Simulating the Social Game of the System of Production of Potato Seeds in Venezuela: the José Antonio Rangel Municipality case.

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Abstract. This paper presents the description and simulation of a system of production of potato seeds as a Concrete Action System, by using Michael Crozier's Systems of Organized Action Theory, and the SocLab simulation platform. This is motivated by difficulties observed in the actual system; e.g., instability of offer and low availability of good quality potato seeds, low importance some actors give to local potato varieties, etc. The analysis of the structure and outputs of the simulation model has allowed us to understand better this problematic situation, and helped us in delineating certain policies in order to improve the system. This is part of a wider research proposal, in which we are elaborating an ideal (wished, a "shall be") model, which will be compared with the actual model, in order to more carefully understand the actual game and delineate policies to move the actual social game towards the desired ideal social game.

Keywords: Social Simulation, production of potato seeds, Concrete Action Systems, SocLab, policy making.

1. Introduction

Like many regions of the world, in Latinamerica, and in particular in Venezuela, consumption and production of potatoes, and potato seeds, is highly important. The region around Mucuchíes town (Jose Antonio Rangel municipality) in Venezuela concentrates the highest national production of potato seeds. This work aims at representing the (social) game of power around the production of potato seeds, and potatoes, in this region, by using Social Simulation.

Social Simulation consists in the modelling of social systems, including economics, organization, politics, history or social-ecological systems (see for example the JASSS on-line journal for a number of examples), for the study of their behaviour and emergent properties by the performance of computer simulations (Axelrod, 1997).

Regarding the simulation of social relationships (Squazzoni, 2012), Sibertin-Blanc et al. (2013a) proposes a formalisation of the Sociology of Organized Action (Crozier and Friedberg, 1980) which studies how social organizations are regularized, as a result of the counterbalancing processes among the power relationships of the social actors. According to this theory, the behaviour of each actor is strategic while being framed by his bounded rationality (Simon, 1998). In this approach, the interaction context defines a *social game*,

where each actor adjusts his behaviour with regard to others in order, as a meta-objective, to obtain a satisfying level of capability to reach its goals. The aim of a social game is to find stationary states, i.e. a configuration where actors no longer modify their behaviour because each one satisfies himself with the level of capability he obtains from the current state of the game, so that the organization is in a regularized configuration and can durably operate in this way.

The formalization implemented in the SocLab platform (El Gemayel, 2013) enables to define the structure of an organization as an instance of a generic meta-model, to study its structural properties with analytical tools, to explore the space of its possible configurations (and so to discover its Pareto optima, Nash equilibriums, structural conflicts and so on), and to compute by simulation, as a result of the social game, how it is plausible that each actor behaves with regard to others within this organizational context.

The SocLab framework has been applied to the study of concrete organizations (see e.g., Sibertin-Blanc et al., 2013a; Sibertin et al., 2014) on the basis of sociological inquiries, as well as theoretical issues related with, for instance, the effect of morality on organizational performance (Terán *et al.*, 2015a).

The present study is motivated by a feeling of dissatisfaction with respect to the actual system of production of potato seeds in Venezuela, and in particular with the system of production of potato seeds in the Mucuchíes area, our actual Concrete Action System (CAS), because of its bad performance. Below, after briefly describing the CAS, we will list some of the sources of such dissatisfaction (for instance low availability of certified national potato seeds, and instability of the market of consumption potatoes).

The work presented in this paper has been based on previous participatory community research in the area (e.g., Velázquez, 2002; Romero, 2005; Romero *et al.* 2005, 2007; Llambí, 2012; Rojas, 2015; Alarcón, 2015), in which the CAS has been described, and a preliminary simulation model was elaborated. This research has been concerned with the bad performance of the CAS, aiming at making clearer the problematic situation and orienting the design of policies to improve the CAS.

The present work also pretends to provide support for policy making, in order to improve the system, in the direction of increasing the use of native potato seeds varieties and satisfying as much as possible the Venezuelan national market. This requires, as we will see below, to enhance the attitude and degree of involvement in the system of some actors. At present, several actors show a bias towards seeking self interest, in detriment of the CAS and national well being. This individualism of the actors is an example of the cultural problems in Latinamerica, which are well described by Fuenmayor (see, for instance, Fuenmayor, 2006). A brief review of such difficulties is presented in Terán *et al.* (2015b).

The paper is organized as follows. The second section introduces the SocLab modelling framework. The third section describes the CAS: the system of production of potato seeds in the Mucuchíes area, in Venezuela, and sets the direction of the research. Section four shows the simulation model. Section five analyses the structure of the model, presents simulation results, and gives a discussion useful for policy making. And, finally, section six offers some conclusions and summarizes further research.

2. Modeling Systems of Organized Action in SocLab.

To enable the modelling of social relationships between the actors of an organization, SocLab proposes a meta-model that catches the common concepts and properties of social organizations and is instantiated on specific cases as models of concrete or virtual organizations or, more generally, Systems of Organised Action and CAS (Crozier, 1964; Crozier and Friedberg, 1980), and for a detailed explanation of this see Sibertin-Blanc *et al.* (2013, 2013b). Accordingly, the model of the structure of an organization is composed of instances of the *Actor* and *Relation* types that are linked by *Control* and *Depend* associations.

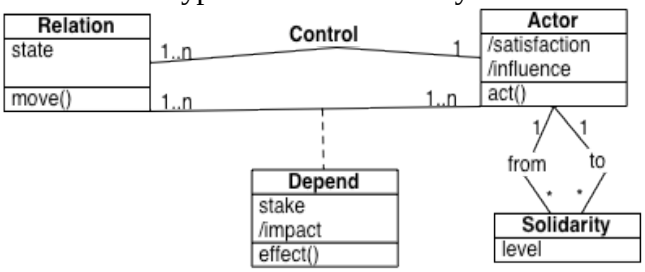

Figure 1. The core of the meta-model of the structure of Systems of Organized Action

Figure 1 shows the meta-model of organizations' structures as a UML class diagram. A relation is founded on an organization's resource, or a set of related resources, that is controlled by a single actor. Resources are material or cognitive (factual or procedural believes or expectations) elements required to achieve some intended actions, so that their availability is necessary for some actors to reach their goals.

The *state* attribute of a relation represents the behaviour of the controller actor with regard to the availability of the resource for the ones who needs it. Its range of value SB goes from the least cooperative behaviour, -1, of the controller preventing the access to the resource, to the most cooperative behaviours, 1, favouring this access, while the zero value stands for neutral behaviours.

The *stake* attribute of the dependence of an actor on a relation corresponds to the actor's need of the relation to reach its own goal, on a scale:

null = 0, negligible = 1,… ,significant = 5,… , critical = 10.

The *effect function* evaluates how much the state of the relation makes the resource available to the actor, so that $effect_r : A \times SB_r \dashrightarrow [-10, 10]$ has values in:

worst access = -10, ..., neutral = 0, ..., optimal access =10.

In addition, actors may have solidarities the ones with regard to others, defined by as function

$solidarity(a, b) \dashrightarrow [-1, 1]$,

where negative values correspond to hostilities and positive values to effective friendships.

Defining the state, or configuration, of an organization as the vector of all relations states, each state of the organization determines on the one hand how much each actor has the means he needs to achieve his goals, defined as:

$$satisfaction(a, s) = \sum_{c \in A} \sum_{r \in R} solidarity(a, c) * stake(c, r) * effect_r(c, s_r) \quad (1)$$

and, on the other hand, how much it contributes to the satisfactions of each other actor, defined as:

$$influence(a, b, s) = \sum_{r \in R;\ a\ controls\ r} \sum_{c \in A} solidarity(b, c) * stake(c, r) * effect_r(c, s_r). \quad (2)$$

This interaction context defines a *social game*, where each actor seeks, as a meta-objective, to obtain from others enough satisfaction to reach its goals and, to this end, adjusts

the state of the relations he controls. Doing so, it modifies the value of its influence and therefore the satisfaction of actors who depend on the relations it controls.

The end of a social game is to reach a stationary state: there, actors do no longer change the state of the relations they control, because every one accepts his level of satisfaction provided by the current state of the game, so that the organization is in a *regulated configuration* and can steadily work in this way.

The actors' strategic behaviour is framed by their bounded rationality (Simon, 1998), where the actors' decision-making process is implemented as a process of trial and error based on a self-learning rule system. Each actor manages a variable that corresponds to his ambition, and the game ends when the satisfaction of every actor exceeds his ambition; see (Sibertin-Blanc et al. 2013b) for details about this collaborative learning process.

To sum up, each simulation run yields a regularised configuration which associates to each actor numerical values for its satisfaction and its influence, and these values may be used to determine whether this configuration is able to arouse a kind of emotion. The game regulated configuration is reached following Simon's ideas of bounded rationality (Simon, 1982).

3. Description of the CAS.

Here we describe the process of production of potato seeds, the actors and the solidarities between actors.

3.1 The origin of the agency: The historical/cultural context of the Concrete System of Action

To understand a CAS we must briefly refer to the context in which it occurs, that where the language and culture, social constructs and particular interests of the actors take place. A culture is in a good state if people looks for and *cultivates, cares about*, common good. A culture is in a good state if it is auto-generative, and autonomous. On the other hand, a culture is in a bad state if it is not autonomous, for instance, if it is highly imitative and oriented by external influence, or by the actors' self interest, creating some processes of change that disturbs its auto-generative capacities.

Until the first decades of 1900, the Latin-American culture was in a good state. It was mainly of a rural character and auto-generative. Common good (including the culture) was cultivated. After few decades in the XX century, a high percentage of people from the country side moved to the cities (the rate: "people in the cities / people in country side" changed from 20/80 to 80/20 in many countries). Along this, imitation of other cultures promoted by, for instance, communication media like radio, TV, CINEMA, etc., increased the demand for material goods, and technology that were poorly pertinent for the Latin-American society. Over time, also the quality of education and caring of common good in general decreased. Finally, the culture transformed for bad, became ill (at different degrees, in almost all countries) in the sense described above as it lost its auto-generative capacity, and autonomy. As a result, socially negative attitudes appear in organizations, e.g., workers distract their effort towards activities different from their duties, creating an institutional problem in the public sector. Consequently, it is not rare to find organizations with groups of power that are look for self interest in detriment of the organizational goal, and the society well being (for more about this see Fuenmayor, 2006).

