CHAPTER 17

THE TERRITORY AS A COMPLEX SOCIAL SYSTEM

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1 INTRODUCTION

The concept of territory as a social construction, bounded by a geographic space, increasingly predominates in the elaboration process of public policies for sustainable regional development (Saquet, 2010; Boueri and Costa, 2013). It is in the social dimension, supported by public policies, that arises the bottom-up development and the organized and articulated local initiatives which trigger territorial socio-political-economic events (Claval, 2008).

The territory arises, thus, as the integration mechanism for public actions, because it is considered that, at some time, all government interference will take effect and will be influenced by it. The spatial character of public policies is a reality, especially when dealing with issues of regional development. In Brazil, some Ministries have used the territorial approach to leverage policies, plans and programs of development, with emphasis on: the National Regional Development Policy of the Ministry of National Integration (MIN), the National Plan for Water Resources of the Ministry of the Environment, and the Program of Territorial Development of the Ministry of Agrarian Development (Matteo et al., 2013).

However, Ministries do not share the same concept of territory. While the MIN develops its national policy for regional development bolstered by the promotion of the economic dynamism of micro and meso Brazilian regions, the Ministry of the Environment has been working with the territory bounded by river basin and has as goals, among others, the decrease of extreme hydrological events and conflicts about water. The Ministry of Agrarian Development (MDA), through its Department of Territorial Development (SDT), has as goal the sustainable development of contiguous rural areas. These areas must present some characteristics, such as: strong presence of family farming, low population density (< 80inhab/km^2), and an "active civil society".[2] Based on these indicators the SDT/MDA created the Rural Territories that constitute groups of municipalities and their

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2. Active civil society means that there are many organized social groups which represent the civil society and that they interact and make formal and informal communicative connections to make collective decisions.

neighbors which share some commonalities regarding economic, cultural or historical identities (Brasil, 2005).

Some challenges arise when analyzing the territory under the bias of its social dimension. Despite being a strong concept in geography, the territory still needs to develop its bases in other disciplines such as sociology and economics (Abramovay, 2007; Signoret, 2011). In fact, the territory can be considered a complex system with the subject, the social actor or a set of social actors, being in the center of the process of territorialisation (Moine, 2006; Leloup, 2010; Queirós, 2010; Encarnação et al., 2010; Lima, 2011; Signoret, 2011). Signoret (2011) argues that the territory is a process of adhesion of some collectivity to a common project linked to economic activities or simply to a historical cultural legacy that reinforces the elements of identity and belonging. However, despite this progress, many questions are still open when it comes to the analysis of territorial systems: what would be a suitable theoretical-methodological framework for this study? If the territory is a fuzzy social construct, how to map these spatially located social phenomena? Trying to answer these questions, this chapter integrates some concepts of geography, sociology, and computing to structure a scientific basis for the study of the territory via the systemic approach.

Thus**,** the territory will be analyzed as a socioterritorial complex system, where the social relations will be studied in the light of the Sociology of Organized Action (Crozier and Friedberg, 1977; Moine, 2006; 2007). This social theory has been formalized in mathematical terms, Sociology laboratory (Soclab) framework,[3] so as to allow a systematic observation of the social systems (Sibertin-Blanc, Amblard and Mailliard, 2006; Sibertin-Blanc et al., 2013). The process of social modeling using the Soclab framework has been applied to some analysis' problems of territorial collective action, such as: a water management in France (Adreit et al., 2009; Casula, 2011; Baldet, 2011) and the mapping of territorial institutional social relations in the Southern Rural Territory of Sergipe (Silva, Sibertin-Blanc and Gaudou, 2011; Silva et al., 2014; Silva, 2014).

Using the concepts and techniques discussed here, this chapter intends to contribute to the formulation of a theoretical-methodological framework for the evaluation of socioterritorial systems which allows the development of diagnostics, as well as the analysis of the consequences of territorial public policies. This chapter will also: demonstrate how the territory and its social components can be systemically analyzed, by the definition of the socioterritorial system; present the Soclab framework, which is a formalization of the Sociology of Organized Action used for analysis of socioterritorial systems; and show some applications of socioterritorial analysis by the Soclab framework.

3. The term Sociology laboratory framework (Soclab framework) corresponds to a method of sociological research based on systemic modeling and computational simulation. However, the term Soclab is also used to describe the software that assists this process, the Soclab software.

The chapter is organized as follows: section 2 presents the socioterritorial systems, where the territory is treated as a concept and defined in the light of the theory of systems; section 3 introduces the Sociology of Organized Action social theory that will be used as reference in our territorial sociological analysis; section 4 unveils the Soclab framework; it describes the metamodel SOA/SCA, its mathematic formalization, the methods of modeling (identification of social actors, resources and their relations) and social simulation (social game); section 5 investigates the prisoners' dilemma according to the Soclab framework; section 6 shows an example of a hypothetical socioterritorial system modeling and simulation; section 7 presents some applications of the Soclab framework to socioterritorial systems, emphasizing the analysis of social power relations in the Southern Rural Territory of Sergipe; section 8 provides the final considerations.

2 SOCIOTERRITORIAL SYSTEM

This section presents a territorial definition based on the social systemic approach, the socioterritorial system. This idea is supported by the fact that the social dimension plays a key role in modern territorial development and that the territory must be treated as a concept and investigated from a sociological perspective.

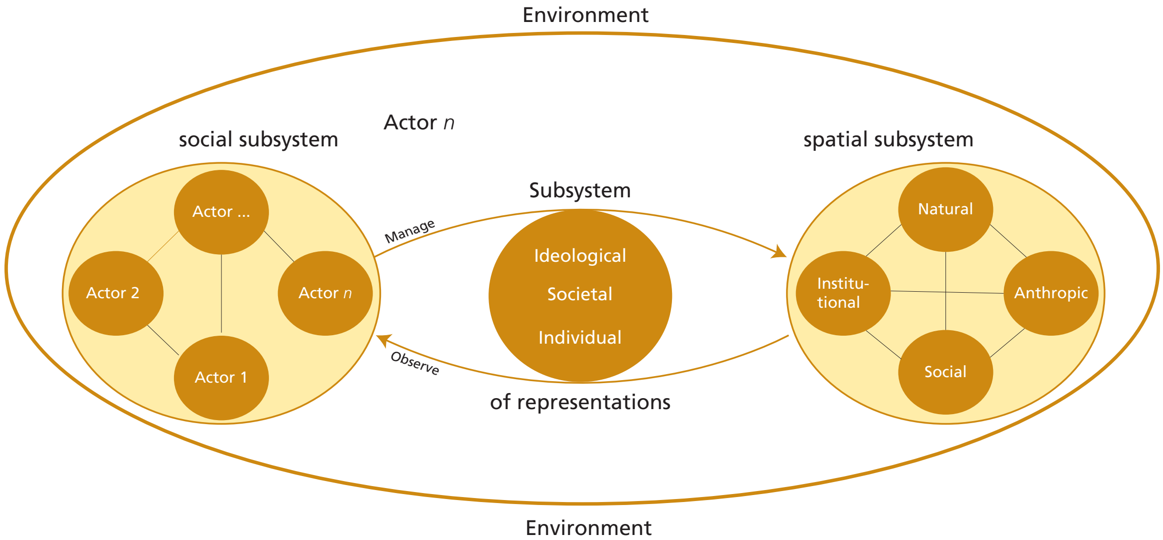
The influence of decisions' decentralization on collective actions focused on regional development is growing due to the complexity of interdependencies among the social actors and the public power at various scales (Claval, 2008). One of the basic premises of this new model is the bottom-up endogenous development, which emerge from local actions and consultations, in addition to the agreements and balances of opposing political forces that are nourished of regional dissemblances, such as cultural identity and history. Then, it is necessary to study the territory considering the dynamics of its social dimension, in addition to its biophysical attributes and its political and administrative divisions.

Saquet (2010) has produced an in-depth analysis of the evolution of the territory as a concept and concludes that there is a need for a focus on social relations, with an emphasis on systemic and integrative approaches. Leloup (2010) highlights the importance of social relations in territorial analytical study as well as the coordination among the actors in the process of territorial development. The author, as well as Lima (2011), emphasizes the following requirements for the composition of a territory: the subject, the social actors with certain autonomy; a common project; a geographical limit; and some territorial regulatory process. According to Signoret (2011), territory only exists if there is a collective project that assembles the people around a common theme and that increases the social interdependence.

The territory is not only the landscape where social relations happens, but also the result of this complex social network which composes it.

In the conceptual territorial systemic model proposed by Moine (2006; 2007), see figure 1, it is observed three subsystems that communicate with each other and form the socioterritorial system, they are: the subsystem of social actors, which brings together communicational processes, strategic decision-making and governance; the spatial subsystem that gathers components of lived space; and the subsystem of representations that acts as an ideological, societal and individual filter between the two other subsystems. According to Moine (2006, p. 126; emphasis added), "*le territoire est un systéme complexe évolutif qui associe un ensemble d'acteurs d'une part, l'espace géographique que ces acteurs utilisent, aménagent et gérent d'autre part*". [4]

FIGURE 1
Socioterritorial system



Source: Adapted from Silva et al. (2014).
Elaborated by the author.

The three subsystems designed by Moine integrate the spatial dimension (local, where social actors act on the real space; and global, where social actors decide about the designed space); the temporal dimension (past, present and future); and the organizational dimension, conditioned by the governance system. The socioterritorial system can then be seen as a complex social system, relatively stable, where the social game occupies a central role. According to Moine (2007, p . 41), "*il s'agit d'un ensemble humain structuré qui coordonne les autres actions de ses participants par des mécanismes de jeux relativement stables et qui maintient sa structure, c'est-à-dire*

4. "the territory is an evolutive complex system that associates a set of social actors on the one hand, and the geographic area that these social actors use, modify, and manage on the other hand".

la stabilité de ses jeux et les rapports entre ceux-ci, par des mécanismes de régulation qui constituent d'autres jeux".[5]

Unlike other approaches in geography (Cole, 1972; Christofoletti, 1979), the method discussed here focuses on social actors, who are responsible for territorial governance, be it public or private. Geographic systems as cities, forests and agricultural areas, for example, have the following properties of complexity: indeterminate nature of the causes of the observed phenomenon; impossibility of understanding the problem by isolating its parts; self-organization from the interaction among the various parts of the system; feedback as a reorientation mechanism around the goal of the system; autoregulatory process as a way of maintaining the system; and recursion, which is the definition of the system by itself.

