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Co-Modeling Process, Negotiations, and Power Relationships: Some Outputs From a MAB Project on the Island of Ouessant

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Abstract:

For many conservation scientists, interdisciplinarity and participation can be efficient in the management of biodiversity. For both methods, new tools and new participative processes such as the so-called "co-modeling process" are required. The key questions addressed in this article are how group dynamics shape the model and why certain perspectives dominate in a process designed to be democratic. It is necessary, therefore, in order to appreciate the design and the legitimacy of the model that has been co-constructed, to address the questions of both the stakeholders' interests and their status in the process. Our case study is a co-modeling program based in a French biosphere reserve. It enabled us to highlight the key role of the mediator who had to govern social relationships and translate disciplinary jargon into a common technical language through a list of co-modeling rules.

Keywords: co-adaptive management; co-modeling; multi-agent system; participation; power relationships

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1. Introduction

Methodologies and the division of labor, which are used to build a model, are traditionally limited to a one-to-one working scene involving one disciplinary expert - an ecologist, an economist, an anthropologist - and one methodologist expert - a mathematician, a statistician or a computer scientist - (Desrosières 2003). In this type of situation, conventions for developing models are adapted to the expert's branch of instruction. The result is that the models designed often provide a poor common language for the discussion between scientists and stakeholders (Boulanger and Bréchet, 2005). Another weakness of the disciplinary approach for describing, understanding and managing complex social-ecological systems is that it frequently fails to take into account complex interdependencies between ecological, economical and social parameters. It can also be a source of negative feed-back at different scales and would appear to be inefficient in the management of sustainability issues (Arrow et al. 2000; Carpenter et al. 2002; Cohen and Tilman 1996; Costanza 1991; Fraser 2003; Levin 1998; Ludwig et al. 1993). By going beyond this specialized approach, more and more researchers have realised that, in order to manage uncertainty, it may be preferable to adopt an interdisciplinary, integrated and participative perspective (Clark and Dickson 2003; Lee 1993; Berkes et al. 2003; Gunderson and Holling 2002; Kinzig et al. 2003; Lal et al. 2002; Olsson et al. 2004; Pretty 1995, 2003). Broadening the traditional scientific division of labor and mobilizing different stakeholders' knowledge improves the information disclosure process and helps in the development of innovative management tools (Berkes and Folke 2002; Dietz et al. 2003; Folke 2004; Olsson et al. 2004). The result is the co-construction of models, indicators or data that are more relevant for users (Bousquet et al. 2002; Briassoulis et al. 2001; Etienne et Collectif ComMod 2005; Moller et al. 2004; Gurung et al. 2006; Levrel 2006; Levrel et al. 2006). Another advantage of this co-construction process, which is now often referred to as "technical democracy" (Callon et al. 2001), is that it may lead to the implementation of a fair process (Joss and Brownlea 1999). The idea of technical democracy is based on a fair procedure paradigm and has less to do with the social process of co-construction (Callon et al. 2001; Joss and Brownlea 1999). Thus, the social interaction which pools different knowledge is very often disregarded.

In this paper we discuss the social process that oriented a Multi-Agent System (MAS) companion modeling (ComMod) process in a French biosphere reserve and identify several empirical trends as to how group dynamics shape the model and why do some perspectives dominate in a process designed to be democratic ? We focused more particularly on the following questions : Why do people participate in this process and in what way can they take action? What are the main sources of conflict ? How does the negotiation process work and what kind of power relationships are revealed ? How does the mediator manage these dynamics in order to ensure, step by step, the making of a common model ?

Theoretical background

Co-modeling approach.

There are two ways to broaden the traditional division of labor in order to develop a social-ecological model (Morin 1994). The first is to build a working group of scientists and to consider that each discipline works in his/her own domain. In this situation, at the end of the research period the scientists present their results to the pool of scientists and the outputs are aggregated. This is a *pluri-disciplinary* perspective in which there is no need for a common language to communicate between disciplines since the different actors are all working at the same time without having to manage the interactions that may otherwise occur, in particular coordination problems and conflicts.

Such a perspective, however, raises several crucial problems. Firstly, disciplinary experts often take little interest in other disciplinary researches for the simple reason that they don't understand the very specialized works of their fellow researchers. Secondly, it is not easy to produce a report after conducting such a program and it is often necessary to publish a large and exhaustive manuscript in order to get the benefit of each disciplinary research. For policy makers and local stakeholders, this encyclopedic trend is not in accordance with the needs of effective management tools. Thirdly, the integrating dimension in this kind of project is poor and a certain amount of incompatibility is observed between the ecological, economic and social outputs. It is still an analytical approach with an ex-post artificial integration.