As expected this kind of selfish interest appears in the CAS we are studying: some actors follow self interest, which are contradictory in relation to their duties. The actual game in the CSA is different from the normative game, the one that ideally shall occur in accordance to the formal organizational mission and regulation, as would be in the case that the culture of the country were in a good state (deeper and more detailed studies of the CSA can be found in Velázquez, 2002; Romero, 2005; Romero *et al.* 2005, 2007; Llambí, 2012; Rojas, 2015; Alarcón, 2015).

We can see a graphical description of both, the formal ideal game and the actual game (or CSA), in Figures 2 and 3, respectively (in both graphs the green arrow indicates the flux of potatoes or of potato seeds). Afterwards, in Figure 4, we present the simulated simplified actual game/CSA (simplified in the sense that some actors are grouped in case of having similar interest, or not taken into account in case of having a low impact on the CSA). In the following, we describe the three games (the normative, the actual CAS and the simplified CSA).

In any case, the growing of potatoes processes as follow (see Figures 2-4): potato seeds are obtained from so called *basic seeds*, which are themselves obtained from *pre-basic seeds*. The productivity of seed plants decreases with the number of generations, for instance, for the Granola variety it is usually as follows: 1/70 at the first generation (1 pre-basic seed generates 70 basic seeds), 1/50 at the second generation (1 first generation basic seed generates 50 basic seeds) and so on, and when the productivity of a basic seed is below about 1/10, it is considered as a seed for the crop of consumption potatoes. Pre-basic seeds do not come from potatoes seeds; they are obtained either from flowers (sexual reproduction) or from manipulation of parts of the plant in a laboratory (asexual reproduction), in which case they are called *vitro-plants.*

In Venezuela, basic seeds producers buy pre-basic seeds from PROINPA, and producers of potatoes for the market buy basic seeds from basic seeds producers and from importers of basic seeds, which come mainly from Colombia and Canada. However, we also observe a *recycling* phenomenon: (low productivity) seeds for consumption potatoes are used as basic seeds. In fact, recycling potatoes as seeds is the mean used by producers to regulate the (un)availability of (certified or imported) seeds.

We will usually refer to what we will call a *sane system of potato seeds* as a contrasting system to be compared with the actual system (to shed light on the deficiencies of this), in order to have a clear reference about the ideal desirable system. Concretely, the sane system of potato seeds, which we will call ***saneSPP***, is defined as *a system aiming at satisfying as much as possible the national demand of consumer potatoes by producing good quality potatoes, and preferring autochthonous/native over non native varieties of potatoes seeds* (this system is supposed to be strongly supported by the Venezuelan State, and to have low influence of actors whose goal is contrary to a sane SPP).

In the ideal, nominal, game the state is involved and represented by a diversity of entities such as the Ministry for Agriculture and Lands (MAL), and the Ministry for Science and Technology (MST). The MST must give scientific and technological assistance. The MAL design the agricultural policies and gives monetary, technical and other kinds of support (instrumental and non instrumental (e.g., organizational aimed at qualitatively improving the system)) either directly or via dependant organizations.

MAL enjoys of the highest monetary capacity for agricultural support in the country, but has a bad management culture and is itself inefficient. *As said above, it designs the*

agricultural policies, but these are not really implemented in practice (this will be better explained in the actual model below). Among the organizations subordinate to MAL we have: a) AGROPATRIA ("AGRO motherland") (AGROPATRIA, 2015), a distributor of inputs including seeds; b) FONDAS (Fund for Agricultural Development), a provider of monetary assistance for promoting agricultural development; c) INIA, the national institute for agricultural research and technological assistance; d) INSAI, the National Institute of Integral[1] Agricultural Health. This entity shall license imported potatoes seeds, by certifying the good quality of the potato seeds. Such a license is supposed to be a requirement to be fulfilled by the imported potato seeds; e) SENASEM, or National Service of Seeds, an entity providing assistance to detect, and combat seed deceases. It provides the certification to the national potato seeds. All this entities, except FONDAS and AGROPATRIA, are represented in Figure 2. FONDAS is not represented because its role is quite simple and instrumental: to offer loans to producers of potatoes, or to producers of potato seeds. AGROPATRIA from 2012 on takes the role of the importers of potato seeds and distribution of agro-chemicals. In Figure 2 we represent importers of potato seeds rather than AGROPATRIA, because in this work we are interested in the model of the CSA up to 2011.

Apart from the Venezuelan State and its dependencies, in Figure 2 we have: a) PROINPA (PROINPA, 2015a, 2015b), a Civil Association of integral producers of potato seeds of the Venezuelan Andean high lands, or Páramo[2]. It aims at generating models of productive diversification in general, and in particular at quantitative- and qualitative-ly improving the national production of potatoes seeds (including the whole production process, and local know-how). PROINPA in practice is the main actor producing pre-basic seeds[3], as INIA realises this role poorly; b) the university research centres, which give technological support to the producers of different kinds of potato seeds; c) the independent producers of potatoes seeds, who produce certified basic potato seeds (some PROINPA's producers also produce basic potato seeds); d) producers of potato seeds to the market and consumers (people and agro-industry after being distributed); e) the producers of potato seeds in another countries (this is a foreign actor out of the national system of production of potatoes, and will not be taken into account in the simplified model); f) the importers of potato seeds.

[1] Integral means a holistic view of agricultural health, and of potatoes. They are normatively supposed to prefer organic and native potatoes.

[2] We use the classification of the páramo "… according to its regional placement in the northern Andes of South America and adjacent southern Central America. The páramo is the ecosystem of the regions above the continuous forest line, yet below the permanent snowline. It is a "Neotropical high mountain biome with a vegetation composed mainly of giant rosette plants, shrubs and grasses" (see http://en.wikipedia.org/wiki/Páramo)

[3] Pre-basic seeds might have either sexual or asexual origin. "Original" potato seeds coming from the flower of the potatoes plant have sexual derivation, while seeds coming from manipulation of parts of the plant in a laboratory are the asexual seeds or vitro-pants. PROINPA only produces vitro-plants. .

Plants coming from pre-basic seeds produce abundant potato seeds in his first generation, and, though decreasing from generation to generation, also in the following two generations (they have too high productivity). Potato produced from vitro-plants in the first, second and third generation is called basic potato seed.

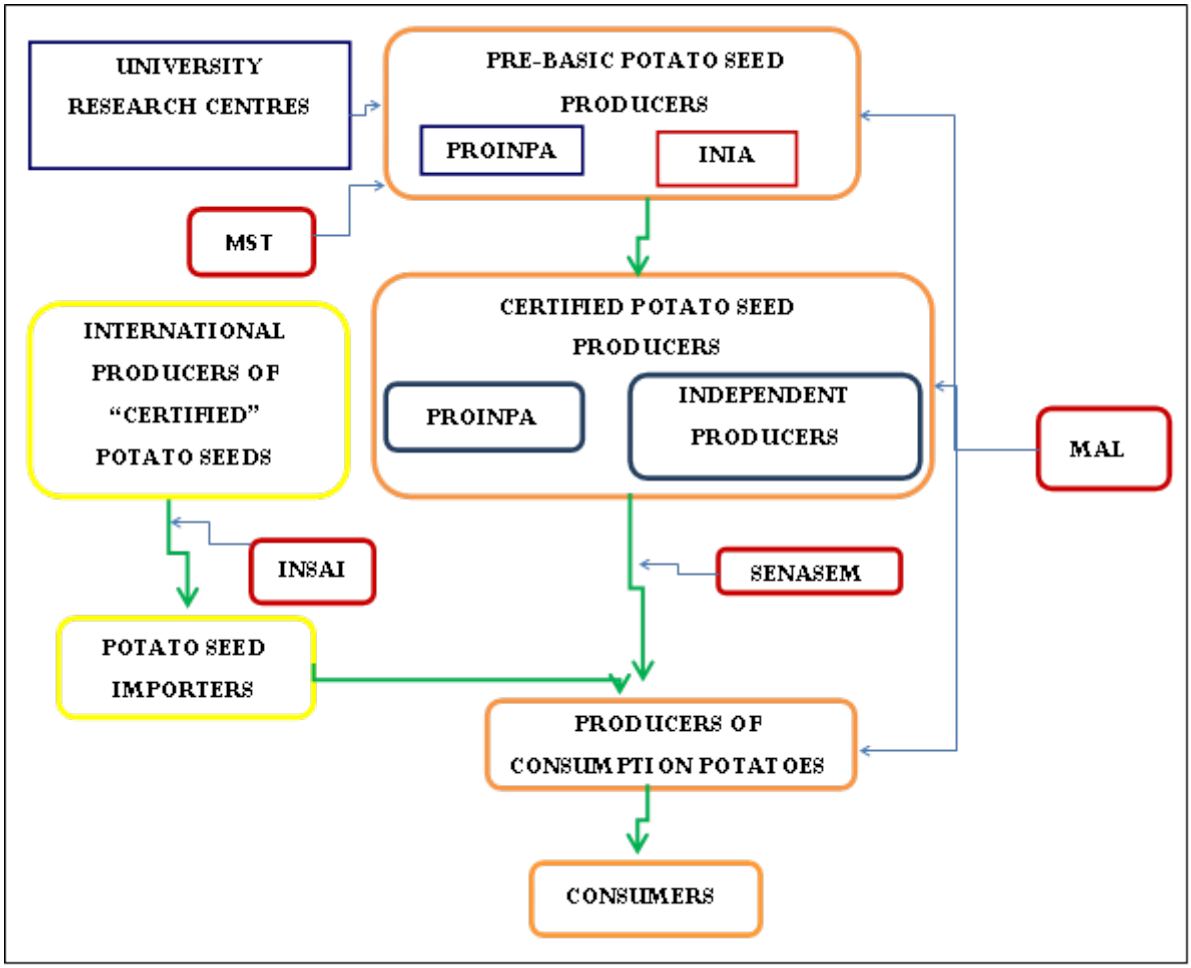

Figure 2. Formal/nominal ideal system, i.e., this is the system that is supposed to exist (in the laws and formalities of the Venezuelan STATE, and in the diary language in Venezuela): all actors are supposed to be strongly engaged and looking for a sane potatoes seeds production process.