The study of socioterritorial systems requires the addition of the social dimension (social systems) to the geographic systems. This means that new elements of complexity must be added to this analysis, they are: the undefined, unstable and poorly structured character of relations among people and groups, conditioned by different values and cognitive systems; the constant presence of counterintuitive and not expected effects of social actions; the conflict as a constant; and a high degree of nested subsystems with high temporal variability.

Socioterritorial system differs from socio-ecological systems in some aspects. Socio-ecological systems have a predominantly local scope, they usually deal with the optimization of the use of a single natural resource, and they are well defined as, e.g., irrigation systems, fisheries, forestry and extractive activities. In these cases, it is possible to model and simulate the system of collective action and decision-making based on specific criteria such as, e.g., the flow of water, the availability of fish, the deforestation rate or the limit of collection rate in extractive activities. Poteete, Janssen and Ostrom (2010) developed a comprehensive work on modeling and simulation of socio-ecological systems. Similarly, the companion modeling uses the role playing game and simulation of socio-ecological systems to facilitate the negotiation process among the social actors (Étienne, 2010).

Socioterritorial systems have fuzzy borders at a regional scale, and additionally the involved resources go beyond the natural ones. Here, the central issue is governance, sociopolitical power relations in a broad sense. The decision-making procedures are not fully known and informal relations have a great relevance. It is not possible to apply optimization solutions to these socioterritorial systems; the main goal, instead, is to understand its social structure, the relations between the social actors, and its operation on issues that affect the collectivity.

5. "...it is a human agglomerate structured that coordinates the actions of its members by means of game engines (social), relatively stable, and that it maintains its structure, i.e. the stability of these games and the relationships between them, by regulatory mechanisms that constitute other games".

It is concluded that the socioterritorial system can be defined as a complex system, composed of three subsystems (social, representation and spatial), that has as its main objective the regional sustainable development. The phenomenon to be observed is the emergence and maintenance of the social power relations that give governance structure and some social cohesion to the territory. Despite showing diffuse borders and few formal rules, the socioterritorial system can be analyzed as a whole with low cohesion but with clear objectives.

Faced with the need to analyze the territory as a social system by means of a systemic modeling process, it is necessary to choose a social theory that meets the following requirements, it must: be adherent to the systemic thought; emphasize the political social system; and be sufficiently comprehensive to aid the process of understanding not strongly structured social systems. The Sociology of Organized Action (SOA) or Strategic Analysis initially proposed by Crozier and Friedberg (1977) and developed by Friedberg (1993) proved to be in line with the theory of systems (Roggero, 2000); prioritizes informal aspects, i.e. informal management practices and behavior modeling of social systems; and, is sufficiently generic to assist in the process of construction of knowledge about organizations with diffuse borders. Besides, this theory has been applied to the analysis of territorialized problems (Adreit et al., 2009; Sibertin et al., 2013; Casula, 2011; Baldet, 2011; Silva et al., 2014; Silva, 2014).

3 SOCIOLOGY OF ORGANIZED ACTION (SOA)

This section will present the Sociology of Organized Action social theory, its components, premisses and a proposal connection mechanism with the socioterritorial system.

The Sociology of Organized Action (SOA) is based on the study of the organization as a political system, consisting predominantly of power relations among social actors. The SOA has the following principles (Sibertin et al., 2013): *i*) the organization is a social construct, produced by the social actors. In other words, it is self-determined and independent of the external environment. The organization is not only the product of formal standards, but the integration of informal and formal rules; *ii*) the social actor always have enough freedom to achieve their own objectives, as well, it will never become a mere organizational instrument; *iii*) the strategies of social actors are characterized by mobilization of resources to carry out some form of power over the other to achieve their own goals, which are not always in line with the aims of the organization; and *iv*) it is assumed a minimum collective order, which is established by the various interdependencies among the relations of power and dependence.

Crozier and Friedberg (1977) observed the organization (formal or informal) as a social construct, not natural or spontaneous, consisting of a finite set of social actors which share one or more objectives. The actions of the social actors are limited or shaped by formal standards of organization and cultural traditions which have evolved historically. The personal choices that arise from circumstantial situations or which are motivated by internal values also limit the action of each social actor. Each actor will have a certain capacity of action that will guide the definition of his strategies in the social game that, in turn, seeks to balance the collective objectives and individual aspirations.

Thus, the coordinated collective action needs a stabilization mechanism that assists the balance of forces in the social game. In this case, the power acts as a regulator and is defined by the authors as "(...) *la possibilité pour certains individus ou groupes d'agir sur d'autres individus ou groupes*" [6] (Crozier and Friedberg, 1977, p. 65). This action on another individual means to establish a connection, an agreement, a contract between the two. The power can be seen as a consensual relationship and not as an attribute, static and unchanging, of each social actor. These power relations will be, therefore, the structure by which social actors will act. However, the foremost component of this theoretical formulation is the 'uncertainty zone'.

In fact, each social actor will have one or more uncertainty zones as factors for integration within a structured field of action in the social game. The uncertainty zones can be interpreted as a resource controlled by a social actor and needed by others, such as, for example, a specific technical knowledge, a moral ascendancy of an individual in a particular group, the ability to punish etc. Whereas in this social game there is no absolute submission of any social actor. Each social actor will have at least an element of persuasion, uncertainty zone, that he will explore at the moment of elaboration of their strategies. The uncertainty zones are a key concept in SOA. In fact, social actors create interdependence by means of these zones which generates more engagement and social cohesion. These uncertainty zones will structure the power relations that may congeal over time and generate resistance to change.

According to Crozier and Friedberg (1977) the social game unfolds through a System of Concrete Action (SCA) which is nothing more than the context where the social actors and their relations of interdependence are immersed. According to Silva et al. (2014, p. 67):

> SCA is an open system, which disregards the other systems whose actors are part (environment) and that represents an intelligible simplification of the real world from the formalization of the structure of the field of action in study. The SCA assumes a minimum of flow of information and mutual understanding among the actors.

6. "(...)the possibility of certain individuals or groups to act over other individuals or groups".

One of the assumptions of the SCA is that the actor is heuristically rational and seeks the realization of its objectives that are defined within a changing context. The social actor acts, rationally, in function of their assumptions about their partners, and of their interpretations of the actions of them. The focus of the SCA is on the local actions that are, at the end of the process, responsible for the emergence of the social system. To model a SCA it is necessary to identify the actors and their intentions, the relations of control and dependence in relation to the uncertainty zones, in addition to the repertoire of possible strategic behaviors.

It is noteworthy that the majority of territorial public policies aims the sustainable territorial development. This development would be based on the decentralization of governance, in terms of increased social engagement in decisions on the territory, the expansion of the level of communication between the social actors and the construction and expansion of social networks. In fact, in addition to the economic system and the human-nature system, it has been the territorial political system that regulates the power relations that constraint the governance process (Silva et al., 2014).

Therefore, it is seen that the social game is the connecting element between the socioterritorial system and the SCA. The socioterritorial system can be seen as an organization characterized by fuzzy borders and internal rules. In this system the informal rules or historical-cultural behavior are more relevant than any structure or formal rule.

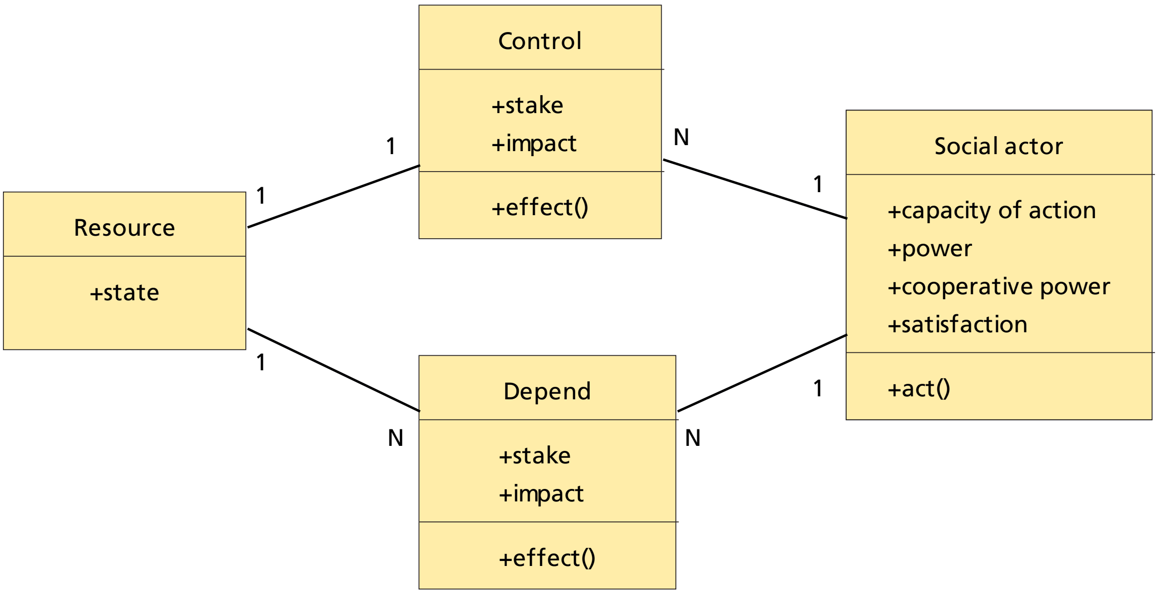
One of the challenges of bringing together socioterritorial systems and SOA/SCA is the correspondence between the social system and the space subsystem. The geographic space or the space subsystem can be considered in three ways: *i*) as an element contributing to the spatial dependence of social actions, so the location could facilitate the cooperation or not by means of physical proximity among the social actors, which may be represented by social relations; *ii*) as a resource or geographic object, which may be represented by means of "uncertainty zones"; and *iii*) as an externality that presses the socioterritorial system which can be another social system, a uncertainty zone controlled by an external social actor or a relation between an element of the system and an external one.

