Modeling Livestock Farmers' Strategies in the Uruguayan Pampa

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Keywords: *decision support; rangelands; multi-agents.*

EXTENDED ABSTRACT

Rangelands are an important ecosystem as they occupy nearly fifty percent of the emerged earth. They are used mainly for cattle production. Uruguay is a country where cattle were introduced by Europeans before their settlement in 1728. High potential rangelands, with rather fertile soils and more than a meter of average annual rainfall boosted the presence of the introduced beasts. Since then, the cattle industry has been very important for the local population, especially from the point of view of international trade. There have been many proposals tending to increase productivity in rangeland areas.

Nowadays, the industry faces new challenges and institutions must adapt themselves in order to facilitate learning and improving the actual situation. The difficulties are that we face complex systems, that there are many points of view and a growing group of stakeholders. We are trying to design decision supporting tools which potentially can improve collective decision making, through the construction of a shared comprehension. For this we admit that it is important to develop whole farm models. The fundamental processes ongoing within the farm household should be modeled in order to simulate and explore the consequences of the dynamics of different interacting systems components.

In order to deal with this problem we have developed a multi agent system, named Arapey, which mimics the evolution of different kinds of livestock farmers in the last thirty five years. The differences among the livestock farmers are their financial and stocking rate strategies. There are some unexpected results. We have presented this model to many livestock farmers and to other persons related to the livestock industry, to test if we can accept that it proposes new interesting aspects of farm management.

Our experience lets us suggest that multi agent systems are able to propose new insights, which could act supporting private or collective action.

We conclude that by using multi-agent systems it is possible to construct a model taking into account different points of view and that modeling and simulating make learning faster. We propose that these models coupled with Unified Modeling Language activity diagrams' are appropriate to describe systems dynamics and to support the construction of shared comprehension as shown by the corroboration of the model's functioning and of its results by a variety of stakeholders.

1. INTRODUCTION.

The study of complex systems is not adequately undertaken by text description or even algorithmic modeling. Mathematical models describe simple systems with homogenous components and little interaction among them. Verbal models are not sufficient for analyzing the consequences of the interactions described and it is hard for the researcher and the reader to determine precisely the implications of the ideas being put forward. These aspects have been analyzed by Simon (1986) and Gilbert and Terna (1999), and, as established by Le Moigne (1990), complexity implies that unforeseen results can arise. Therefore, simulations are tools for exploring the consequences of the constructed models, but can not be taken as predictive. Models are abstractions of reality with the aim of improving comprehension of complex systems. We can argue that even if our models mimic precisely what has happened in the past, we are never sure that the components chosen are important and the dynamics described will persist in the future. Good models give insight into possible human choices and a chance to explore implications of possible interventions (Legay 1997, Holling *et al*. 2002).

Rangelands can be seen as complex systems as they have many components interacting in many ways. There are the physical, the biologic and the social systems with their own dynamics and mutual relations. Multi-agent systems have been proposed for studying these types of systems and there are some interesting results. For instance, Bousquet *et al.* (1999) have shown how it was possible to take into account the herders' practices in Africa to understand the effect of constructing wells in desert areas. In Australia, Walker (2002) has shown how agent based models can be used to model learning, and to anticipate the consequences of public support directed to livestock farmers. As established by Lynam and Stafford Smith (2003) one important result of modeling and simulation should be fastening learning.

2. THE SITUATION IN URUGUAY.

In Uruguay the pastoral community is an important one from many points of view. The pastoral activities occupy 150000 squared kilometers, which is eighty percent of the country's surface. The relation between cattle and people is the biggest in the world, 4 to 1, making the "little" country an actor in international exchanges of meat and wool. From the Uruguayans' point of view, there are important stakes on cattle production and rangeland management. We can mention meat exports, and the industrial activity and job creation derived from abattoirs functioning. There are also cultural activities associated with rangelands.

In the middle of the last century the government and indeed the whole society agreed that it was necessary to increase the productivity of these areas, and a national program was launched with the aim of introducing exotic legumes in the rangelands, with the aim of making pastures more uniform and productive and improve its quality. This project lasted for twenty years and its results were not exactly those expected. The meat and wool productions were only slightly affected but milk and grain productions were greatly improved by the use of the new practices. It became rather evident that it is very difficult to insert exotic plants in regions where soils are variable and the weather irregular.