The second way is to adopt an *interdisciplinary* approach. In this case, in order to solve a common problem, scientists work both together and with the local stakeholders. *Interdisciplinarity* is based on the "disclosure process", i.e., the pooling of information dispersed between different communities of practices in order to promote the co-production of knowledge (Dietz et al. 2003). This approach enables the different actors to integrate all sources of specific information – formal and informal, public and private, quantitative and qualitative, scientific and indigenous – held by the stakeholders. It is based on the assumption that there is a symmetry of ignorance (Arias and Fischer 2000) and that requires all the communities of practices directly or indirectly concerned by a common problem should be taken into account. The result is that, in this context, all the stakeholders can legitimately speak about any subject since there is an element of truth in all the different points of view, even those which may initially appear as being "irrational". The reconciliation of these equity and efficiency principles is called "technical democracy" (Callon et al. 2001). It contrasts with the concentration of technical control in the hands of authorities or experts and grants large sections of the civilian population groups the right to participate in technical design and innovation" (Lee III 1973, p.237). In the modeling community, the *companion modeling* principle would appear to be similar to the technical democracy approach (Etienne and collectif ComMod 2005). Indeed, "the main idea of the companion modeling (ComMod) approach is to develop simulation models that integrate various stakeholders' points of view and to use them within the context of the stakeholders' platform (Röling 1996) for collective learning […] The general objective of ComMod is to facilitate dialogue, shared learning, and collective decision making through interdisciplinary and "implicated" research to strengthen the adaptive adaptive management capacity of local communities" (Gurung et al., 2006).

Multi-Agent System (MAS).

Social-ecological interaction models can provide a common language to facilitate technical democracy and improve sustainable management of social-ecological systems (Arias and Fischer 2000; Boulanger and Bréchet 2005; Etienne 2006; Etienne et al. 2003; Low et al. 1999). Capital stocks (human, social, physical and natural), ecological processes (resilience and productivity), social processes (institutional changes) and social-ecological interactions (human pressure and ecosystem services) must be taken into account by these models (Arrow et al. 2000; Berkes and Folke 1998; Berkes et al. 2003; Costanza 1991; Costanza et al. 2001; Daily 1997; Dietz et al. 2003; Gunderson and Holling 2002; Ludwig et al. 1993; Millenium Ecosystem Assessment 2005; Ostrom, 1990; Pretty 2003).

In order to provide integrative information tools, different models take these elements into account in different ways. However, according to five standardized and quantified criteria concerning interdisciplinarity, uncertainty, participation, long/short-term articulation, micro/macro articulation reported in a recent review (Boulanger and Bréchet 2005; table 1), MAS was ranked first out of six modeling paradigms for its policy-making in sustainable development. A MAS is composed of (Bousquet et Le Page, 2004; Ferber, 1999; figure 1) an environment, that is usually a space (GIS); a set of objects settled in the environment; a set of autonomous software agents (with the specific ability of being active); interactions between agents and objects; and an assembly of operations that make the agent active.

The success of the MAS is due to three specific properties (Bousquet and Le Page 2004; Janssen 2003).

1) Social and behavior assumptions are disregarded in many integrative models. Agents are often considered independent from one another and the decision process is limited to an individual information problem. MAS integrates diversified and interacting agents in the model and each one has his/her own representations, preferences, strategies and constraints. In this context, decision represents both an individual and a collective process where interactions between heterogeneous stakeholders are of utmost importance.

2) Many modeling paradigms are built on the basis of “equilibrium” and “optimum” concepts. In the context where uncertainty is high, these model categories are not suitable. By exploring different “what if” scenarios, MAS helps in articulating long term dynamics and short term preferences. Simulations enable users to take into account uncertainty because it is possible to compare, for example, the best and the worst scenarios, and all the scenarios which correspond to potential concrete future situations or to potential policy decisions.

3) MAS has been proven for its plasticity. This property concerns above all the variety of layers that are related to the diversity of points of view. It is then possible to articulate various representations of a common problem. In particular, the different participants can see, not only what is important to them, but also what is important to other stakeholders. Thus, MAS provides an indirect, yet powerful means for sharing and gathering alternative spatial representations of a same phenomenon.