The next section will unveil the Soclab framework that formalize and implements the core conceptions of the SOA/SAC.

4 THE SOCLAB FRAMEWORK

The System of Concrete Action has formalized by Sibertin-Blanc, Amblard and Mailliard (2006); Sibertin-Blanc et al. (2013), by means of the Soclab framework, to allow the theoretical study of computational modeling of social organizations, as well as to serve as a reference for empirical researches on the field. The metamodel SOA/SCA (figure 2) is composed of two central entities, social actor and resource[7] ("uncertainty zone"), and two entities that links each other and which denotes the relations of dependence and control of one or more social actors with respect to a given resource (Sibertin-Blanc, Amblard and Mailliard, 2006). The entity resource represents the uncertainties zones in SOA/SCA and has as attribute its state, which indicates the degree of access of social actors to it.

FIGURE 2
Unified Modeling Language (UML) class diagram for the SOA/SAC metamodel



Source: Adapted from Sibertin-Blanc et al. (2013).
Elaborated by the author.

4.1 Notation and terminology[8]

Formally the Soclab can be defined as follows:

- a set A of N social actors, A = $\{\alpha_1, \alpha_2, \ldots, \alpha_N\}$.
- a set R of M resources, R = $\{r_1, r_2, \ldots, r_M\}$, represented by the vector of states.
- $\mathbf{r} = [\lambda_1\ \lambda_{2, \ldots,}\ \lambda_M]^T$, where λ_m represents the level of access to the resource r_m , $\lambda_m \in [-10, 10]$. The value λ_m indicates the space of behavior or the level of access to the resource r_m by other social actors. In spite of the

7.In the original proposition the resource is called relation. However, it has preferred the term "resource" because it is more clear and refer directly to what it actually represents. The social relation is given by means of shared resources, i.e. when a social actor is related to another means that it controls a resource that is used by the other or vice versa.

8. The notation used in this work differs from that presented in Sibertin-Blanc, Amblard and Mailliard (2006) and Sibertin-Blanc et al. (2013). The changes occurred in order to provide more concise equations and provide clarity to the social simulation algorithm.

numeric value, λ_m has an qualitative interpretation, i.e. , values close to -10 denote difficulties in access to the resource, values around zero indicates the neutrality of the access to the resource, and values close to 10 demonstrate a good level of access to the same.

- the relations of control: A → R, if $\alpha_n \rightarrow r_m$, then α_n controls r_m , i.e., the value λ_m of resource r_m is determined by α_n,. Each social actor must control at least one resource.
- the relations of dependence: A ← R, if $\alpha_n \leftarrow r_m$, then α_n depends on r_m.
- a stake matrix **S**, where $s_{mn} \in [0, 10]$ and $\sum_{m=1}^{M} s_{mn}=10$, where for each dependency relationship between a social actor α_n and a resource r_m will be assigned a stake s_{mn} so that the sum of all stakes for each social actor must be equal to 10. Each social actor will be responsible for the distribution of these stakes.
- a set E of F effect functions, E = $\{e_1, e_2, \ldots , e_F\}$, one for each relation of dependence and control. All functions are continuous with domain D ∈ [-10, 10] and image I ∈ [-10, 10]. For each dependency relationship, the function computes the effect of resource r_m on the social actor α_n that depends on or controls, it having as independent variable the state of the resource λ_m. For each relation of dependence it is possible to calculate the impact, I_{mn}, of the resource r_m on the social actor α_n, $I_{mn} = e_{mn}(\lambda_m)s_{mn}$.
- a matriz $\mathbf{W}_{\mathrm{NxN}}$ of solidarity where $w_{ij} \in [-1, 1]$, $\Sigma w.j = 1$. Being that values close to -1 symbolize a certain hostility toward the social actor α_i with the actor α_j, the value 0 denotes indifference and values around 1 mean a high degree of solidarity. The matrix **W** is not symmetrical, because each social actor defines a degree of solidarity in relation to the others, i.e. each row i of the matrix represents how the social actor α_i observed the degree of solidarity with him in relation to the others.

4.2 The social actor

The social actor is the agent that controls at least one uncertainty zone, or resource in the adopted terminology. It can be an individual or a group, has goals and collaborates directly or indirectly with the socioterritorial system. The strength of the link between the social actor and the social system depends on the number of connections among social actors and resources. For each social actor you can compute their capacity of action C_n (Eq. 1) and power P_n (Eq. 2), the first being the sum of effects weighted by the respective stakes of relations that he depends on, and the second the sum of effects weighted by the respective stakes of relations that he controls. The cooperative power P_n^c (Eq. 3) can be calculated in a similar way to the P_n, but considering only the sum of the positive effects. These values should be computed and compared considering the same value of **r**.

$$C_n = \sum_{\forall r_m \in R | a_n \leftarrow r_m} I_{mn} \tag{1}$$

$$P_n = \sum_{\forall r_m \in R | a_n \rightarrow r_m} I_{mn} \tag{2}$$

$$P_n^c = \sum_{\forall r_m \in R | a_n \rightarrow r_m \wedge I_{mn} > 0} I_{mn} \tag{3}$$

$$S_n = \sum_{j=1}^{N} C_n w_{nj} \tag{4}$$

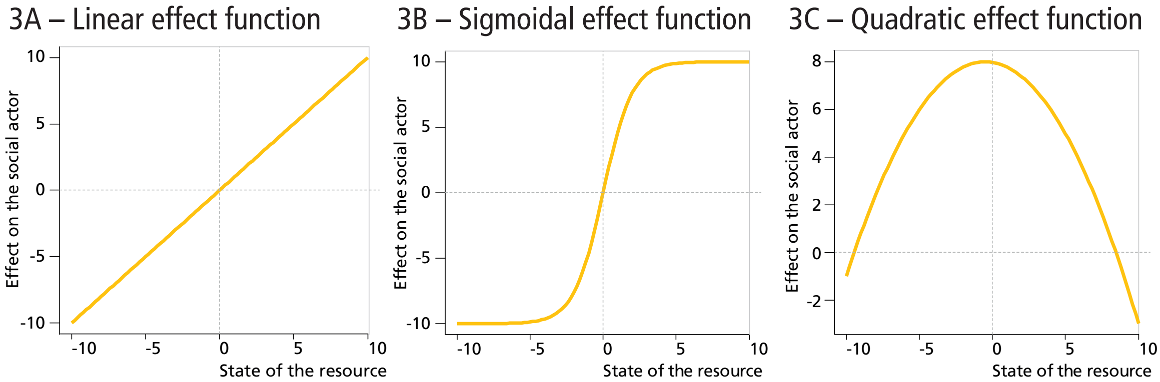
If the matriz of solidarity **W** is taken into account, it is possible to compute the values of satisfaction S_n perceived by the actor α_n (Eq. 4). While the capacity of action quantifies the freedom of action of the social actor, the satisfaction corresponds to the value that will guide their behavior on the basis of the capabilities of the other actors. However, if the solidarities are not considered **W** = diag(1) and $S_n = C_n$.

4.3 The resource ("uncertainty zone") and the effect functions

The resources may be concrete elements such as financial, material or human resources, but also services such as consultancy, technical support, political support etc. Moreover, the geographic space location is a important matter and, thus, it is possible to map these spatial elements as resources since they are controlled by a social actor and shared directly or indirectly by a set of other social actors. The resource is the means by which the social actor establishes the relationship of control and dependence, and your state will define the level of access to it by the social actors.

For each resource, the social actor will specify a value, s_{mn}, which correspond to the level of need for the achievement of their specific goals, measured by the level of satisfaction or capacity of action. To compute the effect a function must be defined, called effect function, which, for each resource-social actor relation, will define the level of effect in the interval [-10, 10] based on the state of the resource, which also varies in the interval [-10, 10]. The curve of the effect function may take any form, however, to simplify the process of interpretation of the results it can be restricted to linear, sigmoidal or quadratic (figure 3).

FIGURE 3
Some examples of effect functions



Elaborated by the author.

The effect function should be interpreted as follows. In the case of a linear curve, passing through the origin of the graphic (figure 3A): the greater the access to the resource, broader will be the effect on the social actor, and vice-versa, and at the origin of the graphic both the access and the effect can be seen as indifferent. In the case of a sigmoidal curve (figure 3B), also passing through the origin: this means that you have a behavior analogous to the linear curve, but with upper and lower limits, i.e., this means that the social actor is sensitive to variations of access to the resource near the origin of the graphic. For a quadratic function with the curve facing down and maximum on the y axis (figure 3C): in this case the effect on the social actor is maximum for the indifferent level of access to the resource and tends to decrease when the level of access to it increases or decreases.

The process of social modelind by Soclab framework should be considered in conjunction with traditional methods of social research. The Soclab framework, however, facilitates and systematize the process of data collection and organization. In Annex A there is a template of a research form to assist the data collection process via interviews, application of questionnaires or, even, based on the experience of the modeler. The software Soclab[9] can be used as technical support to the development of the model and subsequently as the means by which the analysis of the structure, the states of the resources and of the simulations will be performed.