The actual game or CSA, alternatively, is presented in Figure 3. This game, in its reduced version (see Figure 4), will be described in the following sections. For now, let us mention some relevant issues making relevant differences between the actual game and the normative game. First, in practice the Venezuelan state has contradictory strategies and actions; on one side, it favours research and production of national potato seeds; and, on the other side, it supports potato seeds importation, part of which frequently is contaminated (this is allowed by the MAL's subordinate entity, INSAI). The importation process is permeated by corruption, and has brought potato diseases from outside the country, which have infected local lands. Importation of foreign potato seeds discourages national production. Two new actors appear here (see Figure 3): the informal importers of potatoes seeds, who use importation forms no approved by the Venezuelan State and even the "black market"), and the mafia of distributors, who manipulate the market, to speculate with the price of the potatoes, and get particular profits.

In Figure 3, the strongly committed actors are placed at the right side, the lowly identified are in the left side and the other actors are close to the centre of Figure 3. The central actors in some way serve to the other two kinds of actors, allying with both of these in order to achieve their own goals. Because of this, they are in certain form more diffuse or malleable in the

sense that they might follow the interest of the other actors (this is indicated by the discontinuous lines representing these actors in figures 3-4).

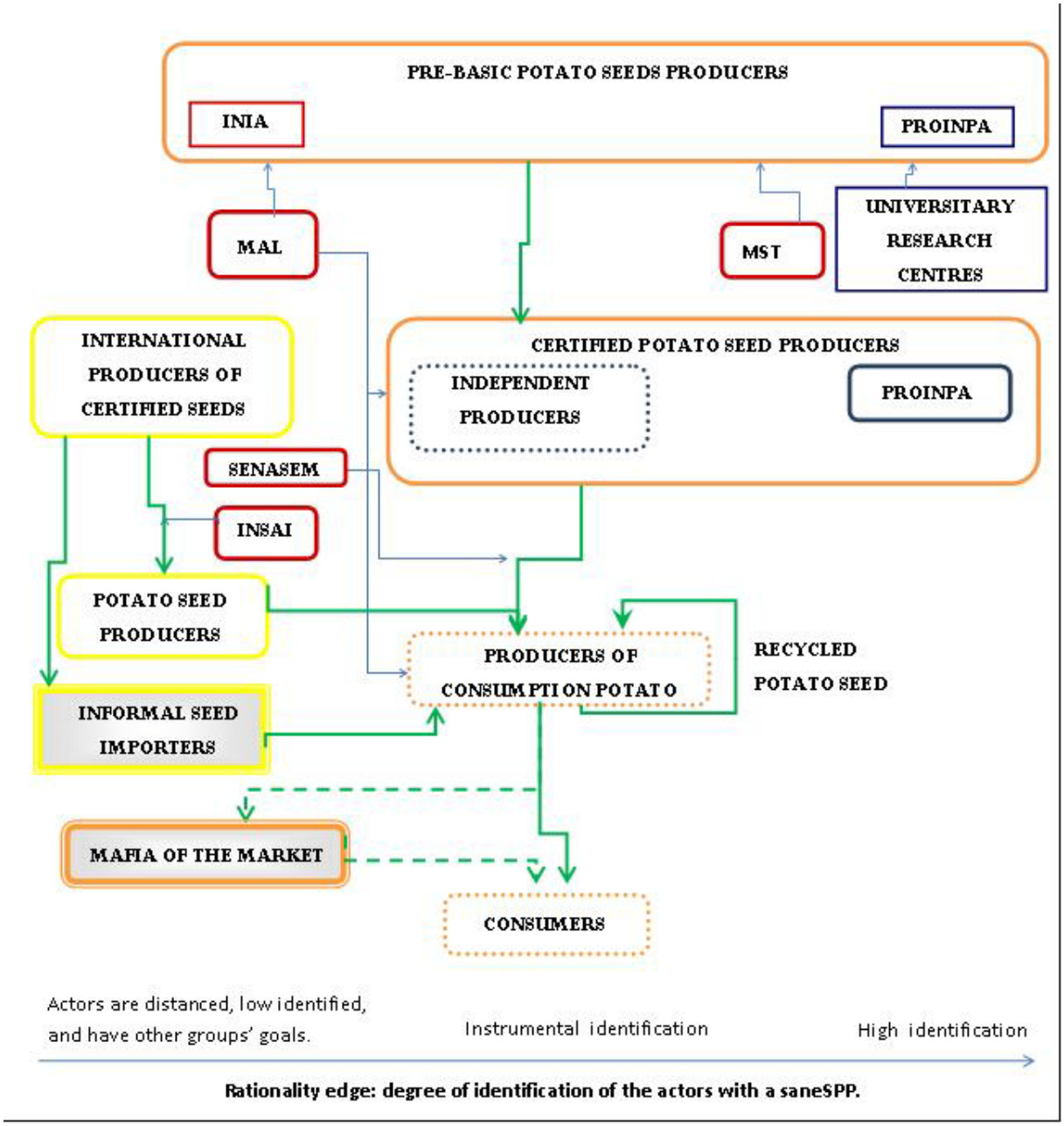

Figure 3. The actual system: actors and relations in the SAC. The actors more identified with a saneSPP are at the right side, the less identified at the left side, and the moderately identified at the centre (their behavior seems more ambiguous if compared with that of the other actors, and because of this are drawn with a diffuse/discontinuous line). Two new actors appear, comparing with the normative system: the informal seed importers and the mafia of the market, as indicated by the double line of the border of the figure. The existence of these two actors has no sense (no explanation) in the normative game.

That game shown in Figure 4 will be simulated in SocLab. As said above, some actors are irrelevant for the model, because they have similar interest and manage similar resources, and then can be joined and represented by a single actor, or can be subsumed in the more relevant actor, in Figure 4. For instance, the MAL represents INSAI, SENASEM, part of AGROPATRIA (other aspect of AGROPATRIA is represented by importers of potato seeds),

INIA and FONDAS. The University Research Centres are subsumed within the actor called PROINPA. MST and PROINPA are represented as a single actor. The international producers of certified potato seed's actor is outside the national game. INIA is discarded as producer of pre-basis seeds, as its production is too low.

The consumers have been eliminated (are not in Figure 4), because their interest can be a function of the interest of the producers of potatoes seeds, and the mafia of the market. Both producers and consumers are not concerned with the quantity of the potatoes. This is different in the *ideal normative* game (in this case the actors look for a saneSPP, and prefer good quality potatoes), where consumer's action, thought as *political pressure*, could be understood as a function of the level of potatoes and the quality of the potatoes (political pressure = constant - constant1 * amount of potatoes - constant2 * quality of the potatoes). However, in the actual CSA consumers' interest is reduced to availability of low price potatoes. We can say that in the CSA the satisfaction of consumers is a function of the satisfaction of producers (consumers' satisfaction = constant1 * producers' satisfaction – constant2 * mafia of the market's satisfaction). In Venezuela, there is an important difference between the producers potatoes price and the market potatoes price.

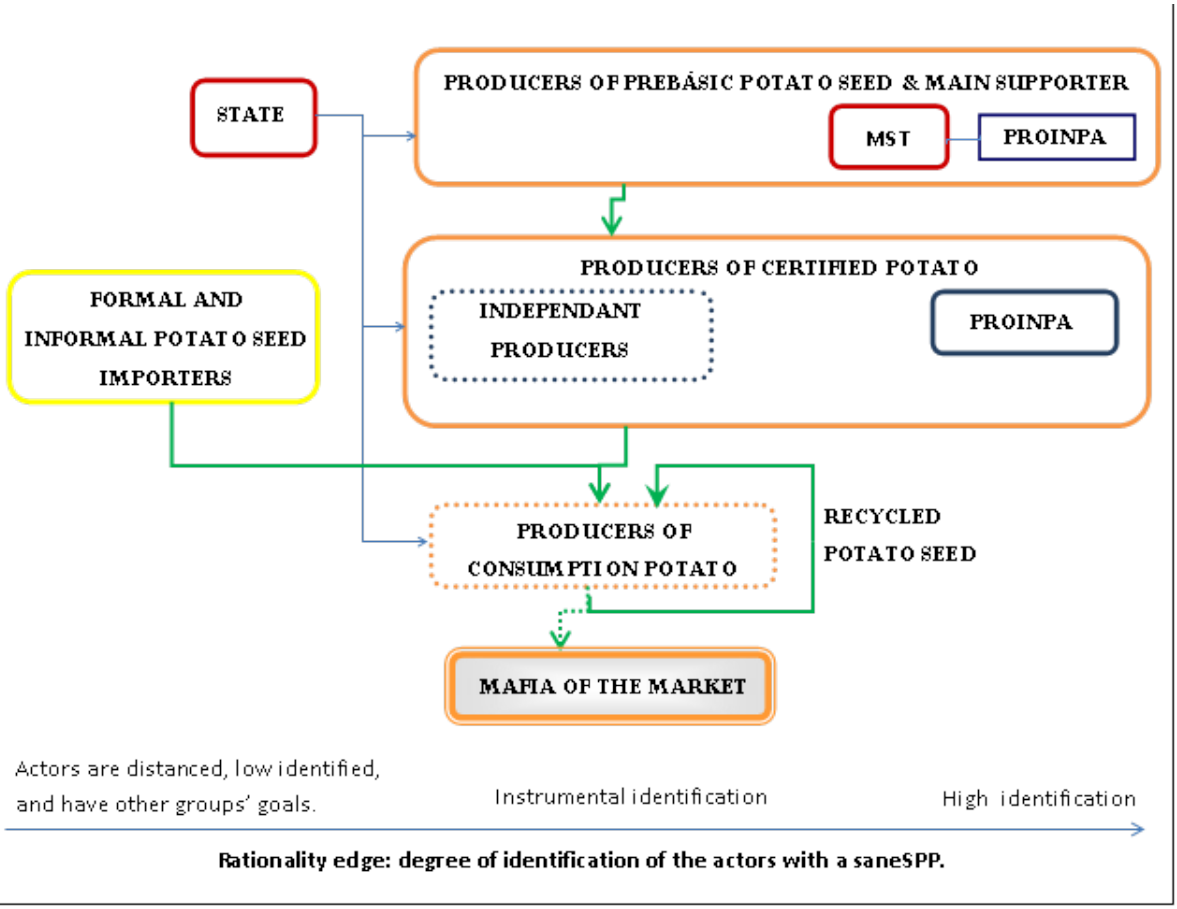

Figure 4. Simplified SAC. As in Figure 3, highly identified actors are in the right side, poorly identified actors are in the left side, and actors with an instrumental identification are in the centre of the figure. Redundant actors in Figure 3 whose action is not too important, etc., have been eliminated or joined to other more important actors.