In order to question the co-construction of integrative models, it is essential to consider commensuration – “the transformation of different qualities into a common metric” – as a social process (Espeland and Stevens 1998). Commensuration leads to classifying and organizing representations of our social and natural environment with the view of taking action (Bowker and Star 1999; Desrosières 1993; Douglas 1986; Hacking 2001; Latour 1987; Porter 1995). It is the same thing for the co-modeling process, which can be considered as a negotiation process between communities of practices supporting alternative points of view on a common problem and leading to the adoption of partial conventions reflecting the opinions of the convention makers (Arias and Fischer 2000; Desrosières and Thévenot 2002; Douglas 1986; Jimenez 1997; North 1999; Westley et al. 2002). In order to evaluate MAS, it is necessary, therefore, above all to analyse all the rules of the game and the social process that lead to changing "qualities" into "quantities" and "differences" into "magnitude".

Case study

In order to evaluate how the interdisciplinary and participative approaches enable the models to bring a common language to light, we analyzed a recently completed MAS companion modeling (2003-2006) carried out in four French biosphere reserves concerned with the same problem of fallow land encroachment.

<u>Social-ecological change on the isle of Ouessant.</u>

During the last thirty years land-use changes in Europe have led both to intensification and abandonment of traditional practices (Mazoyer and Roudart 1997). One consequence of such processes is the development of fallow lands in remote areas and the emergence of new threats on biodiversity (Gondard et al. 2001; Laiolo et al. 2004; Suarez-Seoanne 2002). The Man And Biosphere (MAB) UNESCO program and the French Institute of Biodiversity (IFB) have launched a co-modeling process in order to analyze interactions between human activities and ecological dynamics with the view of supporting collective decision-making processes involved in the global question of fallow land encroachment.

Four French Biosphere reserves were selected (Vosges du Nord, Ventoux, Mer d'Iroise and Lubéron) according to the following three criteria:

- To be strongly concerned with the issue of fallow land encroachment;
- To supply diversity of sociological and historical context of agricultural abandonment;
- To have at hand quantified and mapped data about this process.

We studied more specifically the case of the main isle of Mer d'Iroise Biosphere Reserve – Ouessant (1541 ha.) – located in the west of France (48° 28' N, 5° 5' W).

Recognized as a biological hotspot, the isle of Ouessant is a well-protected area (Natura 2000, Biosphere Reserve, Natural Regional Park and Special Protected Area) currently undergoing a period of rapid social-ecological change. Ecological change is mainly due to fallow land encroachment and tourism development. Social change is characterized by the decrease of the island's population and the tremendous increase in the number of tourists. At the beginning of the 20th century, the isle had a population of 2,661 inhabitants. On the occasion of the last census (1999) the population had dwindled to 956 inhabitants. In 1952, households were still undertaking agro-pastoral activities for their own consumption, with crops in the middle of the isle (34% of the area of the isle), and grazing pastures in the coastal and wetland meadow areas (38%) for as many as 4,500 sheep and 350 cattle (Gourmelon et al. 2001). By 1992, crops had disappeared (1%), pastures (31%) were restricted to the middle of the isle and sheep had decreased to approximately 1,000. By 2003, sheep on the isle had decreased to approximately 650. Cattle had disappeared during the seventies but a small number (30) were re-introduced in 2000.

Between 1952 and 1992, fallow land encroached virtually all over the isle – from 0 % to 43 % of total areas (Gourmelon et al. 1995). At the same time, the number of tourists increased very significantly as shown by the evolution of the number of ferry passengers: from 10,000 in 1950 to 250,000 in 2000 (Kerbiriou et al., 2007), with a continuous annual growth of about + 2,500 passengers over the past twenty years.

Fallow land encroachment is an interdisciplinary problem. First of all, as the main process is ecological (shrub encroachment), it deals with ecology. But it also deals with sociology and ethnology since the current ecological dynamic is due to dramatic changes in agro-pastoral practices and rules-in-uses. It deals with economy because use changes are mainly due to the loss of land resource status. It can be a legal problem because institutional reorganization is hindered to a large extent by access rights. The MAB-IFB project was launched in order to cope with this interdisciplinary question and develop MAS enabling participants to test alternative scenarios for the future of this reserve.

The aim was to create an interdisciplinary team for the Ouessant project, gathering biosphere reserve managers and scientists of both natural and social sciences.