4.4 The social game (the social simulation algorithm)

The Soclab framework defines the social dynamics as being an iterative process where social actors change the state of the resources which they control to achieve their ambitions. This process stops at a particular configuration of states

9. Available at: <http://soclabproject.wordpress.com/>.

of resources, where there is no more interest on the part of the social actor to change their behavior based on their current satisfaction. In computational terms, this behavior is represented by a simulation algorithm where social actors can be implemented as objects endowed with characteristics such as capacity of action, power, cooperative power and satisfaction. Each social actor, or object, will act based on a set of rules created during the simulation process by a reinforcement learning technique. Each rule consists of three components: a vector $\boldsymbol{\varepsilon}$, $\boldsymbol{\varepsilon} = [e_1, e_2, \ldots, e_q]^T$ whose values correspond to the value of the effect function of the resources that it depends on; another vector $\boldsymbol{\delta}$, $\boldsymbol{\delta} = [\delta_1, \delta_2, \ldots, \delta_p]^T$, whose values correspond to the increment, positive or negative, on the resource states that the social actor controls; and a variable F that indicates the strength of the rule. The values of increments and strength are updated every step of the algorithm by Eqs. 5-7, respectively.

$$\delta_{qn}(t) = 2TX(t)\omega,\ \omega \in [-1,1] \tag{5}$$

$$f_1(t) = \big(1 - TX_n(t)\big)f(t-1) + TX_n(t)RR_1\Delta S_n(t) \tag{6}$$

$$f_2(t) = f(t-1) + TX_n(t)(1 - RR_2)\Delta S_n(t) \tag{7}$$

Where $\Delta S_n(t)$ represents the variation in satisfaction of the actor after the application of the rule in time t and ω a random value between -1 and 1. The function $f_1(t)$ is applied to calculate the strength of the rules that are applied at time t-1, while the function $f_2(t)$ to upgrade the strength of the rules applied at time t-2.

4.4.1 Psycho-cognitive parameters

The Soclab framework includes in the simulation algorithm four psycho-cognitive parameters: tenacity, T_n, reactivity, R_n, discernment, D_n, and distribution of reinforcement, $\{RR_1, RR_2\}$, for each social actor α_n. The tenacity takes an integer values between one and ten and determines how much the social actor will explore new rules to achieve his ambition, $K_n(t)$. The higher T_n, greater will be the processing time of the algorithm searching for a solution. The reactivity is also an integer constant, assumes values between one and ten and determines the importance that the social actor attaches to the present and the past in the learning process. The higher the value of R_n, smaller will be the memory which refreshes the exploitation rate, TX_n, and his ambition, $K_n(t)$, the lower the value of R_n, greater will be the importance of the past. The discernment is an integer constant, assumes values between one and five and is used to calculate the threshold γ, Eq. 8, that will be used to define if one rule is applicable or not. So, if the euclidean distance weighted by the stakes between the actual situation[10] and the situation of the rule is less than γ then this rule may be chosen as appropriate. The distribution of reinforcement indicates the percentage of reward that will be given to the rules which led the social actor to a good situation, close to the ambition. At time *t+1* the social actor realizes the effect of the last action track via your satisfaction or capacity of action, and at time *t+2* the actor perceives as the other reacted to their action at time *t*. The distribution of reinforcement of each rule will be divided to these two moments, RR_1 and RR_2, so that you can focus on the immediate perception by assigning a higher percentage for RR_1, or vice-versa, by assigning a greater percentage value for RR_2. The default values are 50% and 50 %.

$$\gamma = \frac{\|S_{n\,max} - S_{n\,min}\|}{D_n} \tag{8}$$

$$C_{n\,max} = \sum_{a_n \leftarrow r_n} \max\{I_{mn}\} \tag{9}$$

$$S_{n\,max} = \sum_j^N C_{n\,max} w_{nj} \tag{10}$$

$$C_{n\,min} = \sum_{a_n \leftarrow r_n} \min\{I_{mn}\} \tag{11}$$

$$S_{n\,min} = \sum_j^N C_{n\,min} w_{nj} \tag{12}$$

4.4.2 Exploitation rate and ambition of the social actor

The rate of exploitation, $TX_n(t)$, of a social actor, $TX_n(t) \in [0.1; 0.9]$ (Eq. 13), determines the way in which the value of ambition, the strength of each rule and the intensity of the action of a new rule will be calculated. The exploitation rate is calculated from the immediate rate of exploitation (Eq. 14), $TXI_n(t)$, calculated at each step of the simulation as a function of the distance between the current situation and the ambition of the social actor, as well as his tenacity.

$$TX_n(t) = \left(1 - \frac{R_n}{10}\right) TX_n(t-1) + \frac{R_n}{10} TXI_n(t) \tag{13}$$

$$TXI_n(t) = 0.1 + \left[\frac{0.8}{1 + e^{\left(-(T_n*(10-T_n)+10))*(dif_n(t) - \frac{10-T_n}{10}\right)}}\right] \tag{14}$$

The ambition of a social actor, $K_n(t)$, is the level of satisfaction or capacity of action desired by him and varies over time. The ambition starts with the maximum value of satisfaction (Eq. 15) or capacity of action (Eq. 16). For the remaining steps it is considered two situations. First, if the social actor not achieved its ambition, then,

10. Represented by the vector containing the values of the effects of all the relations between the social actor and the resources that he depends on.

the ambition will decrease as a function of the distance between the current situation and the ambition, as well as the exploitation rate according to Eq. 17. If the social actor has reached or exceeded its ambition it will increase according to the Eq. 18.

$$K_n(0) = C_{n\,max} \tag{15}$$

$$K_n(0) = S_{n\,max} \tag{16}$$

$$K_n(t) = K_n(t-1) - \left[\left(1 - TX_n(t)\right) * \left(\frac{R_n}{100}\right) * dif_n(t)\right] \tag{17}$$

$$K_n(t) = K_n(t-1) + \left[(S_n(t) - K_n(t-1)) * \left(\frac{R_n}{100}\right)\right] \tag{18}$$

The difference between ambition and satisfaction, $dif_n(t)$, is calculated as a ratio between the satisfaction and the ambition that indicates the part of the satisfaction which the actor has in relation to its ambition (Eq. 19).

$$dif_n(t) = \frac{K_n(t-1) - S_n(t)}{K_n(t-1) - S_{n\,min}} \tag{19}$$

4.4.3 The simulation algorithm

The simulation algorithm is based on the reinforcement learning paradigm, is guided by trial and error and can be summarized in three steps: *i*) perception of social actor; *ii*) decision-making by the social actor; *iii*) execution of the action by the social actor. The ultimate goal of the algorithm is to find a final situation of states of resources **r** such that there is no more interest of each actor in act, i.e., changing states of resources that he controls. At the stage of perception the actor calculates his satisfaction and compares it with his ambition $K_n(t)$. The distance between one and another will determine how the actor will behave in the next phase. At the stage of decision the actor evaluates which rule apply from a list created in the reinforcement learning process. During the execution phase of the action the social actor applies the rule chosen and changes the values of the states of the resources he controls.

The simulation algorithm can be summarized as follows (El Gemayel, 2013, p. 99):

define T_n, R_n, D_n and $\{RR1, RR2\}_n$ for each social actor α_n

initiate r at random

compute the satisfaction $S_n(0)$ for each social actor (Eq. 4)

compute the ambition $K_n(0)$ (Eqs. 15-16)

compute $dif_n(0)$ (Eq. 19)

initiate $TX_n(0)=TXI_n(0)$ (Eqs. 13-14)
for each discrete time t **do**

for each social actor αn **do**

1) **calculate** $S_n(t)$ *(Eq.4)*; $dif_n(t)$ *(Eq. 19)*
2) **update** $K_n(t)$ *(Eqs. 17-18)*; $TX_n(t)$ *(Eq. 13)*
3) **update** the strength of the applied actions (Eqs. 6-7)
4) **select** applicable rule where ‖actual-situation n – *rule.* ε ‖
5) **if** no selectioned rule **then**

   creates *new rule*

   rule. ← *actual-situation*$_n$

   rule. ← (t)(Eq. 5)

   rule.Strength ← *0*

6) **choose** one rule among the ones with the highest strength or the new one

end-for

for each resource r_m **do**

update the values of the states of the resources according to the values σ of the choosen rules