In the last twenty years, many important events have affected the industry. Wool prizes have dropped heavily and the ratio sheep/cattle has fallen from three sheep for one cow, to the current one to one ratio. The most important drought of the century arrived by the end of the 80's. The country has been recognized as free of foot and mouth disease, and this has made it possible to send exports to North America, which had been interrupted for seventy years. An important financial crisis occurred in 2002, leading many banks to bankruptcy.

Another important factor is the foreign consumers' raising attention to environmental factors, such as biodiversity or global warming. Livestock production has many and strong ties with these subjects, so the action of livestock farmers must take these concerns into account.

As a result of all these events Uruguayans livestock farmers and their institutions face important stakes. They are seen as an important factor in the country development. What livestock farmers do is not only a private matter but also a public one.

3. THE MODEL.

Farms trajectory depends on many factors. Some of them are the biological efficiency resulting from the technology applied. Others come from outside the farm, as natural events like rain or frost and market conditions. In our experience these variation sources are not enough to explain the differences observed in the field. We propose that there are "strategic decisions" which could be explored in case they change the trajectory of the farms. In order to improve our knowledge we made some experiences in the sense of Legay (1997). These were a survey, a workshop, some field work on particular farms and bibliographic research (Morales *et al.* 2003). These experiences showed that there were many differences among farmers and that their strategies were diverse.

The model aim was to explore the consequences of different farms strategies, focusing on factors different from the technical activities or the farms' environment described by the climate and the market conditions.

It was implemented in Cormas (Bousquet *et al.* 1998). Its components are nine classes. The social ones include three types of livestock farmers, which differ in their attitude towards risk. We define two types of risk, climatic and financial. The physical ones include the cattle, the farm and the environment. There is some detail in the description of the strategies, but the production function and the relations between climate and production are simplified.

	Financial strategy	**Stocking rate strategy**
Conservative	safe	safe
Intermediate	safe	risky
Enthusiastic	risky	risky

Table 1: The farmers' strategies**.**

The time step is a year. In this year the livestock farmers can borrow money, sell or buy cattle or land, depending on their particular strategies and situation. These strategies do not change. The conservative one does not buy cattle or land borrowing money, and he applies a lower stocking rate than the other ones. On the other hand, the enthusiastic always borrows money and applies a higher stocking rate. The intermediate shares with the conservative the strategy concerning the financial aspects, and shares with the enthusiastic the strategy concerning stocking rate (Table 1).

The results show that the farm trajectories are changed by these strategies, and are little sensitive to the change of the different parameters.

From these we corroborate our initial hypothesis. When describing farms evolution it is not sufficient to take into account the technical functioning – operating decisions - and the farms environment. It is also necessary to describe the strategic decisions, those not associated with the annual operating cycle.

The functioning of the model - as shown in Figure 1- demonstrates that in the conditions of this model we have identified two decisions - different from either the technical operations or the environment- that make a difference in the farm evolution. It is worthwhile reporting some interesting not expected results:

1. The evolution of the most conservative farmer is better than the others,
2. When the financial strategy is the same, stocking rate policy makes a difference.
3. Although there were differences, bankruptcy is not frequent.

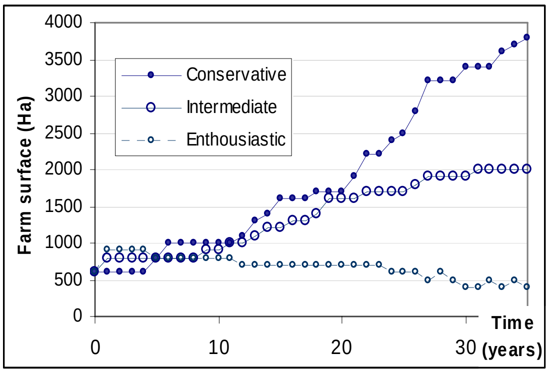

Figure 1: Evolution of farmers' exploitations area.