A selected group was established including two ecologists – one ornithologist and one plant ecologist – one geographer, one modeler, one ethnologist, one economist and one park manager.

Co-construction of the MAS.

For three years an external mediator ran three 2-day co-construction sessions each year. This mediator was the national project leader. It is he who fixed the method for the co-construction of the model. This method seemed legitimate for all the stakeholders since it was clearly announced that this was the main technical constraint of the MAS development. It was tacitly approved by the multidisciplinary group and characterized by two categories of rules:

- “principles of justice” governing all social interactions (in particular the equity between the participants during discussions);
- “rules of the game” ensuring that the model was built collectively (among these rules, some participants were repeatedly reminded of various points such as the interdisciplinary

dimension of the model, the agent-based approach, the step-by-step process, the need to share the same approach in the four biosphere reserves, and computer system capacities which limit the accuracy of the results).

During the co-construction session, the mediator told participants, step-by-step, what they were to do and proposed simple tools so that, as suggested by the adaptive decision-making process (Lal et al. 2002) they may formalize the different ideas expressed (Etienne et al. 2003). The first aim of such a process was to adopt some collective agreements for the different core elements of the model, including :

- Make a list of agents – (human and non-human) – to tackle the question of fallow land encroachment;
- Drawing up an inventory of the key renewable resources for the selected agents;
- Describing renewable resource dynamics – impact of human activities and ecological trends;
- Describing social interactions vis-à-vis fallow land encroachment problems and questions related to this problem;
- Describing the rules-in-use for each agent;
- An agreement regarding the spatial and temporal reference scales.

The conceptual work ended with the core integrative question on time and spatial equivalence scales. To tackle this difficult task, the mediator listed the entities managed by the agents selected in the model, and the group reached an agreement as to the best spatial and temporal scales to account for these management entities.

The mediator established how long each topic could be discussed, ended a discussion when it was directly or indirectly considered as unnecessary or irrelevant for the model. The most difficult thing was to avoid endless discussions about specific points of interest for one disciplinary expert but of no particular use for the project. The main advantage of this step-by-step process is to show the stakeholders that trade-offs have to be adopted because it would be impossible to satisfy all of the disciplinary issues. Moreover, these trade-offs are accepted because they arose from a collective compromise. By proceeding in this way, a conceptual framework was developed, consisting of an interaction diagram (between agents and resources), a state-transition diagram (for the dynamics of renewable resources) and a class diagram (for the agents' behaviours) (figure 2).

The fact that the agreements were adopted without having all the information was not, as such, a major issue, since the model had to evolve along with knowledge and representations. The model was not developed to describe reality but to explore it. It is important, however, to note the irreversibility of time and spatial equivalence scales. Indeed, the entire model would have to be changed to enable these reference scales to evolve.

The second step in the co-modeling approach was to develop the MAS from this conceptual framework. It involved:

- Selecting the territory to be represented in the model;
- Assessing available information and gathering this information;
- Identifying information needs, particularly knowledge of local practices;
- Training one person to take charge of MAS;
- Developing a temporary MAS prototype.

Following these steps, the final model was built: the house of the breeder and the nest of the chough are examples of passive objects; breeders, park managers and choughs are agents; environment is issued from a GIS (island of Ouessant); interactions are composed of social and ecological relationships (figure 2); operations depend on the agents (figure 2) – they might represent grazing pressure for the farmer or stamping and disturbance for the tourist.

Results

Four questions to analyse the social dimension of co-modeling process.

We have already assumed that a commensuration process is a social process. To tackle the social dimension of the commensuration processes associated with the MAS co-construction, we recommend evaluating individual motivations leading a person to participate in this process (1), the means used to realize this commensuration (2), the concrete effects of this process (3), and the means used by these people to resist this commensuration process (4) (Espeland and Stevens 1998).

1) Several motivations encouraged participants to get involved in this project: some were interested in developing a dynamic geographic information system concerning shrub encroachment, one was interested in the new participative methodology represented by the co-construction process itself, one was interested in the indicators used for developing the MAS and one wanted to focus on the population dynamics of one specific bird. Finally, as it turns out, for a majority of participants the issue of shrub encroachment was merely an indirect question.

2) Means included the broadened division of labor, the principles of justice, the list of questions that participants had to answer (rules of the game), the conceptual framework, the MAS, the negotiation processes and the mediator.