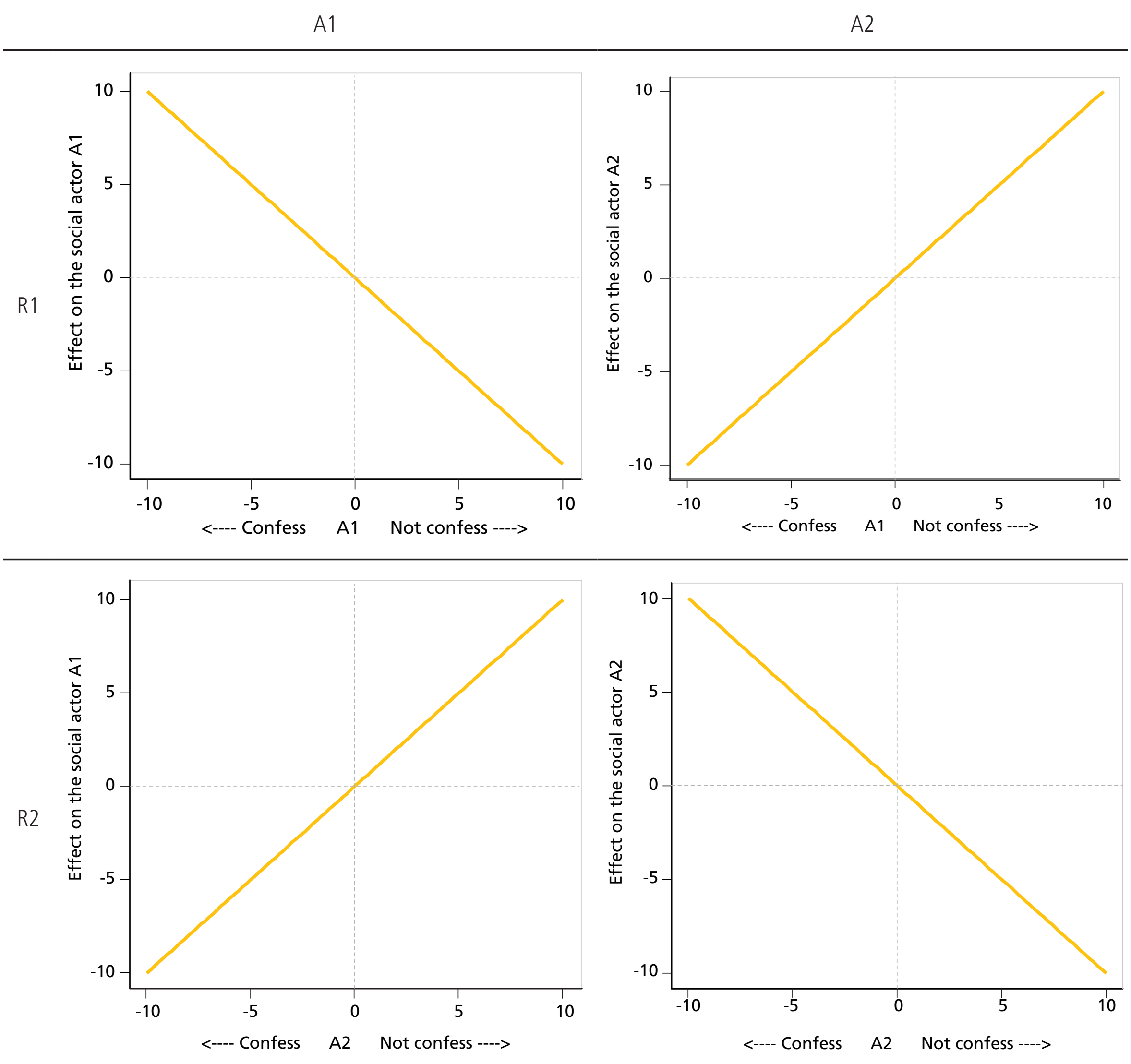
end-for

end-for

5 THE PRISONER'S DILEMMA ANALYSIS THROUGH THE SOCLAB FRAMEWORK

The functions of C_n and S_n can be interpreted as utility functions, as well as are defined in the game theory. So, it is worth to analyze the prisoner's dilemma from the Soclab perspective (El Gemayel, 2013). Consider, therefore, two social actors A1 and A2, suspects and prisoners in two incommunicable and separate jails. Both can confess (C) or not confess (CN) the "delict", and for each combination of choices of these two prisoners there will be a positive or a negative return in terms of time of conviction for each of them. If both deny the crime the joint penalty assigned to them will be the minimum, when both confess the joint penalty is maximized, when one confesses and the other does not, the first will receive the minimum sentence and the other the maximum penalty.

GRAPH 1
Effect function for all relations



Elaborated by the author.

In this situation the uncertainty zone controlled by each social actor is their choice to confess or not. At the same time that each prisoner controls their uncertainty zone, he depends on the status of the situation of the uncertainty zone controlled by the other, then it is observed a situation of interdependence between these two social actors. The distribution of the stakes will follow this situation, because no matter the decision of A1, despite controlling his own uncertainty zone, is the state of the uncertainty zone of A2 that will define the satisfaction of A1.

In this way, A1 assigns the weight (stake) one for the resource that he controls, R1, and the weight nine to the resource controlled by A2, and vice-versa. The resources R1 and R2 will assume states in the interval [-10,10] in a way that negative values mean confess and positive values mean do not confess. It has opted for linear effect functions that behave inversely for each resource and for each social actor as shown in graph 1. Observing R1, it is noticed that A1 will have more positive effects if he confess independent of the choice of A2, state of R2. The same happens with A2 for R2 and R1 (El Gemayel, 2013).

Table 1 shows the capacities of action (C_n) calculated from a combination of particular values of R1 and R2. If it is considered the overall C_n, which is the algebraic sum of the capacity of actions of the social actors, the best case happens when both not confess (80,80) and the worst case, when both confess (-80, -80), that corresponds to the Nash equilibrium (Dutta, 1999).

TABLE 1
Satisfactions for social actors A1 e A2 considering particular values of R1 and R2

		R2 states		
		-10	0	10
	-10	-80/-80	10/-90	100/-100
R1 states	0	-90/10	0/0	90/-10
	10	-100/100	-10/90	80/80

Elaborated by the author.

The social simulation, considering different values of the stake distribution, shows that the social game changes according to how social actors weight the relevance of the resources that they control and depend on. The table 2 presents the results of simulations performed using the Soclab software for the social system presented above. According to El Gemayel (2013), it has considered the same values of discernment (D_n=*1*), tenacity (T_n=*5*), reactivity (R_n=*5*) and distribution of reinforcement {$RR_1=s_{nR1}*10\%$, $RR_2=s_{nR2}*10\%$} for both social actors. The simulation has performed one hundred simulations with 200,000 steps each one at most.

The distribution of stakes denotes how a social actor will face the social game. If someone puts more stakes on the resources that he depends on it means that he expects a cooperative game, otherwise, if he puts more stakes on the resources that he controls, then the game will be a non-cooperative one. The simulations have performed varying the stakes for each social actor from zero to one, or from totally cooperative (0/10) to totally non-cooperative (10/0), according to the table 2. The results showed that: the capacity of action is maximum in the extremes and decreases until the minimum value, zero, when the stakes are equally distributed; the final states for the resources stabilizes positively for cooperative social games and negatively for non-cooperatives ones; and it needs more steps of simulation to reach the equilibrium when the stakes are equally divided.

TABLE 2
The results of the social simulation for the prisoner's dilemma taking into consideration the variation of the stakes distribution

	Stakes distribution of social actor A1 for the resources R1 and R2										
	<- Totally cooperative				Nash equilibrium			Totally non-cooperative ->			
	0/10	1/9	2/8	3/7	4/6	5/5	6/4	7/3	8/2	9/1	10/0
Capacity of action for A1 (average)	100	80	60	40	20	0	20	40	60	80	100
State of the relation R1 (average)	10	10	10	10	10	-10	-10	-10	-10	-10	-10
Number of steps needed for the convergence (mean)	1060	5646	13644	18446	19486	21183	17232	14766	11888	6320	25

Elaborated by the author.
Obs.: It is shown only the results for the social actor/resource A1/R1 because this social game is symmetric, so the results for A2/R2 are exactly the same.

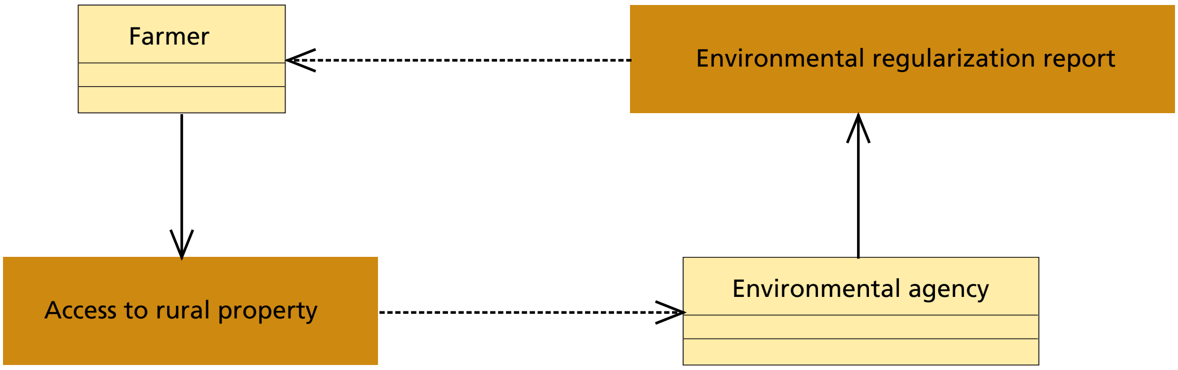
It is important to notice that the social game in the Soclab framework tries to reach a stable state observing the sum of the all social actors' capacity of action/satisfaction. The table 2 shows that, in this social game, this stability is equivalent to the Nash equilibrium only when the stakes are equally distributed.

In sum, this exercise showed that the Soclab framework can be a suitable tool to design social games and, by the effect functions, to generate payoff matrices.

6 EXAMPLE OF A HYPOTHETICAL SOCIOTERRITORIAL SYSTEM

Consider a socioterritorial system composed of two social actors, the farmer and the environmental agency. The first controls the resource "access to rural property" while the second controls the resource "environmental regularization report" (figure 4). The environmental agency must have physical access to the resource controlled by farmers, while the farmer needs to regularize their property to have access to financial resources. Although it seems a win-win game, if the farmer fully facilitates the access of the environmental agency it may compromise its production and consequently his income; if the farmer completely block the access he will not have the means to finance their activities. On the other hand, the environmental agency cannot fully exercise its supervisory power because it can lead to mistrust the farmer that may eventually block the access to the rural property. The environmental agency, then, would seek to maintain a level of access to this resource controlled by farmers to achieve, at least, the minimum goals of the agency.

FIGURE 4
UML diagram for the hypothetical model of the hypothetical socioterritorial system



Elaborated by the author.

Once defined the social actors and the resources that make up the system, it is necessary to proceed with the distribution of stakes for each resource, i.e., define the weight of each resource for each social actor within the socioterritorial system (table 3). Although dependent on the environmental regularization, the farmer allocates more stakes, six, for the resource "access to rural property", because the risk of having their economic activity blocked by environmental monitoring prevents him from giving more attention to resource controlled by the environmental agency, four stakes. In turn, the environmental agency depends almost entirely on the "access to rural property", eight stakes, in order to attain the internal goals of the agency through the "environmental regularization report", two stakes.