3.2 Observed difficulties in the CAS, and direction of the research.

Below some of the symptoms of the bad performance of the CAS[4] are listed:

a) usually there is scarcity and high prices of consumption potatoes –it is often necessary to import consumption potatoes from Colombia or from Canada;

b) currently, low availability of certified potatoes seeds – producers have to use recycled seeds in order to regulate the market of potato seeds;

c) when PROINPA increases its production of PREBASIC_S, it has difficulties to sell the additional production, because the demand placed by SEEDS_PROD is low, even when there is a need for increasing production of CERTIFIED_S, which is grown from PREBASIC_S;

d) A bottleneck is observed in the production chain, between PROINPA and POTAT_PROD, i.e., CERTIFIED_S usually is in a lower level than the required value. SEEDS_PROD, who control this resource, seems to be a very fragile actor. In addition, SEEDS_PROD has the competition of SEEDS_IMP, who controls IMPORTED_S, which is afforded by the STATE;

d) usually, the STATE does not care enough about the good condition of the CAS and in particular of the process of production of potatoes seeds. The STATE basically worries about the existence of potatoes in the market, whatever be its quality, variety and origin (either imported or national), and the STATE administrators are specially concerned with marginal benefits they get from the importation of potatoes seeds (this is expressed in low availability of fertilizers, potato seeds, pesticides, etc). Even more, it has happen that the STATE does not cares if the imported seeds are not finally planted – some years the potato seeds have got rotten and lost. The STATE is ambivalent, on one hand, it gives certain support to national production (SUPPORT_N), but on the other hand this support is poor and in addition it affords imported seeds, which commonly contaminate local lands. It seems that the low identification[5] of the Venezuelan state with the national production of potato seeds is a critical factor that makes difficult the creation of a saneSPP;

e) unsteadiness of the prices and high difference between the producers price and the market price (usually producers price is lower than 50% of the market price);

f) the national potatoes market highly depends on the Granola potato seed variety, which is a non native variety, while the native varieties are not commercially cultivated – native varieties require less use of pesticides and adapt much better to local diseases, local lands and climate (over time consumers and producers, both unaware about these facts have preferred Granola over local potato seed varieties);

g) it is common to import infected potato seeds, contaminating local lands;

h) most of the CAS actors seem to be highly selfish (distanced from a saneSPP), looking for particular and immediate benefits, and lowly concerned with the well being of the CAS, for instance, SEEDS_IMP, the STATE and MAFIA_MARKET – only PROINPA and, in a lower level, SEEDS_PROD are preoccupied for a good CAS.

[4] The reference or contrast to observe the CAS is what we have called a saneSPP, defined above, in which the bad symptoms would not occur; e.g., in a sane SPP, the STATE regulates and supports the well being of the CAS, and stop sustaining importation of infected potato seeds.

[5] Organizational (system, or in-group) identification characterizes the strength of the actor's membership to the system, organization, or group, and includes both a motivational component (his attachment to group goals) and a cognitive component (sharing of the group culture) (Simon, 1998).

i) Despite of the instability problems generated by MANIPUL_M this resource is appreciated by SEEDS_IMP, because such manipulation helps in arguing in favor of importing potatoes seeds.

Observing the listed problems and issues in the CAS, it is of our interest to investigate, by using the simulation model:

i.1) The instability of the CAS associated to the volatility of the potato demand and prices.

i.2) The bottleneck in the production of CERTIFIED_S, and the character of the fragility of the SEEDS_PROD.

i.3) The ambiguous behavior of the STATE.

i.4) The influence of the highly selfish actors (MAFIA_MARKET and SEEDS_IMP) on the CAS, and that of the actors concerned with the well being of the CAS (PROINPA and CERTIFIED_S).

Accordingly, questions of interest are:

q.1) how much (degree of influence) the distanced and selfish actors, MAFIA_MARKET and SEEDS_IMP, are responsible for the instability of the CAS?

q.2) have PROINPA and SEEDS_PROD an appropriate level of influence as to direct the CAS towards a saneSPP?;

q.3) are really the SEEDS_PROD a frail actor, and if so, how and why this happens?;

q.4) which configuration of the resources and behaviors of the actors are responsible for the bottle neck at the level of CERTIFIED_S?

q.5) how can we describe the ambivalent role of the STATE, who somewhat supports national production but simultaneously affords IMPORTED_S, which brings diseases to local lands, and is the competition of (national) CERTIFIED_S.

We will analyze both the structure of the model and the simulation results in order to answer these questions.

3.3. Identification of the actors

PROINPA_MST

PROINPA is a Civil Association of Integral (prefer organic, and native potatoes) Producers of Potato Seeds in the Venezuelan Andean high lands, or Páramo. As said above, it aims at generating models of productive diversification in general, and in particular at quantitative- and qualitative-ly improving the national production of potatoes seeds. Among other things, it produces vitro-pants (potato plants grown in vitro). PROINPA enjoys also very good cognitive capabilities, management practices, good quality lands, and good market connections. It is strongly engaged in a saneSPP (this system should be supported by the STATE, and both IMPORTED_S and RECYCLED_S have a secondary importance compared with CERTIFIED_S). On his side, the Ministry of Science and Technology (MST) formally is responsible for the national research policy, and executes the governmental budget aimed at supporting scientific research in the country. This Ministry gives technological support to the system of production of potato seeds, especially via PROINPA (e.g., by

constructing for PROINPA labs to grow vitro-plants). Contrary to PROINPA, MST is concerned only with monetary issues (it does not has good cognitive capabilities about potato seeds production, for instance). Both, PROINPA and MST show a high level of identification with a good system of national potato seeds production, nevertheless PROINPA is autonomous, and highly motivated, as it is continuously involved in action, not sporadically (as the STATE).

The mean of action of this actor is the production of Pre-basic seeds (generally vitro plants), including the varieties: “Única”, “Granola”, R12, and “varied certified seed”. Interpretation from left to right of the state of this relation is from low to high quantity and quality of pre-basic seeds. These are used to produce the basic certified seed, which in turns is used to produce potatoes for the market. They have better quality than certified seeds and recycled potato seeds, because of their high productivity, and because they are disease free (phytopathologically healthy). Then, they are appreciated by actors in different forms. The demand of these kinds of seeds is a source of power to the actor controlling them. This relation is called: PREBASIC_S

SEEDS_PROD

This actor represents the national producers of potato seeds. It produces seeds for potato producers (POTAT_PROD), who in turn provides potatoes for the consumption market/distributors. It gets pre-basic seeds from both PROINPA and potato seeds importers (SEEDS_IMP). It constitutes an important link between PROINPA and the POTAT_PROD and highly contributes to a saneSPP. If this actor does not perform its role properly, then a bottleneck would appear in the system, affecting the production of vitro-plant, what actually sometimes has occurred, preventing an effective flow of the potato seeds from PROINPA to the POTAT_PROD. A good information system, and a good system of distribution of vitro-plants, certified seeds, would help in diminishing this problem. The STATE’s action is fundamental for strengthening the link among the actors of the CSA. SEEDS_PROD are a frail actor, who prefers sometimes to produce potatoes for the market than potatoes seeds, if production of potatoes seeds is not well remunerated and appreciated.

The mean of action of this actor is production of basic certified seed. These seeds require a good quality certification, which in Venezuela is given by the INSAI, one of the entities being part of the STATE actor. These seeds are the main input (along imported potato seeds, and recycled potatoes) to produce potatoes for the consumption market. This relation is called CERTIFIED_S.

SEEDS_IMP

Importers of potato seeds often import potato seeds with diseases. This actor is lowly committed in a saneSPP. The resource managed by this actor is important for the STATE, consumers and PRODUCERS of potatoes, especially when the amount of potato seeds in the national market is too low. In order to get authorization to import potato seeds, this actor is interested in generating the opinion that the level of potatoes seeds and potatoes in the market is low, and thus it can benefit by the action of the MAFIA, who manipulate the market. If the level of potatoes seeds in the market is perceived as too low, or is going to be too low in a

near future, then the government would be prompted to give foreign currency to the SEEDS_IMP to buy potato seeds from outside the country.

The main mean of action of this actor corresponds to the quantity of imported potatoes, including the fact that a high quantity improves the probability to import potato diseases. The graph shows the value of the quantity of imported seeds, which sometimes has a bad quality, comes into the country in a too high level, and is subsidized. Import of large amount of potato seeds, part of which usually have bad quality, as well as manipulation of the market of potatoes by the MAFIA_MARKET, disfavor the endogenous or local production of potato seeds. The negative value of importation of potato seeds (low importation represented to the left side of the horizontal edge) favors national production of all kinds of potato seeds and consumption potatoes. Importation of potatoes seeds is proportional to the STATE's support to import potato seeds, since importing potato seeds needs to get foreign currency, that afforded by the State . Thus, this relation merges actions of potato seeds importers and of the State's department that allocates fund for potato seeds import. This resource is called IMPORTED_S.

POTAT_PROD

This actor is the set of farmers who grow potatoes for the consumption market. These potatoes are used both for individual consumption and agro-industry. Also, potatoes are used as recycled (low quality) potato seeds by the POTAT_PROD itself. POTAT_PROD is interested in a good price of potatoes, and then it has no interest in producing excessively - its goal is to produce an appropriate quantity of potatoes in order to keep a good market price of potatoes. POTAT_PROD controls two relations: production of potatoes, and use of recycled seed. POTAT_PROD benefits from the MAFIA, as long as the action of this actor does increase too much the price of the potatoes, and affects the demand. Even more, as long as POTAT_PROD works in favor of a high production of potatoes, as well as of an accessible potatoes price, his satisfaction can partly be used as an indicator of consumers' satisfaction. However, consumers' satisfaction is also affected by the MAFIA's satisfaction. In effect, consumers' satisfaction might be defined as c1*POTAT_PROD satisfaction – c2*MAFIA's satisfaction, where c1 and c2 are positive constants. MAFIA's satisfaction is product of its appropriation of part of the price consumers' pay for the potatoes, which appears because of the artificially high prices generated by MAFIA's controlled relation: MANIPUL_M.