3) The step-by-step process brought up some interesting emergent effects. First, the core questions about fallow land encroachment were gradually and collectively explored. Secondly, the problems of uncertainties were clearly formulated and enabled participants to define a set of complementary research programs. Thirdly, agreements, which were accepted by all the participants, gradually turned into conventions, paving the way for the building of a common language. These emergent processes may be defined as a meaning convergence process helping to create a community of interest around the issue of fallow land

encroachment. Another result was the emergence of "territories" managed by the participants. Indeed, all the disciplinary experts wanted to have their own questions, their own students and their own responsibilities in order to clarify their role in the co-modeling process, have specific tasks and develop a specific knowledge in relation with their own disciplinary issues. Thus, the different participants acquired a specific legitimacy to talk about specific issues and it becomes difficult, thereafter, to discuss these points collectively. The experts also insisted on the core importance of their subjects in the current dynamics and did everything they could to defend their own "territories". This emergence of territories lead to a problem of legitimacy when a participant wanted to speak about issues other than his/her own.

4) Participants can resist the commensuration process in different ways. The first of these is to refuse to take part or, at least, to avoid taking an active part in the co-construction process. This is the case for one participant who did not attend any of the co-construction sessions. Moreover, he was a source of inefficiency for the team because he always announced that he was coming and then failed to notify his absence in due time. It was impossible, therefore, for him to be replaced before the session started. Finally, this participant did not spread information within the group. Our conclusion is that this participant had more to loose than to gain in the reduction of information asymmetries and in the creation of a common language for working on social-ecological interaction on the island.

<u>The negotiations.</u>

During the co-modeling process, "representation conflicts", i.e., the differences of opinion as regards fallow land encroachment were the main source of disagreement. They occurred essentially when the social-ecological system was being described and agreements had to be adopted in order to choose stakeholders, interactions, resources, scales and so on. As many different words were used – shrub, fern, bramble, thicket, grassland, fallow, etc. – and as each of these words was defined differently by the different participants, the first difficulty was the terminology used to define the different vegetation classes. This result is confirmed by a recent interdisciplinary experience (Haag 2006): during the interdisciplinary process, people used different concepts to express the same thing and gave a different meaning to the one and same concept. The first aim, therefore, of the co-modeling process was to ensure that the different participants came to a mutual agreement as to a common definition of the used concepts.

In the four biosphere reserves, conflicts between the scientists during the process occurred mainly during the territory selection (1), the determination of the reference scales (2) and the conceptual model co-construction (3).

1) In our case study, the limits of the territory were easy to define because Ouessant is an island.

2) The time and spatial reference scales, which define the running step duration and the minimum cell size of the spatial model, were more difficult to establish. One of the key questions was how to simultaneously take into account vegetation dynamics and the population dynamics of a rare bird – Chough (*Pyrrhocorax pyrrhocorax*) – (Kerbiriou et al. 2006). Indeed, the bird population was assessed as being sensitive to tourists hiking on small tracks requiring a very small pixel to be represented in the model – one thousand times smaller than for describing vegetation dynamics. The solution retained to solve this problem was to choose a pixel size permitting an analysis of the vegetation dynamics while integrating the presence of tracks as an attribute of this cell.

3) The main divergences occurred during the design of the Ouessant social-ecological conceptual model. Negotiations occurred essentially in the qualitative dimensions of the model, particularly when identifying and describing the interactions which constitute the main source of the dynamics of the social-ecological system. Quantitative data were not discussed in great length because they were often considered as “true” and “accurate”. For

the agent selection, many discussions involved the breeders. At the beginning, the sheep breeder was the only agent actually taken into account. But after a certain amount of discussion, it appeared that the cattle farmer probably had an equivalent impact on the current shrub encroachment dynamic. Goat breeders were also added at a later stage. Indeed, a field study demonstrated that they were partially aware of fallow land process: their goats were often placed in fallow land edges and probably had a key impact on fallow land overspreading. These decisions were reinforced by updated statistical data showing that sheep numbers decreased whereas goat and cattle numbers increased.