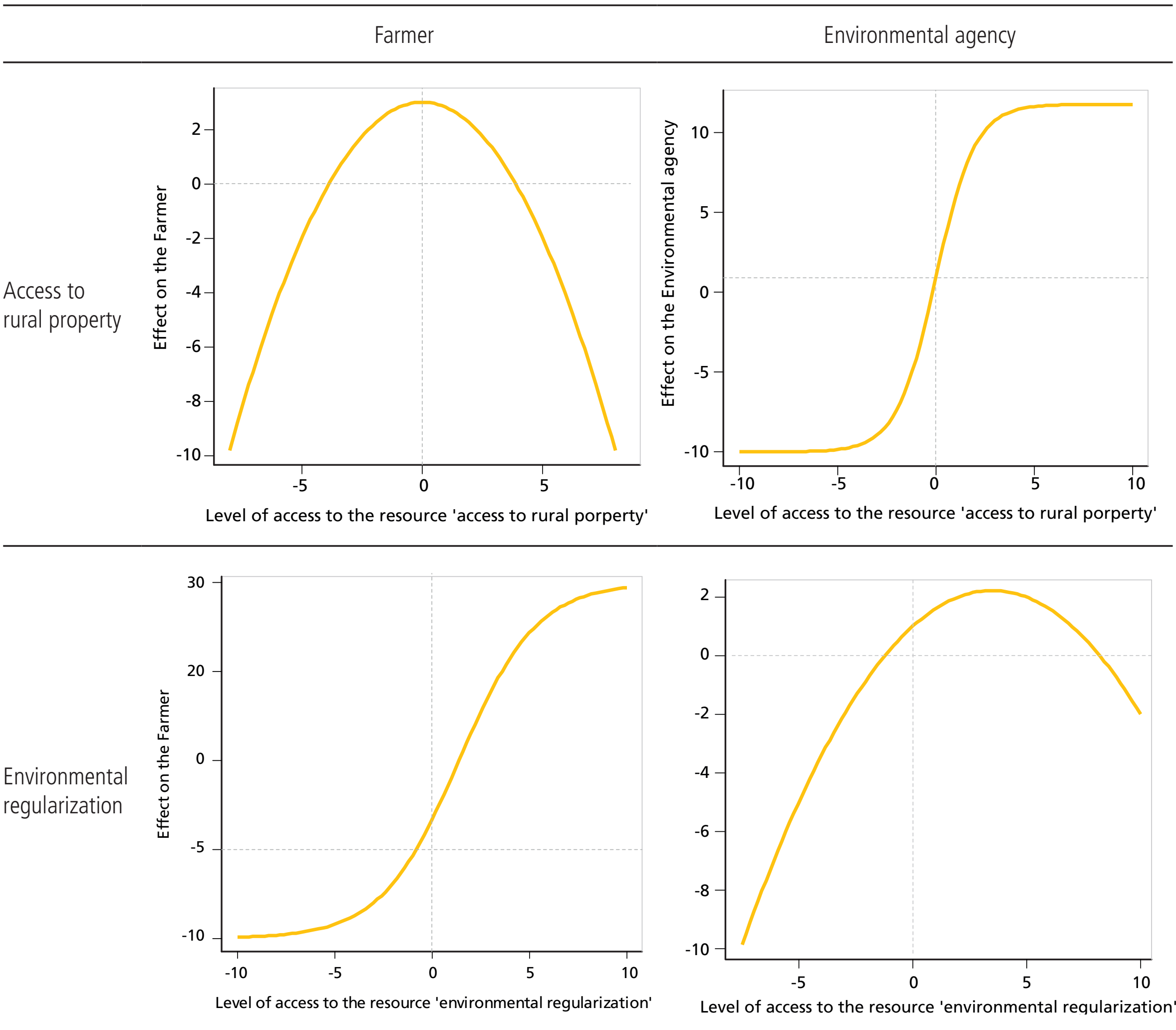
TABLE 3
Distribution of stakes by resource

	Farmer	Environmental agency
Access to rural property	6	8
Environmental regularization	4	2

Elaborated by the author.

The effect functions describe, by means of a continuous curve with domain and image in the range [-10,10], the effect of the resource on the social actor that depends on it. In this hypothetical case, it has four effect functions as shown in graph 2. The effect function of the farmer for the resource "access to rural property" is quadratic and means that the effect increases if the access to this resource is near to zero (neutrality). The effect function of the same actor for the resource "environmental regularization report" is sigmoidal, i.e., the greater the access to this resource greater will be the effect on the rural producer. For the environmental agency the effect function for the resource "access to rural property" is also sigmoidal with lower and upper limits equal to -8 and 8, this means that the greater the access to rural property better will be the impact on the agency. However, for the resource "environmental regularization report" the agency has its peak in return for a certain access, the minimum goal of the environmental agency, and decays to the other states.

GRAPH 2
Effect functions for each relation social actor – resource



Elaborated by the author.

After running the simulation algorithm for this case it has observed that the socioterritorial system reached its stability in an average of 11,843 steps, for the states of "access to rural property" and "environmental regularization report" equal to 4.18 and 5.95, respectively, with an individual capacity of action equal to 104.93 and 76.48 for the actors farmer and environmental agency, respectively (table 4). These values correspond to 66% and 68% of the percentage equivalent to the maximum possible capacity of the actions of the respective actors.

The analysis of the capacity of actions and states for the various iterations of the simulation algorithm, see table 4, show that the environmental agency has less freedom because it depends on a restricted resource. The resource "access to rural property" varied less because it will be in a narrow limit that the farmer can achieve the best of their capacity of actions.

TABLE 4
Mean and standard deviation for capacity of actions and resources for converged situations from the simulation algorithm

		Mean	Standard deviation
Capacity of action	Farmer	104.93	5,26
	Environmental agency	76.48	2,19
State of the resources	Access to rural property	4,18	0,47
	Environmental regularization	5,95	1,20

Elaborated by the author.

7 APPLICATIONS OF THE SOCLAB FRAMEWORK IN SOCIOTERRITORIAL SYSTEMS

The empirical origin of SOA and its formalization through Soclab framework allowed the application of this theoretic-methodological approach in some territorial problems of analysis of collective action (Adreit et al., 2009; Casula, 2011; Baldet, 2011; Silva, Sibertin-Blanc and Gaudou, 2011; Silva et al., 2014; Silva, 2014). These applications can be considered as analysis of power relations in socioterritorial systems and presents certain general characteristics such as: are inserted in contexts of territorial multidisciplinary research; are exploratory and not conclusive approaches; to some extent, the social actors related to agriculture, the main human activity which modifies the natural environment, are present in the governance of the all analysed socioterritorial systems.

The next two subsections will briefly review these works and describes in some detail a case study about the analysis of power relations in the Southern Rural Territory of Sergipe, Brazil.

7.1 A brief review

Although the Soclab framework had been elaborated to deal with any kind of collaborative social studies the main focus has been the analysis of socioterritorial systems. Casula (2011) used this approach to investigate the social structure around the water management in Corse, France, and showed that it increase our capacity of understanding the microfoundations of the overall behavior of that kind social system.

Adreit et al. (2009) applied the Soclab in sociological analysis of the behavior of social actors tied to agriculture in the river basin Adour-Garonne, southwest of France. This is a vulnerable area in terms of pollution of rivers and their tributaries mostly due to agricultural activity. According to the authors, although the Soclab framework be more appropriate for exploratory analysis of the social structure and their power relations around a particular set of resources, it is possible to use the results of modeling and simulation to take concrete decisions. Thus, from the analysis of the capacity of action and power, according to the definitions of Soclab, the authors evaluated the acceptability and applicability of public policies elaborated to reduce the pollution of the rivers.

Baldet (2011) and Sibertin-Blanc et al. (2013) analyzed the conflicting relations between social actors involved in the prevention and management of flood risk in the basin of the river Touch, southwest of France. This scenario has two groups of social actors, those who represent the municipalities of agricultural areas and those who represent the municipalities of the metropolitan area of Toulouse. The first are obliged to reserve part of their arable area to prevent flooding in urban areas, represented by the second group. The solution adopted was the change in perspective regarding the interpretation or conceptualization of the river, it should be managed as an integrated element in an ecosystem and not simply as a continuous flow of water. The social actor SIAH, intermunicipal association for the management of the river Touch, was responsible for this perspective change.

In this study the Soclab framework has been used to evaluate four hypotheses: *i*) the social actor SIAH, according to the actor-network analysis, is an obligatory passage to the other; *ii*) the social actor SIAH holds the means to introduce significant changes in the management of flood risk; *iii*) the social actor SIAH has allies with enough power to impose his strategy; and *iv*) the agreement on the "Territorial Public Interest" extinguished the main conflicts in territorial system. The authors validated the first three hypotheses and concluded that the social actor SIAH has enough power to drive the paradigm shift and that this power is purely cooperative. In spite of this, the paradigm shift hasn't ended the conflict between these two opposing groups.

7.2 The Southern Rural Territory of Sergipe, Brazil

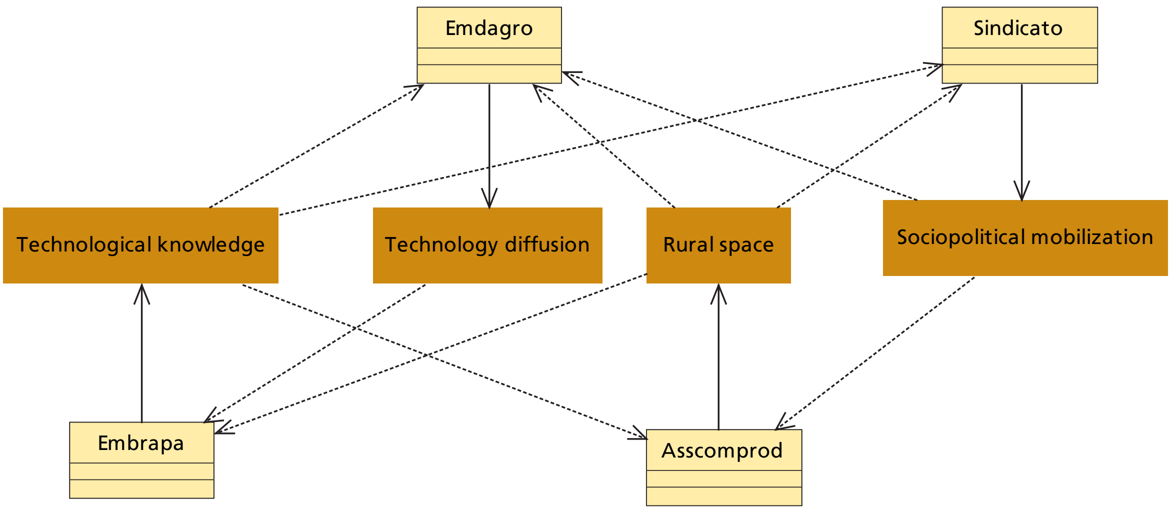
Silva et al. (2014) applied the Soclab framework in modeling the Southern Rural Territory of Sergipe (SRTS), which is part of the Sustainable Rural Development Public Policy of the Ministry of Agrarian Development (MDA). This empirical research had as objective the survey of the main social actors and their relations of interdependence in order to serve as a possible baseline for future analyzes of the impact of territorial policy of the MDA. The analysis took as a point of departure the territorial council, which is responsible for the coordination and governance of the SRTS.