Production of potatoes represents the central resource in the system of production of potato seeds. It is appreciated positively by all actors, and justifies the existence of the system. This resource will be called POTATOES.

Usage of Potatoes as seeds favors several actors, because also it provides potatoes for the market, however, productivity and quality are low. The actors getting benefits from this practice are: the State, the mafia and producers of potato seeds themselves. Actors who consider this practice as negative are the other providers of seeds, including PROINPA, importers of potato seeds, and producers of certified seeds. In fact, recycling potatoes as seeds is the mean used by producers to regulate the (un)availability of certified or imported seeds. This resource is called RECYCLED_S.

STATE

This actor is constituted mainly by the Ministry for Agriculture and Lands (MAL), and a set of administrations dependant on this ministry, whose formal goal is to promote agricultural production in the country (MAL, INIA, INSAI, FONASEM, etc, see above). It is responsible for designing and implementing the agricultural national policies. It includes several agencies having, in practice, a closely similar identification (middle negative level) concern with an ideal saneSPP. It gives two kinds of support: instrumental, especially monetary founds; and, non instrumental, such as for instance, technological and organizational assistance to improve the system of production of potatoes seeds (e.g., increasing the synergy among the actors, as well as the quantity and quality of the product). However, the STATE badly fulfils its role and it is too much instrumental. Cognitive and organizational resources would improve qualitatively the system of production of potatoes seeds beyond what only monetary support can offer. Such resources help, for instance, PROINPA to produce good quality potato seeds, which in turn are used by other actors. As said above, this second kind of support is almost inexistent. It seems that the rationality of the practice does not follow the rationality of the formal statements and policies of the STATE. In addition, the interest of the STATE for politicism is sometimes in conflict with the ideal good STATE's support of the system of production of potatoes seeds, because of the scarcity of resources (many times there is preference for politicism, and support to national production is neglected).

The mean of action of the STATE is national production support, which includes diverse inputs, such as: agro-chemicals, loans, technical guidance, or equipment for PROINPA. Support is directed to producers of pre-basic potato seeds, producers of certified potatoes, producers of potatoes for the market, and importers of seeds. Support indirectly benefits also the MAFIA, because an active potatoes market leaves room for manipulation of the market (it helps in increasing potential difference between the price of potatoes at the production place/ and the price in the market). This relation is called SUPPORT_N.

MAFIA_MARKET

This actor is comprised of part of the distributors of potato seeds, who manipulate the market in order to get power and economical benefits. For instance, they speculate by hiding a quantity of potatoes from the market in order to "artificially" increase the price of the potatoes. These practices give the mafia a strong influence on the market, since their action can artificially generate high/low prices. This, in turns, will have an important effect on diverse actors, and then on the whole system of production of potatoes seeds. For instance, an artificially high price will incentivize production of potatoes (and use of recycled seeds), but constraint the demand, while giving false and contradictory signals to other actors, including the producers of potato seeds – manipulation destabilizes the market of potatoes, and then also the market of potato seeds, creating a high price of the potatoes, and subsequently a decrease in the demand, first of potatoes and then of basic and pre-basic seeds (following at the inverse the production chain). This distortion of the market sometimes facilitates arguing in favor of importation of potato seeds, because of the perception of low availability of potatoes in the market. In turn, imported potato seeds along the delivering of hided potatoes

create the opposite effect: too much potato in the market, which falsely incentivizes low prices. Likewise, artificial low prices entail negative effects. Thus, the MAFIA creates instability in the market, which, for instance, affects PROINPA's production of vitro plants, as the market moves from high to low demand, and then to high demand again. Wrong signals from the market do not allow PROINPA and other actors to properly adapt to the real needs, as they follow untrue signals. Furthermore, wrong behavior of the actors generates incorrect new signals, an incorrect feedback (e.g., likelihood for leaving unsatisfied demand in the market increases). In a saneSPP, the action of the MAFIA_MARKET would be balanced by the negative reactions and effects of this intervention on the market. For instance, this actor would have difficulties to get support from the banks and the government. However, such negative effects do not exist in the actual market of potato seeds we are studying, since the government, banks, etc, do not take into account such kind of actor's harmful action in evaluating the actors' behavior.

The main source of action of this actor is the manipulation of the market of potatoes for consumption. Negative values of this relation correspond to the absence of manipulation and positive values to a high level of manipulation of the market. This relation is called MANIPUL_M.

3.4. Solidarities

Solidarities appear because certain individuals are members of several groups constituting the actors. For instance, some individuals grouped in SEEDS_PROD are also members of PROINPA. Thus, what generates satisfaction for SEEDS_PROD generates certain satisfaction also for PROINPA, and vice versa. In particular, some members of the POTAT_PROD actor also belong to actors SEEDS_PROD, MAFIA_MARKET, or SEEDS_IMP. We find the following intersections, and thus the corresponding pairs of actors linked with solidarities:

SEEDS_PROD with PROINPA, and with POTAT_PROD
POTAT_PROD with MAFIA_MARKET, and with SEEDS_IMP
MAFIA_MARKET with SEEDS_IMP

Other solidarities are due to common interest between SEEDS_IMP and the STATE in using part of the support, given by the STATE to import potato seeds, for their own particular benefit. For instance, particular negotiations feature a considerable difference between the international price of potato seeds, and the price at which the imported potato seeds are sold in Venezuela, generating a significant difference which could be kept by the officials of the STATE and SEEDS_IMP; or, part of the amount of foreign currency afforded by the STATE to import potato seeds might not be used to buy potato seeds, but rather deviated towards bank accounts of particular individuals. There is, then, a sort of alliance between the STATE and SEEDS_IMP, represented by the solidarity between them.

Table 1: Matrix of Solidarities between actors. Each cell represents the solidarity of the actor in the line towards the actor in the column. The absolute value of the solidarity indicates its intensity.

--->	**PROINPA_ MST**	**SEEDS_ PROD**	**SEEDS_IMP**	**POTAT_ PROD**	**STATE**	**MAFIA_ MARKET**
PROINPA_MST	0.95	0.05	0.0	0.0	0.0	0.0

SEEDS_PROD	0.05	0.9	0.0	0.05	0.0	0.0
SEEDS_IMP	0.0	0.0	0.8	0.05	0.1	0.05
POTAT_PROD	0.0	0.05	0.05	0.85	0.0	0.05
STATE	0.0	0.0	0.1	0.0	0.9	0.0
MAFIA_MARKET	0.0	0.0	0.05	0.05	0.0	0.9

4. The SocLab Simulation Model

This model is comprised of five actors, with a relation each one, except the actor producer of potatoes, POTAT_PROD, who controls two relations. Table 2 shows the dependence of actors on relations. The more pertinent relations are POTATOES, CERTIFIED_S, IMPORTED_S, and SUPPORT_N. The POTAT_PROD, who control the relation POTATOES, has a strong potential for getting satisfaction, as the system presents an important dependence on the relation it controls (POTATOES), and this relation presents low conflict (all actors are interested in POTATOES).

Table 2: This matrix shows the dependence, effect function and stake, of the actors (in columns) on the relations (in lines) (stakes in bold character indicate the actor who controls the relation). Each actor allocates a normalized total value of ten (10) stakes marks. For each effect function, the x-axis represents the state of the relation which is set by the actor controlling the relation, while the y-axis is the scale of the resulting effect on the actor. The last column, "relevance", indicates the total addition of the stakes that actors place on each relation.

effect	**PROINPA_MST**	**SEEDS_PROD**	**SEEDS_IMP**	**POTAT_PROD**	**STATE**	**MAFIA_MARKET**	**RELEVANCE**
PREBASIC_S	**3.0**	1.5	0.5	0.5	0.5	0.5	6.5
CERTIFIED_S	1.5	**3.0**	1.5	1.5	1.0	1.0	9.5
IMPORTED_S	1.0	1.0	**3.0**	2.0	2.0	1.0	10

POTATOES	 1.0	 1.5	 1.5	 **3.0**	 3.0	 3.0	13
RECYCLED_S	 1.0	 1.0	 0.5	 **1.0**	 0.5	 1.0	5
SUPPORT_N	 2.0	 1.5	 1.0	 1.5	 **2.5**	 0.5	9
MANIPUL_M	 0.5	 0.5	 2.0	 0.5	 0.5	 **3.0**	7

PROINPA

PROINPA is highly interested in a saneSPP, and, accordingly, is concerned with the relation it controls (stake 3) and with all other relations in the system, and especially (highest stake) with those on which production of vitro-pants directly depends on. It is positively impacted by those relations in favor of a saneSPP. In this sense, the most important relations, apart from PREBASIC_S (the relation it controls), are: CERTIFIED_S (stake 1.5), because it is grown from CERTIFIED_S (determining the demand of CERTIFIED_S); and the STATE's SUPPORT_N (stake 2), since it provides technological equipment, pesticides, and monetary help. Additionally, it is positively affected in the technological chain, though indirectly, by the POTATOES (stake 1), because its production demands CERTIFIED_S; and, negatively, by the amount of IMPORTED_S (stake 1), since this alternative certified seed competes with the national CERTIFIED_S. Similarly, high values of RECYCLED_S and MANIPUL_M have a negative effect on PROINPA, because of their harmful impact on a saneSPP (low productivity RECYCLED_S competes with CERTIFIED_S, and MANIPUL_M generates instability in the potatoes production system) (these relations receive stakes 1 and 0.5 respectively).

SEEDS_PROD

SEEDS_PROD concern is close to PROINPA's, but it is less worried respect to a saneSPP. Because of this, the effect of the increase of CERTIFIED_S, the relation it controls, on it, does not always augment. SEEDS_PROD is concerned with the resource it controls (CERTIFIED_S has stake 3), and with resources affecting production of CERTIFIED_S, especially with PREBASIC_S (stake 1.5), POTATOES (stake 1.5), and SUPPORT_N (stake 1.5). It is moderately worried by the seeds that compete with CERTIFIED_S: IMPORTED_S, and RECYCLED_S (both receive stake 1). It is even less concerned with MANIPUL_M (stake 0.5), since its effect on CERTIFIED_S demand is indirect – MANIPUL_M could induce high prices, affecting POTATOES demand, and only then affecting CERTIFIED_S demand.