<u>Power relationships.</u>

Along with the negotiations process, power relationships were revealed between participants. The influence/power of a participant increased if he/she (table 2) :

- delivered specific knowledge on the social-ecological Ouessant system and conducted field works in this area. This enabled him/her to give the name of an inhabitant, describe a local problem in detail, bring information that nobody else had and provide a good systemic knowledge;
- he/she belonged to the laboratory supporting the project ;
- he/she had a high position in the university because it gave him a favorable status during the discussions ;
- he/she belonged to the biological sciences because it is a program on biodiversity in which social disciplines necessarily had an instrumental function ;
- he/she was skilled in social-ecological topics and knew both the social and the ecological disciplinary jargon. Indeed, this capacity enabled the participant to develop cogent arguments and to go beyond the borders between disciplines;
- he/she knew other participants well enough to speak without taking the risk of being judged or having no supporters ;

- he/she was used to the MAS because he/she knew the agent-based modeling jargon and the ensuing technical constraints (what can one model and what can one not model, what are the "methods" and the "attributes"?) whereas the others did not participate because they did not want to appear as being incompetent.

Of course there were many other criteria explaining why participants got the upper hand during discussion, such as their fluency or eloquence or whether or not they had allies in order to enforce an argument. In all cases, individual weight evolved during the co-construction process and depended very largely on the individual position towards co-construction organisation constraints and on the number of persons who were able to face it. For instance, a PhD student who was not in a key position, at the onset of the process, became a key resource person after a short period because he alone was able to provide a good knowledge of the Ouessant social-ecological system, and this was important for the launching of the co-construction process. Thus, even if he had a low status, he "controlled" a considerable amount of uncertainty asymmetries at a key moment. During the following steps, however, power relationships evolved along with and at the same time as the organisation constraints and the source of uncertainty.

The key role of the mediator.

When it comes to the point, the "technical democracy" dimension of MAS co-modeling process depends on many factors and during the co-construction process it seems impossible to achieve a genuine equality between participants.

To tackle this problem of power relationships, researchers who adopted the Companion Modeling Approach have developed an ethic charter[1] that gives a core importance to the mediator (Etienne and collectif ComMod 2005). Indeed, the mediator has the crucial function – and responsibility – to facilitate and govern negotiation processes in order to balance the

[1] http://cormas.cirad.fr/ComMod/fr/charter/content.htm

power relationships during the co-construction process. To achieve this task, the Ouessant mediator constantly redirected the discussions towards the interaction between social and ecological issues in order to go beyond the simple disciplinary questions and underline social-ecological interdependences. Moreover, he often gave the decisive technical, disciplinary and epistemological arguments when it became necessary to make some trades-offs between divergent points of view. The mediator was at the very heart of all the discussions and continuously translated collective agreements into a user-friendly MAS language in order to embody the diversity of knowledge in the model. By enforcing the rules of the game, he also helped enforce the principles of justice and managed the co-construction process. Had it not been for the mediator, the majority of participants would not have agreed to take into account all the social parameters, the sheep breeders behaviours would not have been considered as key problem, the PhD students would not have had the legitimacy to influence the co-construction process, and the vegetation ecologist would not have taken into account the bird population dynamics with the resulting problems of scales. The mediator represented the judiciary order of the technical democracy system, guaranteeing that the separation of powers was respected.

In this situation, the mediator must be legitimate for all participants. In the case of the isle of Ouessant, the mediator appeared as legitimate because he knew a lot about fallow land encroachment and had previous experience in co-construction modelling. He also knew the participants quite well, had a good command of social and ecological jargons, was a professor in conservation biology, had managed the national co-modeling program and knew all about the MAS.

Applicability of the model.

According to the original purpose of the program – develop a model that could facilitate collective decision processes concerning fallow land encroachment – it is possible to consider that nothing has really come out of the MAS model until now. Indeed, this model is not used by managers of the biosphere reserve to improve the dialogue about the fallow land issue.

There are probably two reasons to this. The first is the complexity of the model. Thus, the co-construction process took into account the diversity of opinion and integrated it in the MAS, in respect with the technical democracy principles. But, at the same time, the result of this process was that the model became excessively complex and tedious. For instance, the initialization phase of the model took 18 minutes and one single simulation took 2 hours. This is too long for a user-friendly model which, in order to facilitate collective discussion, needs to be reactive and interactive. The second key problem of this model was local stakeholders' lack of participation, which led to neglecting the users' needs concerning the issue of fallow land encroachment.

However, if we consider the MAS model outputs in terms of scientific applications, the co-modeling process clearly helped in providing more accurate information about social-ecological interactions, in improving the interdisciplinary knowledge about the fallow land encroachment issue and in creating a scientific community of interest about it.