The Southern Rural Territory of Sergipe, Brazil includes twelve municipalities. The total population comprises 278,955 inhabitants, of which 44% resides in rural areas. It has more than a thousand settled families and 20,599 rural properties attached to the familiar agriculture. The agriculture (orange and coconut) and livestock are the main rural economic activities (Siqueira, Silva and Aragão, 2010).

The Ministry of Agrarian Development (MDA) created the SRTS in 2007. To rule this new entity, it has created a council, composed of representatives from institutions tied to the familiar agriculture, to design a plan for a sustainable territorial development. Despite some initiatives, this process is still going on. In general, it has perceived a fragile social engagement around the territorial council and a sectoral bias that isolates the territory from other economic, environmental and social actions.

The research has executed by means of interviews, questionnaires and documental analysis and the first social actors and resources draft became visible in Silva et al. (2014). This paper showed that some social actors, associated with the environmental conservation and to the economic activities, does not take part in the SRTS council and that there was not a strong engagement among the communitarian rural associations and the council. So, it has decided to model only the relations among social actors that have strongly tied with the SRTS Council. The solidarities were not considered, so $S_n = C_n$.

FIGURE 5
UML class diagram for part of the SRTS socioterritorial system



Elaborated by the author.

7.2.1 The model

It has assumed that: the behavior of social actors which are part the same group is homogeneous enough to allow us to represent it by only one social actor (e.g., associations, unions, majors, banks and municipal councils); it is possible to identify informal relations among social actors by yours institutional resources.

Figure 5 shows part of the UML class of the SRTS socioterritorial system. In this graphic some social actors have represented (Emdagro, Sindicato, Embrapa and Asscomprod) as well as their resources and the links among them.

The chart 1 shows the social actors from the SRTS and the resources controlled by them (Silva, 2014). For each resource it has defined a range of accessibility which denotes whether one resource is available or not and in what extent.

CHART 1
The list of social actors and their resources

Social actor	Social actor's description	Resource	Resource's description and accessibility
Pronese	The Company for Sustainable Development of the State of Sergipe manages programs and activities in rural areas with a focus on poverty reduction, managing credit programs and design of environmental management plans.	Consulting on SD	Consulting on sustainable public policies for rural areas. There is no restriction to access this resource, so the accessibility is in the range [-10,10].
Emdagro	The Agricultural Development Company of Sergipe works with the family farming and sustainable agriculture.	Technical assistance and rural extension	The lack of structural capacity limit the access to it and prevents a greater commitment of Emdagro with their customers, so there is some restriction to access it [-8, 8].
		Technology diffusion	Range of access is [-10,6].
Asscomprod	The communitarian/producers associations organize the community politically and administratively.	Rural space	The access may not be complete and is rarely inaccessible, [-9,9].
Banco	The Banco do Nordeste, the World Bank and the Banco do Brasil finances low cost projects for local sustainable development.	Financial resources	The range of access is [-6,6].
Condem_ Cmds	The Economic Council for Municipal Development / The Municipal Council for Sustainable Development.	Plan for municipal development	The plan for municipal development by CONDEM/CMDS. It can assume extreme situations, [-10,10].
Prefeitura	City hall	Public policies for municipal's sustainable development	This resource can assume extreme situations, [-10,10].
Sindicato	Rural workers' Union.	Sociopolitical mobilization	Meant sociopolitical mobilization as the ability of the Rural workers' Union to mobilize people for the defense of the union ideology. Range of access is equal to [-9,9].
Embrapa	Brazilian Agricultural Research Corporation.	Technological knowledge	The access to it is extremely limited due to various social and not social aspects of our society, [-5,5].

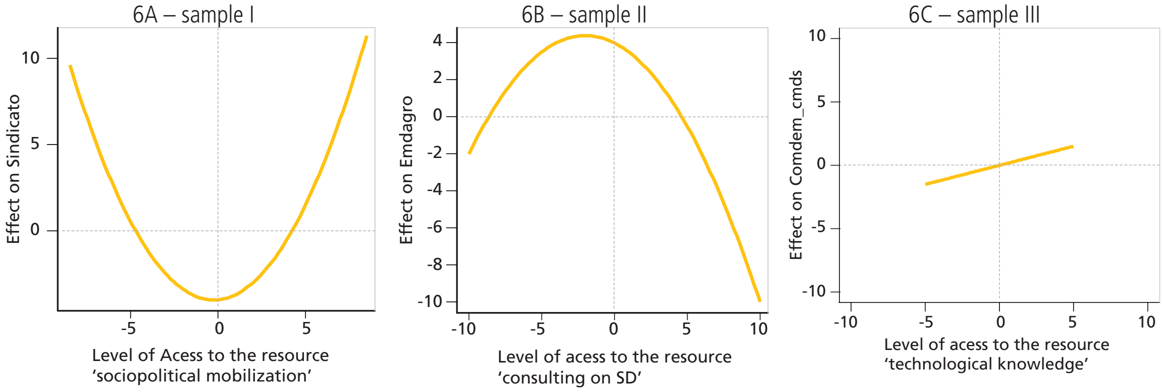
Source: adapted from Silva (2014).
Elaborated by the author.

The stakes of the social actors have distributed to all resources according to a cooperative social game, so each one put more stakes on resources controlled by others. As expected, Embrapa is the least dependent on the others. As an agrarian research organization with a limited capacity to technology diffusion its stakes were put on resources controlled by the Emdagro and in the rural space controlled by the Asscomprod (Silva, 2014).

The effect functions are illustrated in figure 6. The effect of the resource "sociopolitical mobilization" on the Sindicato social actor reflects that it will be negative only for a situation where people are apathetic, the value of this resource is around zero. Otherwise, this social actor, which represents the rural's labor force, will get positive effects for negative values of the resource, which means sociopolitical demobilization or vulnerability, and for positive values, which means a completely social engagement (figure 6A).

Figure 6B shows the effect of the resource "consulting on SD", controlled by Pronese, on the Emdagro. The parabolic curve shows that the extreme difficulty of access this feature negatively affects Emdagro, as well as the abundant supply, because Emdagro not have the means to reach the demand generated by the unrestricted access to the resource. The impact will be positive only for intermediate situations, so a restricted access can be a turning point and forces the Emdagro to assume the role of consultant in sustainability. The effect will also be positive for slightly easier access situations, as this would generate requests of feasible actions by the Emdagro.

FIGURE 6
A sample of the effect functions from the model



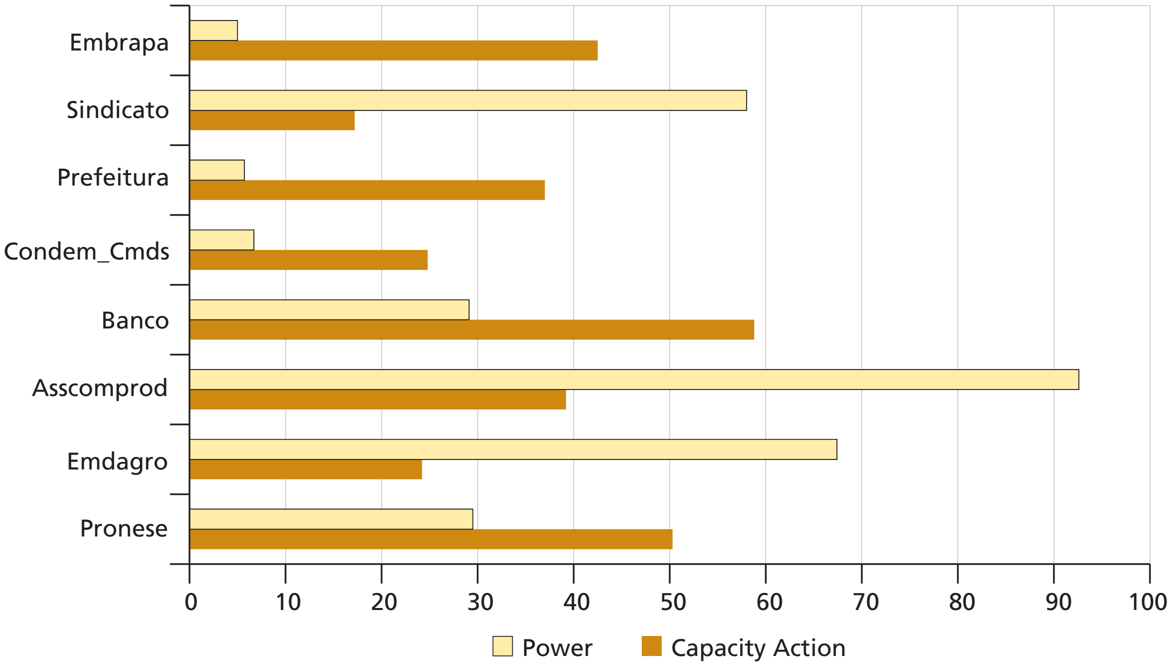
Source: Silva (2014).
Elaborated by the author.

The last graphic is a good example of a restricted resource, range from -5 to 5 (figure 6C). This short straight line shows that the effect of the "technological knowledge" on Comdem_cmds is almost insignificant, or that this social actor does not use such kind of information in the decision making process.

7.2.2 The simulations

To perform the social simulation to check if this socioterritorial systems is stable or not, and to see how is the distribution of power and capacity of action among social actors it has used the Soclab software. It has considered default values for all psycho-cognitive parameters and performed 100 simulations with 200,000 steps each one at most. The social simulation algorithm reached the stability in 98% simulations with an average steps of 73,883.