SEEDS_IMP

SEEDS_IMP is interested in his own relation (stake 3), and in justifying importation of potato seeds. Consequently, it prefers a low level of the alternative competing national seeds, especially of that having good quality: CERTIFIED_S (it places a much higher stake on this high quality seed (1.5), than on RECYCLED_S (0.5), the low quality seed). It is particularly interested in the instability of the national market of potato seeds, and consequently on MANIPUL_M (good level of stake: 2), as this helps in justifying the need for importing potato seeds. The demand of seeds is linked directly to the level of produced POTATOES, consequently this relation receives a good stake (1.5). The STATES's support to national production SUPPORT_N has a relevant impact on the stability of the market, so it receives a relatively good importance (stake 1). SEEDS_IMP is much less concerned (low stake) with PREBASIC_S, because this resource has an indirect effect on the demand of IMPORTED_S (stake 0.5).

POTAT_PROD

POTAT_PROD is basically affected by its own production of potatoes (resource POTATOES) (good stake: 3), and by resources required for producing potatoes (medium stake), i.e.: a) CERTIFIED_S and IMPORTED_S, preferring IMPORTED_S (stake 2, a bit higher than that given to CERTIFIED_S (1.5)) because this gives higher reputation to their production of potatoes among other producers (who could buy POTATOES to be used as RECYCLED_S) and market distributors; b) SUPPORT_N (stake 1.5), for instance, pesticides, fungicides, and chemical fertilizers; and, c) RECYLCED_S, in a lower level that the other two kind of seeds (stake 1), since its productivity is lower than that of CERTIFIED_S and IMPORTED_S. POTAT_PROD gives low importance (small stake: 0.5) to PREBASIC_S, and to MANIPUL_M, as these resources impact only indirectly on the production of POTATOES.

STATE

The STATE is not highly identified with a saneSPP, and so its concern is somewhat different from that of PROINPA, and close to that of POTAT_PROD. The STATE is moderately concerned with the relation it controls, SUPPORT_N (2.5 stake), as it depends more on what the other actors give. Administrators of the STATE are interested in providing what actually the consumers demand: POTATOES (stake 3), without caring too much about their origin and quality. This is due to the fact that these administrators seek for the votes of the consumers in order to be re-elected in their administrative positions. Because of this, the STATE gives stronger support to IMPORTED_S (stake 2), as an easy form of getting seeds in order to sustain potatoes production, than CERTIFIED_S (stake 1). Meanwhile, the STATE is lowly worried about PREBASIC_S, RECYCLED_S, and MANIPUL_M, as these resources do not directly affect the potatoes production (stake 0.5).

MAFIA_MARKET

The MAFIA_MARKET is mainly concerned with the resource it controls, MANIPUL_M (stake 3), and with POTATOES (stake 3), since it is interested in the existence of an appropriate quantity of potatoes in the market, which facilitates MANIPUL_M. It also shows concern, though in a lower level (stake 2), for CERTIFIED_S, RECYCLED_S and IMPORTED_S, since these relations have direct impact on the production of consumer potatoes. SUPPORT_N and PREBASIC_S have low importance (stake 0.5) for MAFIA_MARKET, as these resources affect more indirectly the potatoes production.

5. Some results.

This section shows the simulation results, which help in answering questions q.1 to q.5 (see section 3.), associated to tendencies and particular behavior observed in the CAS.

In addition, in relation to the behavior of the STATE we would like to test the following *hypothesis 1*: A higher identification of the STATE with the actual CAS would notably favor the increase of national production of potato seeds, and qualitatively change the actual system towards a saneSPP.

The structure and/or behavior of the model should: on one hand, reflect and be coherent with the named observed issues and problems listed above (section 3), and, on the other hand, hopefully give answers to the above listed questions. For now, we will address the first issue, while the second issue will be aborded after. Accordingly to the listed issues and problems, we expect to observe in the model:

e.1) Convergence (because of similar interest) of PROINPA and SEEDS_PROD (actors highly compromised with a good CAS) on one hand, and STATE and SEEDS_IMP, on the other hand (actors lowly compromised with a good CAS).

e.2) Conflict of interest between the two subset of actors with convergence named in e.1) (because of their different interests).

e.3) A high influence of POTAT_PROD, because POTATOES is positively appreciated by all actors. In addition, it controls the most relevant relation: POTATOES (see Table 2) – POTATOES is what the consumers finally demand, and this gives sense to the existence of the CAS.

e.4) A somewhat good level of influence of SEEDS_IMP, because IMPORTED_S is well valued by POTATO_PROD and by the STATE; and a fairly good level of influence of the MAFIA_MARKET, because MANIPUL_M is valued by SEEDS_IMP, and could also be positively appreciated by POTAT_PROD. This influence would be in correspondence to the instability of the price and availability of potatoes in the market. Despite of their, at least partial, negative impact in the CAS, the potential influence of the highly selfish actors, MAFIA_MARKET and SEEDS_IMP, might not be too much lower than that of the actors concerned with the well being of the CAS (PROINPA and CERTIFIED_S).

e.5) Influence of SEEDS_PROD no much higher than that of IMPORTED_S, which would explain the fragility of CERTIFIED_S compared with SEEDS_IMP. The frailty of SEEDS_PROD would also give reasons for the weakness of the demand of

PREBASIC_S – let us remember that SEEDS_PROD generates a bottleneck in the production process, because of its low production of CERTIFIED_S and low demand of PREBASIC_S.

e.6) A regulated simulation configuration closes to the Nash equilibrium configuration, since most of the actors act for their own interest, without trusting the others.

e.7) A low influence of the STATE, because of its ambiguous behavior, supporting resources required by actors in conflict, e.g., CERTIFIED_S (conflicting with SEEDS_IMP), and IMPORTED_S (conflicting with PROINPA and other actors). Contrarily, the STATE different contributions would generate retributions and great satisfaction.

e.8) The STATE is disengagement respect to a saneSPP.

5.1. Structural analysis of the model.

Table 4 presents the state of the relations and the satisfaction of the actors, when the global satisfaction and the satisfaction of each actor are maximized (respectively minimized, in Table 5). The configuration for the maximal (resp. minimal) satisfactions of the whole system (306.1 (resp. -296.8)), is better represented by the maximal (resp. minimal) satisfaction of the potato producers (209.1 (resp. -236)) than by any other actor (the next one is the STATE (171.3 (resp. -176.9)). In addition, certain conflicts and convergences among or between actors appear, including the followings:

(1) Convergence between PROINPA and SEEDS_PROD. The configuration that maximizes the satisfaction of one of them provides the other with a good satisfaction, and the same holds for their minimal satisfactions. This result stems straightforward from the similarity of their dependencies on other actors (cf. Table 2 above). The results also show the conflict between these actors and the MAFIA_MARKET and SEEDS_IMP, as well as with the STATE though in a lesser degree, for both maximal and minimal values.

(2) Convergence of the STATE with SEEDS_IMP, on one side, and with POTAT_PROD, on the other side. Maximizing (resp. minimizing) the STATE's satisfaction considerably increases (resp. decreases) the satisfaction of the other two; and maximizing (resp. minimizing) the satisfaction of either POTAT_PROD or of SEEDS_IMP, increases (resp. decreases) the STATE's satisfaction. In addition, the SEEDS_IMP are strongly in conflict not only with PROINPA but also with SEEDS_PROD.

These observations confirm expectations e.1 and e.2.

It is also important to notice that the global satisfaction is not so bad when the MAFIA_MARKET's satisfaction is minimal, and that the same holds for SEEDS_IMP when MAFIA_MARKET's satisfaction is maximal (SEEDS_IMP somewhat benefits when MAFIA_MARKET achieve its interest, what is coherent with expectation e.4).

Table 4: This table shows (in lines) the configurations (state of relations) and the actors' satisfactions for (in columns) the maximal satisfaction, both global and for each actor.

		GLOBAL	PRONPA	SEEDS_PROD	SEEDS_IMP	POTAT_PROD	STATE	MAFIA
State of the relations	PREBASIC_S	10.0	10.0	10.0	-10.0	10.0	7.0	-3.0
	CERTIFIED_S	3.0	10.0	2.0	-10.0	10.0	6.0	-3.0
	IMPORTED_S	10.0	-10.0	-10.0	10.0	10.0	10.0	-2.0
	POTATOES	5.0	10.0	10.0	10.0	4.0	10.0	-3.0
	RECYCLED_S	-1.0	-10.0	-10.0	6.0	4.0	10.0	-3.0
	SUPPORT_N	4.0	10.0	10.0	-7.0	10.0	-3.0	-3.0
	MANIPUL_M	10.0	-10.0	-10.0	10.0	-3.0	-3.0	10.0
satisfaction of actors	PROINPA_MST	42.7	**97.3**	87.2	-75.8	57.5	14.6	-25.8
	SEEDS_PROD	48.9	71.6	**94.7**	-61.1	34.2	26.4	0.5
	SEEDS_IMP	43.5	-56.8	-47.2	**84.3**	8.1	35.6	16.6
	POTAT_PROD	66.5	20.6	13.2	10.6	**84.4**	48.2	1.4
	STATE	64.4	-2.8	-3.7	59.1	40.6	**91.6**	-10.8
	MAFIA_MARKET	40.2	-66.9	-51.6	5.5	-15.8	-45.1	**90.5**
	GLOBAL	**306.1**	62.9	92.5	22.5	209.1	171.3	72.5

Table 5: The table shows (in lines) the configurations (state of relations) and the actors' satisfactions for (in columns) the minimal satisfaction, global and for each actor.

