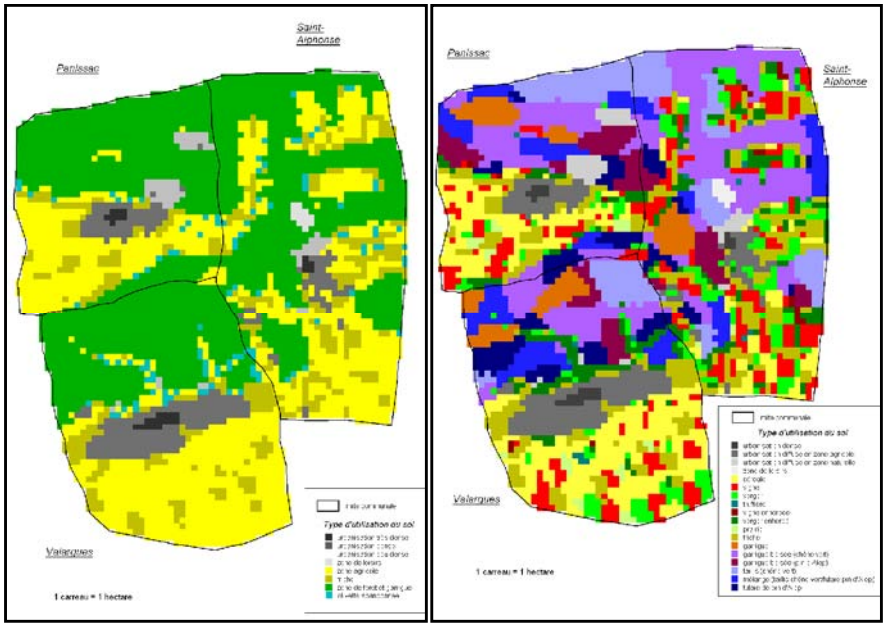

Figure 3: Vegetation viewpoint used in the model (right) and in the RPG (left)

The model runs on an annual time step, so the vegetation viewpoint is updated every year and provides a representation of land use at the beginning of summer. A wide range of indicators is calculated which can be plotted on graphs (i.e. fallow land area, urbanising ratio, burnt area, number of houses affected by fire) or charted on maps (tree cover and

dominant species, age of fallow lands, urban density, etc). Any indicator mentioned as a key data item for taking decisions or evaluating their activity by the participants during the co-construction workshops was implemented in the model.

5. PLAYING WITH THE MODEL

For discussing collectively on visions of the future, the role-playing game tool was selected because it allowed points of view to be shared and opinions challenged in a friendly way (Bousquet et al., 2002). This phase is very important because it encourages the participants to question each other's points of view, to discover the impact of their practices on the other participants' practices and resources, and to experience clear power relationships. It also reveals the difficulty of getting agreement on land management in complex situations. That is why, at this stage, it is newly necessary to pay special attention to the convocation process (Etienne, 2008): choice of the participants, location of the RPG sessions, mode of invitation. It was considered that Nîmes Métropole was entitled to urge the participants to discuss wildfire prevention, and the invitation signed by the vice-chairman presented the RPG as a mediation and collective thinking tool. The sessions were organised in one of the villages of Nîmes Métropole community, but inside a folk museum funded by the District Council. At each session 3 mayors, or their delegates for environmental or urbanisation issues, from 3 different villages, were invited as well as a developer, the officer of Nîmes Métropole in charge of environmental issues and one forest technician from the Forest Service.

The environment was similar to the environment of the agent-based model with the 3 neighbouring villages that were given a nickname like a local traditional name (i.e. Panissac). As mayors get confused with detailed vegetation maps, land use categories were extremely simplified with only 5 types: garrigues and forests, urban areas, olive groves, crop fields and fallow lands (Figure 3). Urban areas were divided into 3 levels of population density, and olive groves were identified as weeded or not. Special attention was paid to the spatial layout of the room (Figure 4) with 3 boxes for the 3 mayors, a big round table for Nîmes Métropole, 2 small tables for the Forest Service and the developer, and an interactive white board used both for representing the cadastral survey and land use map. The computer and the model were apart in a corner of the room.