Conclusion

The co-construction methodology is based on the technical democracy principle. The broadened division of labor used to develop the MAS enabled the inclusion of several stakeholders who, in spite of their different views on the issue of fallow land encroachment, finally managed to form a community of interest. However, our case study highlighted the fact that it is necessary to analyse negotiation processes and power relationships in order to understand the source of the conventions on the basis of which the MAS is built.

The participants do not, actually, have the same capacities for acting on the conventions.

In particular, MAS co-construction would appear to favour people who have partial qualitative knowledge on many elements of the social-ecological system at the expense of people who have some extremely precise quantitative knowledge on specific points. Thus, collective discussions concerning the model are often pragmatic, give core importance to the context and take into account subjective opinions.

Next, as suggested by the technical democracy paradigm, our case study highlighted the core role of the rules – principles of justice and rules of the game – which ensure the management of interactions between participants during the co-construction process. Separation of powers is the most important of theses rules. The main component of this separation of powers is the judiciary order represented by the mediator because his role is crucial during the social process. It is he who institutes the first rules of the game on the basis of which it is possible to launch the firsts discussions of the collective work. He manages the social interactions and power relationships in particular. He gives the decisive argument when confronted with fundamental problems of trade-offs. The mediator, therefore, must have a high level of exteriority and the “ability to be legitimate” for all the participants during the co-construction process. Exteriority gives a “neutral” status to the co-construction process, gives an objectivity property to the MAS and creates a fair process.

The mediator is then a guarantor who ensures that, during the co-construction process, the principles of justice are respected and that the model itself is robust, legitimate and socially accepted. Finally, the core issue of the MAS co-construction process is the mediator’s social position, his/her human “skills” factor and the extent of his/her personal investment in managing the co-construction process and promoting the MAS.

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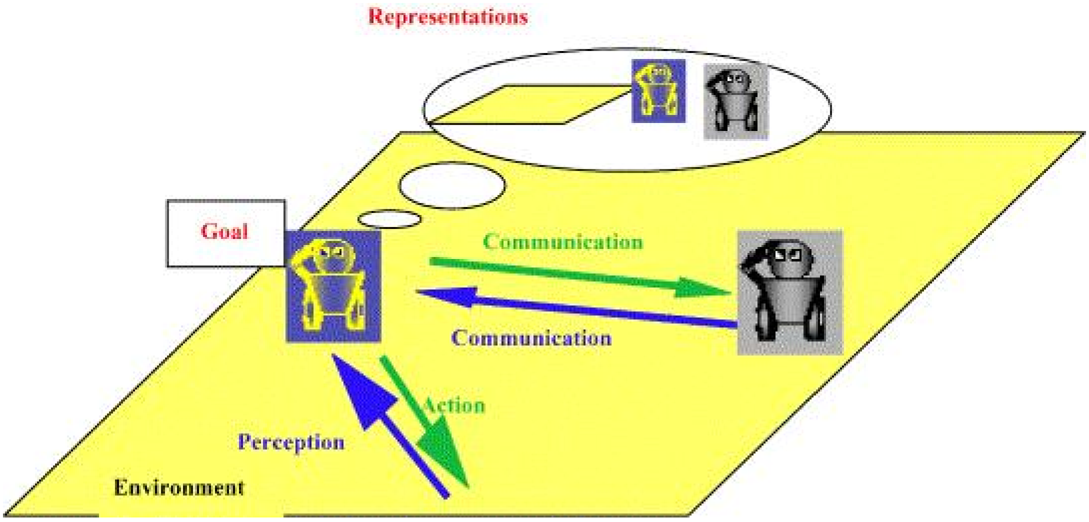
Figure 1: Multi-agent model



Ferber, 1999

Figure 2 : Some views of the Ouessant model.