		GLOBAL	PRONPA	SEEDS_PROD	SEEDS_IMP	POTAT_PROD	STATE	MAFIA
State of the relations	PREBASIC_S	-10.0	-10.0	-10.0	10.0	-10.0	-9.0	10.0
	CERTIFIED_S	-10.0	-10.0	-10.0	10.0	-10.0	-9.0	10.0
	IMPORTED_S	-10.0	10.0	10.0	-10.0	-10.0	-10.0	10.0
	POTATOES	-10.0	-10.0	-10.0	-10.0	-10.0	-10.0	10.0
	RECYCLED_S	10.0	10.0	10.0	-10.0	-10.0	-10.0	10.0
	SUPPORT_N	-10.0	-10.0	-10.0	10.0	-10.0	10.0	10.0
	MANIPUL_M	-10.0	10.0	10.0	-10.0	6.0	7.0	-10.0
satisfaction of	PROINPA_MST	-68.6	**-98.6**	-98.6	77.4	-59.0	-16.3	57.9
	SEEDS_PROD	-69.5	-96.5	**-96.5**	41.2	-61.2	-22.2	36.5
	SEEDS_IMP	-32.3	53.4	53.4	**-87.0**	-11.7	-29.6	5.6
	POTAT_PROD	-66.5	-35.3	-35.3	-21.7	**-84.8**	-58.1	69.6
	STATE	-40.4	-3.7	-3.7	-57.8	-55.5	**-86.0**	49.0
	MAFIA_MARKET	-19.5	28.3	28.3	-33.0	36.2	35.2	**-85.7**
	GLOBAL	**-296.8**	-152.4	-152.4	-80.9	-236.0	-176.9	132.9

We can also compute configurations for which the influence exerted by each actor on others is maximal or minimal (not shown here). Analyzing the potential influence of each actor over the whole CAS, defined as the difference between the maximal and the minimal influence each actor can give, we have the following order of the actors:

POT_PROD: 103.3 – (- 98.5) = 201.8
SEEDS_PROD: 48.2 – (-50.9) = 99.1
PROINPA: 44.8 – (-47.8) = 92.6
SEEDS_IMP: 39.9 – (-45.9) = 85.8
STATE: 40.7 – (- 24.4) = 65.1
MAFIA_MARKET: 29.3 – (- 29.3) = 58.6

POTAT_PROD has the highest potential influence, the double of the following actor; meanwhile, actors with smallest potential influence are the STATE and the MAFIA_MARKET. These results correspond to what is expected (expectation e.3): production of potatoes is the goal and the *raison d'etre* of the system we are considering; contrariwise, the existence of the system would not be so strongly affected by the vanishing of STATE and MAFIA_MARKET. In fact, the importance of the STATE and MAFIA_MARKET rests on the other actors, which are operational in the production process (of potatoes and potato seeds, as shown in Figures 3-4).

SEEDS_PROD have a stronger potential influence than the STATE. Actually, this could be seen as an indirect potential of influence of the STATE, since the STATE affords foreign currency to import potato seeds.

5.2. Simulation Results.

We present the results for an experiment consisting in 100 simulation runs. Figure 5 shows that relations PREBASIC_S, IMPORTED_S and MANIPUL_M are at very high levels, while other relations are at relatively lower levels. A good level of PREBASIC_S is necessary for an efficient and effective (sane) CAS, because the effectiveness of its effect requires a good level of collaboration with SEEDS_PROD (given their direct link in the production chain). However, the level of CERTIFIED_S is low, i.e., such collaboration does not occur. Even worst, the level of CERTIFIED_S is lower than the level of IMPORTED_S. All this is in concordance with expectation e.5. This break corresponds to the bottleneck in the production process in the CAS. Furthermore, the high levels of IMPORTED_S and MANIPUL_M are not in favor of a saneSPP. This is consistent with expectation e.4. Figure 5 also shows that the level of support by the STATE is far too low for a saneSPP, coherently with expectation e.8.

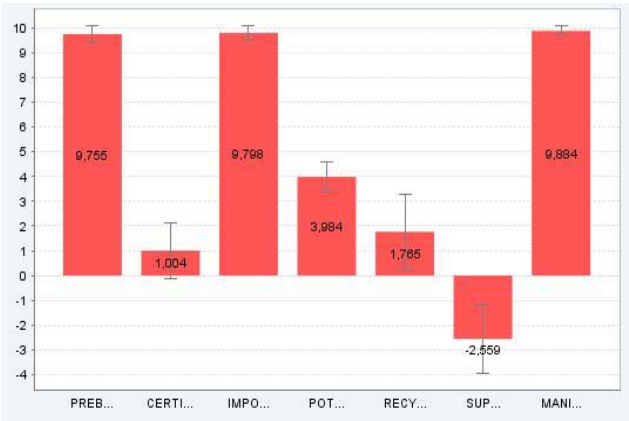

Figure 5. Mean of the state of the relations (100 simulation runs).

As can be seen in Figure 6, POTAT_PROD is the actor with the highest influence. The STATE deceives because of its low involvement, while it is the actor getting the highest satisfaction (in concordance with expectation e.7). Although the STATE and the MAFIA_MARKET give the less, they have good levels of satisfaction. In turn, PROINPA gets very low satisfaction, despite it strongly collaborates. This is consistent with Table 6, where we can observe that PROINPA is the actor getting the lowest percentage of satisfaction

(55.54%), while the STATE is giving the less percentage of satisfaction (i.e. having the minimal percentage of influence: 54,18 %). Despite of all these difficulties, at the mean of the simulation configurations, the global satisfaction (267) represents 87.2% of the maximal possible global satisfaction (306.1).

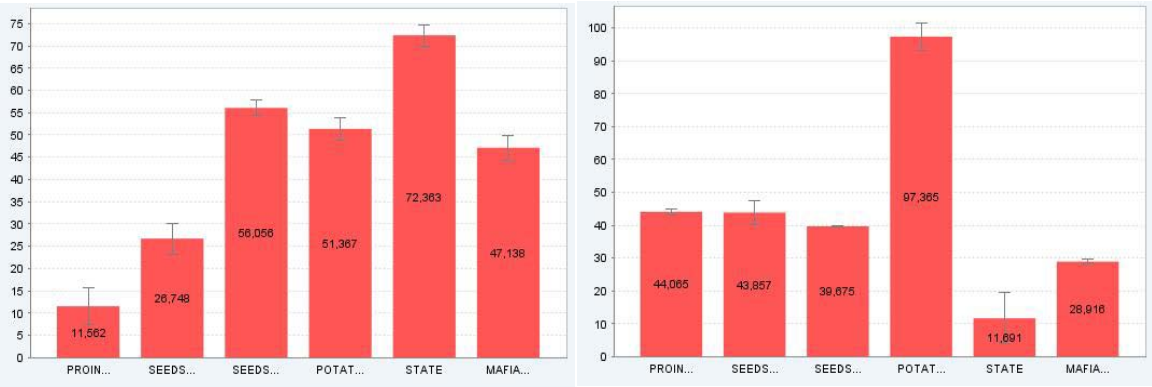

Figure 6. Mean of the satisfaction (at the left side) and influence (right side) of the actors, considering 100 simulation runs.

Table 6. Mean satisfaction and influence of actors given in percentage, i.e. in proportion regarding the range of each value (mean over 100 runs).

	% Influence	% Satisfaction
PROINPA_MST	99,12 %	55,74 %
SEEDS_PROD	97,13 %	64,61 %
SEEDS_IMP	99,29 %	84,05 %
POTAT_PROD	97,89 %	80,47 %
STATE	54,18 %	90,05 %
MAFIA_MARKET	99,44 %	75,66 %

Finally, Table 7 shows that the simulation configuration is very close to the Nash Equilibrium configuration, what indicates that most actors act for their own interest, without any trust in others (this confirms expectation e.6). The main difference between the two configurations occurs for RECYCLED_S.

Table 7: The table allows comparing the value of the relations, and the global satisfactions, got for the configurations: Nash equilibrium, mean of the 100 runs.

Relations	Relation at Nash Equilibrium	Averages of simulations	Deviations of simulation averages
PREBASIC_S	10	9,75	0,34
CERTIFIED_S	2	1,00	1,15
IMPORTED_S	10	9,80	0,28
POTATOES	4	3,98	0,61
RECYCLED_S	4	1,77	1,50
SUPPORT_N	-3	-2,56	1,37
MANIPUL_M	10	9,88	0,18

Global sat. at this stage	262	267	

5.3 Discussion and Policy Making.

In this section we use the previous analysis of the model to partially answer the above placed q.1 to q.5 questions. Some of these questions will be better addressed in further research and experimentation with the model, as will be explained below.

To partially address such questions we need to refer to the alternative/contrasting rationally defined above, represented by a saneSPP (efficiency and efficacy are in accordance to the view indicated by such a rationality). This system must be well supported by the STATE, and must prefer CERTIFIED_S over RECYLCED_S and IMPORTED_S. In this case, also MANIPUL_M must be low, because the consumers should be very well satisfied: as the consumers' satisfaction increases with the increase of the POTAT_PROD's satisfaction, and decreases with the increase of the MAFIA's satisfaction, a high satisfaction of the consumers occurs if satisfaction of POTAT_PROD is high, and if satisfaction of the MAFIA is low, which requires a low level of MANIPUL_M.

To reach such a system, a structural change is required (in the present system), change that involves transformations in the attitude of the actors, and the implementation of certain policies, especially by the STATE, consumers and POTAT_PROD. For instance, consumers and producers should be better coordinated and motivated to prevent the negative action of the MAFIA, as well as appreciate more the native varieties of seeds, and the quality of the produced potatoes; and the STATE must increase the quantity and quality of SUPPORT_N.

Comparing the addition of the influence (for the configuration of the mean of the simulation runs) of the actors whose attitude is in favor of a saneSPP: PROINPA, and SEEDS_PROD (44+43.9 = 87.9), with that of those actors distanced from this alternative system: SEEDS_PROD, and MAFIA_MARKET (39.7+28.9 = 68.6), we realize that the values are not too different. In addition, both of these two groups of actors have influence lower than that of the POTAT_PROD (97.4). This leads us to conclude that PROINPA and SEEDS_PROD do not have enough influence to facilitate the transformation of the CAS towards a saneSPP, because their influence is not high enough in relation to the influence of the distanced actors. This would be different if they had the help of the POTAT_PROD, who have a very elevated influence. Also, an elevated support from the STATE (improving its actual influence 11.7) could help those actors to move the CAS towards a saneSPP. In addition, MAFIA_MARKET and SEEDS_IMP have important responsibility for the instability of the system and the low availability of potatoes and potato seeds, however their influence is not high enough as to create this problems by themselves alone: also POTAT_PROD and the STATE (because of its contradictory behavior), have responsibility on that. These comments have addressed questions q.1 and q.2.

The fragility of SEEDS_PROD seems to be associated to the competition of SEEDS_IMP and the elevated support the STATE gives to IMPORTED_S. A measure of such fragility is the level of satisfaction of SEEDS_IMP: the influence it receives shall rather be received by SEEDS_PROD. Given that SEEDS_IMP's satisfaction (56) doubles

SEEDS_PROD's satisfaction (26.7), we conclude that SEEDS_PROD are highly vulnerable. This answers question q.3.