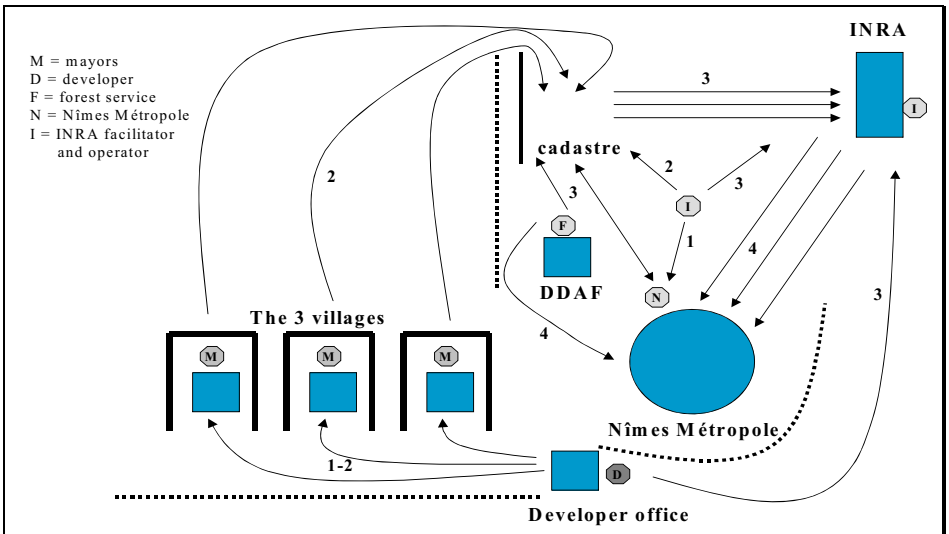

Figure 4: Spatial design of the RPG room and movements made by the participants during the 4 steps of one round

Each round of the game was made up of 4 steps. First, while the participants acting as mayors defined the limits of the urban zone (land suitable for development) and established the range of land prices according to the cadastral plot location, the participant acting as an urban developer threw 3 dice to sort the area he could develop over the next 3

years and thought about the characteristics (density, livelihood) of the corresponding developments. Secondly, a set of negotiations between the 3 mayors and the developer took place in order to decide the location and density of the developments to settle during the 3 following years. Simultaneously, the participant acting as the Forest Service designed a fuel-break aimed at reducing the fire hazard for the forest and advised the mayors on the development of his village with major sensitivity to fire. At the same time, the participant acting as Nîmes Métropole sorted an agriculture or recreation project and thought about the best place to establish it. Thirdly, the mayors went to the cadastral interactive map to identify the coordinates of the plots they agreed to develop and signed the corresponding building permit. Finally, the computer operator entered the decisions made by the participants, ran the model for 3 years (cropland abandonment, urban development, shrub and pine encroachment, wildfire), and printed the new land use maps of each village. Meanwhile, Nîmes Métropole invited the participants to negotiate about the sorted project. At the end of the negotiation, a decision has to be made on what to do, where and who pays. At the beginning of the following round, the facilitator made participants aware of the new value of their key indicators: cash, popularity rating, area burnt by wildfires, and land use maps. Depending on time availability of participants, after 3 to 5 rounds, the RPG is stopped, and after a short break, all the players are invited to discuss what happened during the session. The debriefing is mainly focused on 5 aspects: how participants feel, what do they think about the realism of the model, what was their individual strategy, did they become aware of vegetation dynamics and its impact on fire propagation, and what happened during the periods of negotiation.

6. EVALUATING PARTICIPATORY MODELLING

The Nîmes Métropole case study is part of a large-scale exercise in which about twenty companion modelling (ComMod) research projects were evaluated. The aim of the evaluation was to assess the impact of the ComMod approach in different ecological and socio-economic contexts around the world, and to get ideas about how to improve the ComMod approach in the future. Within this framework, a common designer questionnaire and participants' evaluation framework were elaborated and applied to Nîmes Métropole case study. The designers' questionnaire was completed by the project designer, in order to capture the designers' initial perceptions of the context and to record how it changed over the lifespan of the project. It also permitted the methods and associated artefacts used during the project to be identified and their impacts on the participatory and learning process to be analysed. The objective of the Participants' evaluation framework was to assess how the participants' experiences corresponded to the project team's perception of how the project was carried out.