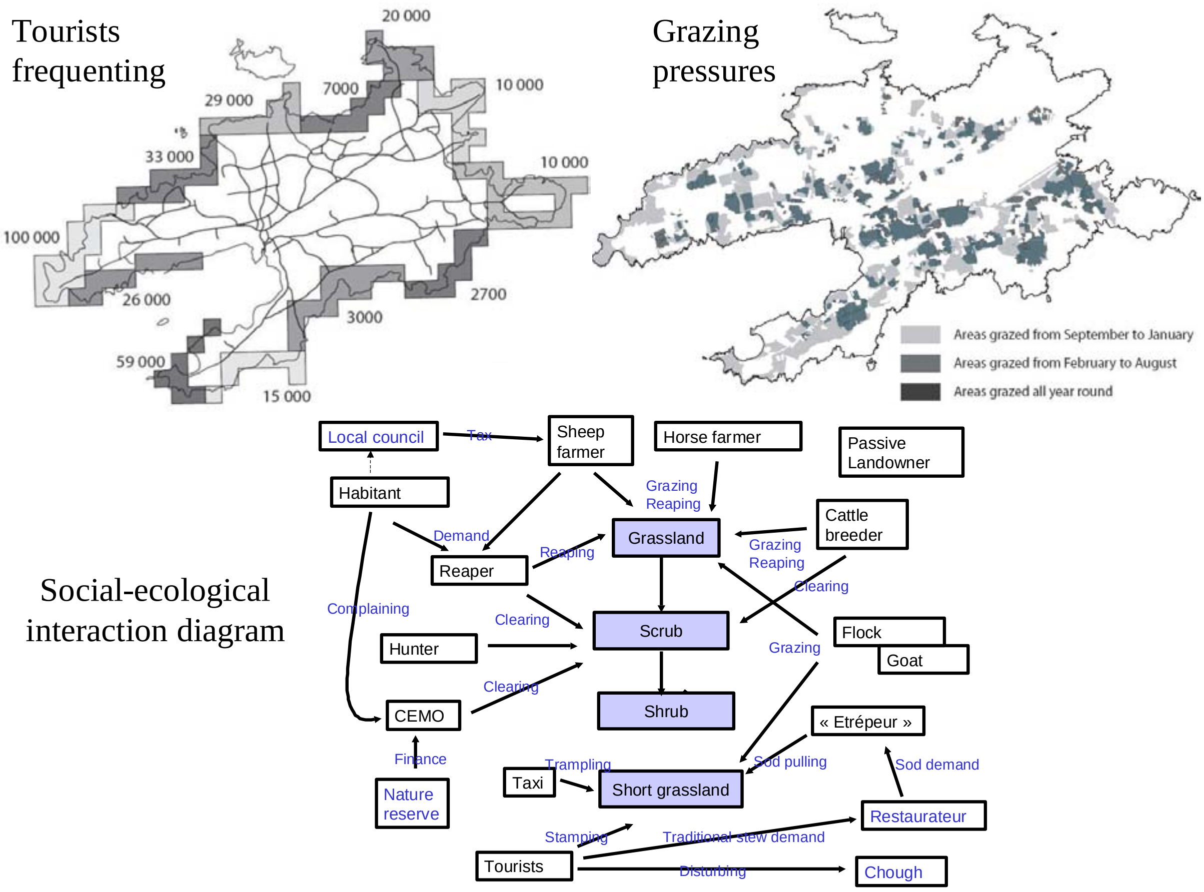


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Table 1: Relative strengths and weaknesses of various modeling approaches with respect to criteria for sustainable development policy-making

Criteria / Model	Interdisciplinary potential	Long-term, inter-generational	Uncertainty management	Local-global	Participation
Multi-agents	0,29	0,27	0,30	0,34	0,40
System dynamics	0,29	0,29	0,08	0,11	0,20
Bayesian networks	0,17	0,07	0,39	0,17	0,13
General equilibrium	0,10	0,21	0,08	0,11	0,08
Macro-econometrics	0,10	0,10	0,10	0,09	0,10
Optimisation	0,05	0,07	0,06	0,17	0,08

Boulanger et Bréchet, 2005, p.343

Table 2: Relative status of participants during the negotiation phase from 7 criteria.

Participants	1	2	3	4	5	6
Specific knowledge on Ouessant island	PhD thesis on the Ouessant island	Never work on the Ouessant island	Lives and works on the Ouessant island	Several project on the Ouessant island	Never works on the Ouessant island	Field works on the Ouessant island
Laboratory membership	Laboratory which supported the project	External laboratory	External laboratory	Laboratory which supported the project	Laboratory which supported the project	External laboratory
Status in the University	Professor	Professor	PhD student	Professor	Engineer	PhD student
Distance from biology	Low	High	Low	Medium	Medium	High
Command of social and ecological jargon	Experience in inter-disciplinarity	Experience in inter-disciplinarity	Experience in inter-disciplinarity	Experience in inter-disciplinarity	Experience in inter-disciplinarity	Interdisciplinar PhD in conservation biology team
Relation with other participants	High	Low	Medium	Medium	Medium	Low
Knowledge on MAS	No training	No training	Two weeks MAS training	No training	Two weeks MAS training	Two weeks MAS training