3.1 The expression of different points of view.

As explained later, the models' results and functioning should be coherent with what is already known. To verify that we have constructed a lot of probes, which allowed us to verify the model's correctness, and also other probes to express its results in the same parameters usually used by different stakeholders. It was then possible for them to contrast the model's results against their experience and previous knowledge.

3.2 Corroborating and participating.

As it is difficult to verify the models functioning (Manson 2000), (Gilbert and Terna 1999), we choose to simulate a recent period, as we should be able to identify anomalous results. We hoped that the extension of this period should be enough to detect the differences among strategies.

When coping with these kinds of models it is difficult to corroborate its results comparing them to existing data, but, as Edmonds and Moss (2004), and Manson (2000) establish, multi agent systems facilitates a direct correspondence between what is observed and what is modeled and the evidence may be anecdotal or "common sense".

In order to test if the model results agree with what different stakeholders know, we exposed them in many occasions to livestock farmers and their representatives, extension officers and so on. We always asked people what the results should be, before exhibiting the model's results. Nobody accepted to advance a result, even if the situation was very familiar to them. The model's functioning and its results, allowed the different stakeholders to construct new appreciations, coherent with what they already knew. It is difficult to know how learning can be assessed. According to Ison *et al*. (2000), it can be defined as a broadening of the repertoire of choices for purposeful action, as granted by an observer. From this point of view we can say that learning took place.

As the model consists of intuitive description in terms of objects and agents, it is intelligible and transparent for most of the livestock farmers. For instance, they associated the model with real situations they knew. Diagrams have been proposed as useful tools in order to make intelligible complex practices without reducing them to a few simple techniques (Hubert B. 1994). We promote the use of UML (Unified Modeling Language), a description language of models (OMG 2003). In our experience, UML diagrams' have been used as a communication tool allowing clear and unambiguous explanations. In our model, assumptions of the modeler can be inspected without being an expert in computers either in theoretical biology or economy. This point is important when trying to support decisions (Lynam and Stafford Smith 2003). When presented to different farmers, they were able to associate other real farmers they know, with the different types of agents simulated in Arapey. They agreed that the results of the simulations mimic what had really happened even if behaviors are caricatured. So, we hope that we have some tools to go beyond the "problem of implementation" of computer tools designed to support farmer's decision (Mc Cown 2002).

Note that the exploration of the problem includes not only finding out about its "instrumental" features (official public declarations of aims and objectives, existing projects, etc.) but also studying its social and political aspects. This is very important, since feasible and desirable changes are never the solely result of instrumental logic (Checkland and Holwell 1998). Inside the different institutions in charge of these kinds of problems, it is never obvious who holds the most powerful views (Lynam and Stafford Smith 2003).

3.3 The difficulty of learning about "slow" variables.

We considered "improving" our model letting our agents to learn and change their strategies, and at that moment we realize that the dynamics of changing strategies is not clear. In real world, farm or global strategies do not change, unless very important events take place. The question is how farmers perceive the consequences of their strategies, in order to learn and adapt.

We then realize that the differences shown by our model appear slowly. It takes a decade to see the consequences of different strategies clearly. In real life, that implies the presence of a "memory system" not usually found, except, sometimes, in elders (Berkes and Folkes 2002).

4. CONCLUDING REMARKS.

Using multi-agent systems we can explore some consequences of our work on rangeland management from different points of view. Multi agent systems let us represent the same model from different points of view. In our case we considered the point of view of ecologists, farmers and politicians. In the case of Arapey, the results show that the interest of the farmers and those of the ecologists were coincident, but it also shows that the farmers' interests are not necessarily the same as those of the society represented by politicians.

Other important result is that when confronted with slow variables, stakeholders have difficulty in recording its evolution and consequences, and that in this case multi agent systems can fasten learning.

Diagrams have been proposed as modeling and communication tools (Hubert B. 1994). We have had some good results using the Unified Modeling Language (OMG 2003) and we are nowadays adjusting the methodology to open the "black box" of the farms functioning using activity diagrams. These diagrams have been useful when explaining the model's functioning: Livestock farmers and technicians were able to comprehend it, and to compare its results with their experience. This is crucial, since the only way a model user can really increase confidence in a model is when the results can be traced back to assumptions (Sorensen and Kristensen 1992).

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