Because of the fragility of SEEDS_PROD and the competition of SEEDS_IMP, at the simulation configuration the SEEDS_PROD keep at a low level his controlled resource CERTIFIED_S, what strongly affects the interest of PROINPA, generating a bottle neck between PROINPA's CERTIFIED_S and POTAT_PROD's POTATOES (low level of CERTIFIED_S). This discussion addresses question q.4.

The ambivalent behavior of the STATE can be characterized with a vector having two components: SUPPORT_N, and support to SEEDS_IMP. SUPPORT_N includes both, instrumental and non instrumental support to national production, where non instrumental support is understood as assistance to improve the synergy of the CAS, improving its performance in the direction of a saneSPP, and involving: high aid to SEEDS_PROD, POTAT_PROD and consumers in order to coordinate them better and make them more aware about the need of a saneSPP. Consequently, the action of the STATE can be characterized by the vector (-2.6, 9.8) (state of the relations SUPPORT_N, and IMPORTED_S, see Figure 5). Neither of these components is in concordance with a saneSPP. This allows us to reject the Hypothesis 1 placed above. The defined vector gives an answer to question q.5.

The ambivalent behavior of the STATE could be even better characterized with a three components vector, by separating the two components of SUPPORT_N: instrumental support to national production, non instrumental support to national production, and support to SEEDS_IMP. This characterization of the STATE will be used in further research.

6. Conclusion and Further Research.

In this paper, a model of a system of potato seeds of the Mucuchíes area in Venezuela (the CAS) has been presented, with the aim of understanding better the game of power in the CAS, and some problems that the CAS presents. Among such problem we have: the instability of the price and quantity of produced potatoes, a bottleneck in the production of national certified seeds, and the poor involvement of the Venezuelan State in the CAS. The structure of the model and the simulation results have been analyzed in order to confirm that the model satisfactorily represents the CAS, and to gain understanding of the CAS about the observed problems. This allows to delineate policies that could be implemented to structurally change the actual system towards what we have called a *sane system of production of potato seeds or saneSPP:* a system producing preferably high quality native potato seeds, satisfying as much as possible the national demand.

The structure of the model and the simulation has shown conflicts and convergence of actors, coherently with what is observed in the CAS: e.g., convergence of, on one side PROINPA and SEEDS_PROD, and, on the other side, SEEDS_IMP and the STATE. These two subsets of actors are in conflict. The simulation also allows us to explain the instability of the prices and availability of potatoes in the CAS: it is due to the relatively good level of influence of SEEDS_IMP and MAFIA_MARKET, actors non interested in a saneSPP, compared with the influence of PROINPA and SEEDS_PROD, actors compromised with a saneSPP (the influence of the last two actors is not enough as to overcome the influence of the first two actors). The last two actors would need the compromise in favor of a more stable

CAS of the POTAT_PROD and the STATE, what at present does not occurs, in order to overcome the influence of the two first actors. Additionally, the model has permitted to explain better other important matters observed in the CAS, including: each actor looks for its own interest, without any trust on the others (the simulation configurations are close to the Nash equilibrium), the low involvement of the STATE in the CAS (shown by its low instrumental and almost inexistent non-instrumental support to national production of potato seeds, and its good support to imported seeds, which compete with national certified seed). We have concluded that a higher involvement of the STATE, while maintaining its actual attitude, is not enough to help in moving the CAS towards a saneSPP, but rather a deeper change on the STATE attitude is required (the STATE must be re-educated, to say it in some form).

All this permits a better understanding of the problems observed in the CAS, and consequently an improved position to design policies and strategies to transform the CAS towards a saneSPP. Among the policies identified in the paper, some are oriented to improve the organizational form (better integration and coordination) and the awareness of the potato consumers and potato producers respect to the need of a saneSPP. This will increase the potato consumers' and potato producers' motivation, as well as their action capabilities and effectiveness in favor of decreasing the actual difficulties of the CAS (working along PROINPA and SEEDS_PROD).

In further research we will elaborate a descriptive and a SocLab model of a saneSPP, founded on: (1) theoretical ideas, and (2) empirical observation of a community system of production of potato seeds (the *Mano a Mano* ("hand to hand") organization, see: https://consumirdeotromodo.wordpress.com/), which presents practices coherent with a saneSPP. This model will be used to contrast and comprehend better the CAS, and as a reference to design policies oriented to transform the actual CAS into a sane CAS. We will test the following hypothesis:

Hypothesis 2: In the actual CAS, an STATE reeducated and highly identified with a saneSPP would significantly favor the increase of national production of potato seeds, and would facilitate the transformation of the actual CAS towards a saneSPP.

We will also explore the difference between a STATE identified with the actual system, and a STATE identified with a saneSPP, by experimenting and comparing the model of the actual CAS with the model of a saneSPP. This contrast will help us in delineating policies to direct the actual CAS towards a saneSPP. Such policies will be created working along the involved communities, including the MANO A MANO community.

7. References.

Agropatria (2015). *AgroVenezuela. Ministerio del Poder Popular para la Agricultura y Tierra*. Retrieved on November 2015 from: http://www.agropatria.com.ve/

Alarcón Lisbeth (2015). Modelado y Simulación del Sistema de Acción Organizada de Producción de Semilla de Papa del Municipio José Antonio Rangel. Undergraduate Final Project. Universidad de Los Andes. Mérida.

Axelrod, R. (1997). Advancing the Art of Simulation in the Social Sciences. In R. Conte, R. Hegselmann and P. Terna (Eds), Simulating Social Phenomena (pp. 21-40). Lecture Notes in Economics and Mathematical System. Springler-Verlag.

Crozier, M. (1964). *The Bureaucratic Phenomenon.* University of Chicago Press.

Crozier M., and E. Friedberg (1980). *Actors and Systems: The Politics of Collective Action*, The University of Chicago Press..

El-Gemayel, J. (2013). *Modèles de la rationalité des acteurs sociaux*. PhD of the Toulouse University, France.

Fuenmayor Ramsés (2006). *El Estado Venezolano y la posibilidad de la ciencia* (*The Venezuelan State and the Possibility of Science*). Edited by Fundacite-Mérida, Mérida, Venezuela. http://www.cenditel.gob.ve/carpetas/archivos/fuente/291

Llambí, L. (2012). Procesos de Transformación Territorial y Agendas de Desarrollo Rural: El Municipio Rangel y la Asociación de Productores Integrales del Páramo (PROINPA) en los Andes Venezolanos. *Agroalimentaria*, 19-30.

PROINPA. (2015a). *Red Socialista de Innovación Productiva Integral del Cultivo de Papa municipio Rangel Estado Merida,Venezuela.* Retrieved on November 2015 from: http://www.innovaven.org/Timotes/2a%20Sesi%C3%B3n%204a%20R%20Romero.pdf

PROINPA. (2015b). *PROINPA Mérida Venezuela*. Retrieved on November 2015 from: http://proinpameridavenezuela.blogspot.com/

Romero, L. (2005). La estrategia de la semilla en el sistema papero de los Andes de Mérida. Una visión desde la perspectiva agroecológica. *Tesis de Doctorado*. Mérida, Venezuela: Instituro de Ciencias Ambientales y Ecológicas, Facultad de Ciencias, Universidad de los Andes.

Romero, L., & Monasterio, M. (2005). Semilla, Actores e Incertidumbres en la Producción Papera de los Andes de Mérida. Realidades y Escenarios Bajo en Contexto Político Vigente. *Cayapa*, 35-58.

Romero, L., & Romero, R. (2007). Agroecología en los Andes Venezolanos. *Investigación*, 52-57.

Romero, R. (Enero de 2015). Contexto Politico Vigente en en Municipio José Antonio Rangel. (R. Rojas, Entrevistador)

Rojas Raví (2015). Descripción del Sistema de Acción Organizada de Producción en Torno al Cultivo y Producción Semilla de Papa: Caso Municipio José Antonio Rangel. Undergraduate Final Project. Universidad de Los Andes. Mérida.

Sibertin-Blanc C. et J. El Gemayel (2013a). Boundedly Rational Agents Playing the Social Actors Game - How to reach coopération". In *proc. of IEEE Intelligent Agent Technology Conference*, O'Conner L. (Ed.), 17-20 nov., Atlanta.

Sibertin-Blanc C., Roggero P., Adreit F., Baldet B., Chapron P., El Gemayel J., Mailliard M. et Sandri S. (2013b). SocLab: A Framework for the Modeling, Simulation and Analysis of Power in Social Organizations », *Journal of Artificial Societies and Social Simulation* 16 (4) 8, jasss.soc.surrey.ac.uk/16/4/8.html.

Simon H. A. (1982) *Models of bounded rationality: Behavioral economics and business organization* (Vol 1 and 2). The MIT Press.

Simon H., 1998. Economic Rationality: Adapative Artifice, In *The Science of the Artificial, 3rd Edition*, p. 26-50, The MIT Press.

Sibertin-Blanc, C., Teran, O., (2014). "The Efficiency of Organizational Withdrawal vs Commitment". In *Proceedings Social Simulation Conference (SSC 2014)*, Barcelon (Spain), 02-05/09/2014, Francisco J. MIGUEL (Eds.), Universitat Autonoma de Barcelona.

Squazzoni, F., (2012). *Agent-Based Computational Sociology*, Wiley

Terán Oswaldo, Christophe Sibertin-Blanc y Benoit Gaudou (2015a). "The influence of moral sensitivity on organizational cooperation". *Kybernetes* (Emerald), Vol. 44 Iss 6/7 pp. 1067 – 1081. (enlace http://dx.doi.org/10.1108/K-01-2015-0015).

Terán Oswaldo, Ravi Rojas, Liccia Romero, Lisbeth Alarcón (2015b). Model of the social game associated to the production of potato seeds in a Venezuelan region. Open ABM. Available at: https://www.openabm.org/model/4606/version/4/view.

Velásquez, N. (2002). Desarrollo Sustentable, Modernización Agrícola y Estrategias Campesinas en los Valles Altos Andinos Venezolanos. *Los Andes, Escenarios de Cambio a Distintas Escalas*. IV Simposio Internacional de Desarrollo Sustentable.