For the Nîmes Métropole case study, it was decided to carry out a third-party evaluation conducted by an external researcher in order to minimize bias and get more confident results. The evaluator attended only the five sessions of the role-playing game as a simple observer, and was totally unaware of the contents of the project before beginning the evaluation process. Thus, although she had personally applied a ComMod approach in another context (runoff in a crop watershed), she can be considered as neutral with no vested interest in the outcome of this research project. She began the evaluation process in April 2007 by interviewing the project designer, with who she completed the designers' questionnaire. On this occasion, they discussed the implementation of the participants' evaluation framework. Among the 37 people who participated in one or several workshops (participatory modelling and/or role-playing game session), it was necessary to select someone to be interviewed. The 3 stakeholders belonging to the core group (Figure 1) were considered as compulsory members of the sample. Among the participants in the participatory modelling process, 6 people were selected so as to keep a representative of every institution (Table 1). When there were several people from the same institution, the those who attended the largest number of meetings were selected. Among the participants in the role-playing game sessions, the two urban developers, and all the mayors were interviewed, and in the case of their delegates, only the ones in charge of urbanisation were kept on the list. Finally, 3 additional interviews were carried out with officers from

the District Council who were interested in widespread use of the RPG with other villages concerned with the same issue.

Between April and June 2006, the evaluator conducted 23 individual interviews lasting 30 minutes to 2 hours depending on the participants. The full interviews were transcribed as well as the debriefings of the RPG sessions to supply complete raw material for evaluation. The evaluation was also based on the analysis of the documents provided by the project team: mainly the canvass describing the steps followed while applying the companion modelling approach and a log book detailing day by day the chronicle of what has been done (people involved, date and place, type of meeting, inputs, outputs). Publications, technical reports, master thesis and other background documents were also provided by the research team.

Table 1. Institutions involved in the participatory modelling process and its evaluation

	Participants in the process	Participants interviewed for the evaluation	Group
Research team (INRA)	2	1	Core group
Agriculture and Forestry Service	1	1	
Nîmes Métropole urban community	2	2	
Urban planner	2	1	Working group
Farmers' Association	2	1	
Private Forest Service	1	1	
Public Forest Service	3	1	
Land tenure Service	1	1	
Livestock Extension Service	1	0	
Fire Brigade	1	1	
Urban developer	2	2	RPG group
Mayors or their delegates	14	8	
District Council	5	3	Extra group
Total	**37**	**23**	

The interviews allowed to identify several decision-making related to the participation of mayors in the RPG sessions. One mayor decided to modify his urban planning project by integrating fallow lands nearby the urban area. Among the 5 mayors that the Agriculture and Forestry Service get in touch with to encourage them to develop a fire prevention plan, 4 get involved. They mentioned the RPG helped them to better understand the interest of such a plan and provided them useful information to discuss and argue its implementation.

7. DISCUSSION

Interviews carried out for the evaluation process showed that this new way of working was welcomed by most participants. All participants enjoyed the participatory, interactive and constructive aspects of this original way of working. During the participatory modelling workshops, they particularly enjoy the fact that everyone had the opportunity to give one's opinion and had time to understand the viewpoints of the other participants. The role-playing game sessions were considered by participants as catalysts having strengthened or accelerated the development of social relationships between them. For example, the officer from the regional Agriculture and Forestry Service realized during the sessions of role-playing that the urban developers were interested in fire prevention issues and felt really involved. That gave her the idea to include them as partners in new projects focused on this topic, such as the design of leaflets on fire prevention techniques at the interface between natural areas and urban zones.

Participants came to understand that it was necessary to manage in a genuinely cooperative way the constraints related to urbanisation and fire prevention, and that it was essential to pay more attention to vegetation dynamics on arable lands and natural areas. For example, some mayors discovered the possibility and the value of creating recreation areas as a buffer between the forest and urban zones. Role-playing game sessions were also an opportunity to initiate a discussion about the concept of "intercommunality" to sensitise the mayors or their delegates to the need to develop serious cooperation between villages for fire prevention issues. Urban planners and developers involved in the participatory process gave assurances that their practices in urban development will now take better account of fire hazards in their new projects of urban or mixed development zones.

In accordance with situated action principles (Suchman, 1987) and organizational learning theory (Argyris and Schon, 1996), participatory modelling led to a collective consciousness of the impact of fallow land encroachment near to urban zones on urban development dynamics and its impact on fire hazard dynamics. Discussions after playing with the model made clear the necessity of collective reflection on fire prevention procedures and urban development planning. But it also brought to light the need for specific financial support for integrating these costly devices to the new urban development projects, both in terms of initial investment and maintenance cost.

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