GRAPH 3
The average value of capacity of action and power for stable social games after one hundred simulations



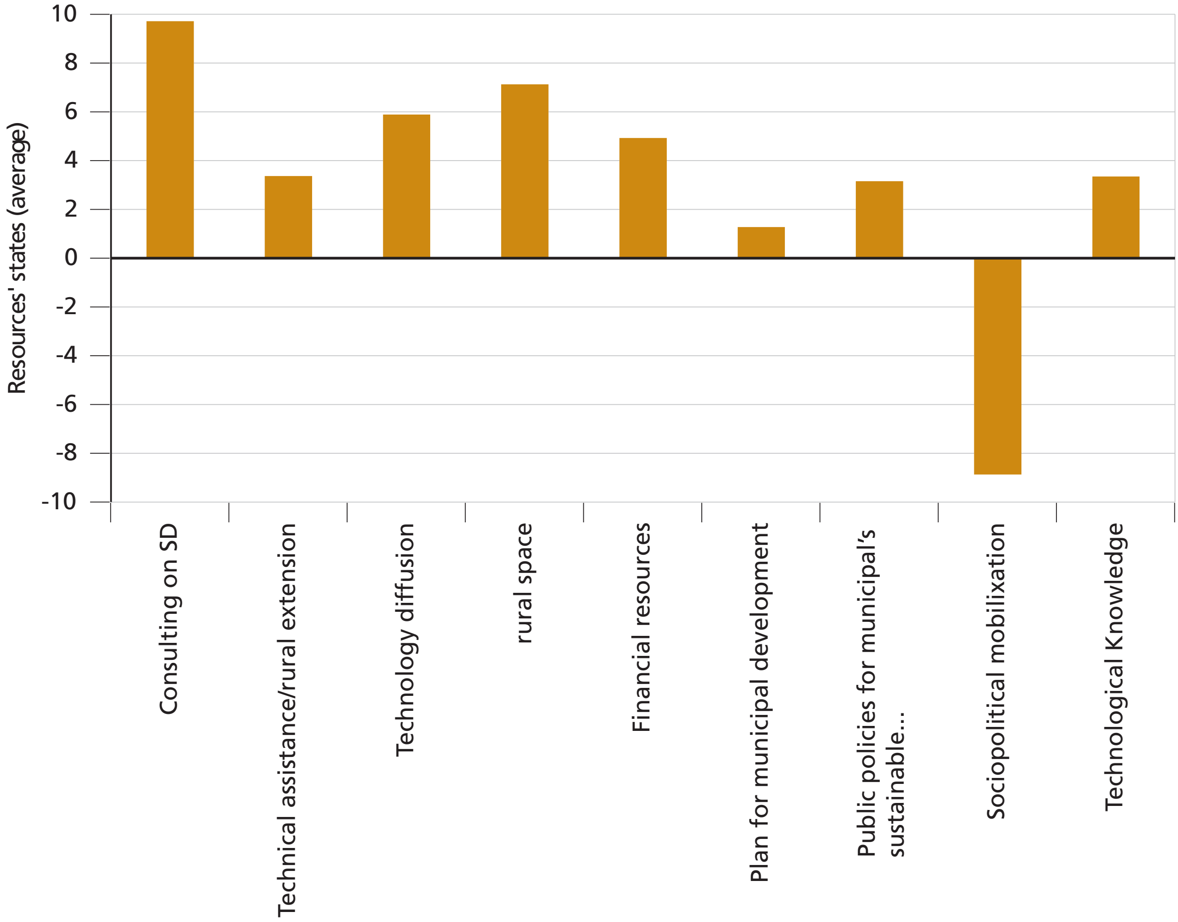
Elaborated by the author.

The graph 3 shows the average values for capacity of action and power for all social actors. The Banco, the Pronese and the Embrapa have high scores for capacity of action (55.09, 49.30 and 41.23, respectively), this means that they have more chances to cooperate with others. The Sindicato is the social actor with the worst capacity of action (16.70), this suggests that the Sindicato is somehow locked and placed with a limited space of action. Despite of the centrality and importance of the Emdagro it has a small capacity of action (20.62), so the two resources controlled by this actor do not give him the necessary capacity due to its opposition to others actors and its limitation to attend the demand for rural assistance. Analogically, the same occurs to the Prefeitura and to the Condem_cmds.

The most powerful social actors are the Asscomprod (92.6), the Emdagro (67.4) and the Sindicato (58), this means that they control important resources and which maximize the impact on each of these social actors. In fact, the Asscomprod controls a key resource, "rural space". The Embrapa (5), the Prefeitura (5.7) and the Condem_cmds (6.7) have the worst values for the variable power.

Only two resources presented a greater access to it after converging simulations, "consulting on SD" controlled by the Pronese and "rural space" controlled by the Asscomprod (graph 4). In fact, they are key social actors that shares their resources without restriction. Some resources' states stabilized in the neutral region, around zero, this means that this socioterritorial system shows some kind of indifference toward local initiatives (plan for municipal development, public policies for municipal's sustainable development) and to the technological developments.

GRAPH 4
The average value of the resources' states for stable social games after one hundred simulations



Elaborated by the author.

7.2.3 Territorial public policy assessment and some remarks about this case study

A comprehensive assessment of a territorial public policy is a tough task and it demands a multidimensional approach to take into account as many as possible aspects of the reality to be understood. The Soclab framework address part of this challenge but does not offer a falsifiable and conclusive method. However, it showed to be effective to systematize the information from sociological studies, to map social relations, to evaluate the stability of these interdependences, and to construct a baseline for future comparisons of different relational states for the same socioterritorial system.

In our case study, the Soclab framework showed some evidences that the SRTS socioterritorial system could be interpreted as a stable organization, that presents some characteristics which must be addressed in order to explain the overall functioning of the system, such as: it showed to be, to some extent, sectorial, so privileging only matters related to the family farm group; there are some resources with restricted access; and, there is a power/capacity of action distribution imbalance among the social actors. Obviously, one way to change this scenario is adding new social actors to bring a new structure to the social game by changing the formal and informal rules of the territorial council.

Silva (2014) evaluated two scenarios for this socioterritorial system by changing a effect function and the range of access to a resource. All the results have evaluated/validated by researchers with enough expertise to judge the plausibility of the simulation outputs.

8 FINAL CONSIDERATIONS

Although there are already mechanisms of territorial observation, it is important to emphasize the need for interdisciplinary methods that integrate the different concepts of areas of the guiding principles of sustainable development. In this chapter the theory of systems is used as the common thread of connection between the social system of actors, their relations of power and space system through the Soclab framework. The socioterritorial system approach can be modeled for different purposes and proved to be applicable in the processes of territorial public policy evaluation.

The analysis of power in socioterritorial systems through SOA allows the establishment of the interdependencies between the various social actors through the relations of control and dependence on the "uncertainty zones" which can serve as subsidies for studies in the areas of social networks and social cohesion. The strategic analysis does not allow one to conclude categorically if some sociterritorial system will reach or not your goals, but if he has the necessary conditions for this instead.

The conceptualization territorial proposal by Moine shows a tendency to focus the analysis of the human-space interaction in the system of social governance. However, this new direction adds to the process of territorial analysis the challenge to integrate the space system to the social system. This work has been simplified this task through the mapping of geographic elements as relations and resources in the Soclab framework.

The modeling process through the Soclab framework presents increasing difficulty as the number of social actors and resources are added to the model. The main difficulties are the construction of the effect functions that requires deep knowledge of the problem and the analysis of the results of the simulation for the cases with multiple actors and resources. In fact, the simulation algorithm has exponential complexity which imposes limitations of computacional processing simulation.

One of the main applications of the Soclab framework is in the exploratory analysis of the social relations to search: whether or not the socioterritorial system is stable and in what conditions it occurs; if there is an imbalance in the distribution of power between social actors, which can explain, among other things, the indifference of certain actors; and the establishment of a baseline for comparative purposes. Of course, the use of Soclab framework also creates a standardized record of territorial sociological investigations.

The process of social modeling and simulation creates opportunities and challenges for research and development in various areas, such as: a multivariate statistical analysis of the results of the simulation; the evolution of the link between the spatial system and the social system; the spatialisation of the results and subsequent connection with models of land use; the analysis of the social system by means of other social theories; and the design of systems of analysis and monitoring of territorial public policies.

Finally, it is expected that the method of modeling and simulation exposed in this chapter could collaborate in the process of understanding the complex socioterritorial systems as well as assisting the government in the planning and development territorial public policies.

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ANNEX A

TABLE A.1
Simplified suggestion of a survey form for the construction of socioterritorial model (mainly, the effect functions) based on Soclab framework

Social Actor:________________________________	Relevant resources ("uncertainty zones") for the social actor		
	A	B	C
1. What resources are needed for the completion of their tasks and achieve their goals?			
2. Who controls the resources?			
3. How important is the resource for your activity? (0.10)			
4. Describe your behavior in the case of restricted access to feature			
5. Evaluate the effect of the behavior described in item 4 in its activity (-10.0)			
6. Describe your behavior for the case of unrestricted access to feature			
7. Evaluate the effect of the behavior described in item 6 in its activity (0.10)			
8. Describe your behavior for the case of neutral situation with regard to access to feature			
9. Evaluate the effect of the behavior described in item 8 in its activity (-10,10)			
10. What is the situation usal with regard to access to the resource?			
11. Evaluate this situation in terms of impact on their activity (-10,10)			
12. For each social actor assign a value which represents a solidarity degree with the others. Values close to -1 means a situation of conflict, values close to zero denote neutrality or impartiality, while values close to 1 correspond to a cooperative relationship.			

	Social Actor A	Social Actor B	Social Actor C	Social Actor D	Social Actor E	Social Actor F
Solidarity						

Source : Sibertin et al. (2013).

The values of question 3 should be normalized so that the sum of all and peer assessment resulted to the social actor is equal to ten. Questions 4 to 11 should be used for the construction of the effect functions. The values of the question 12 will be used to construct the matrix $\mathbf{W}_{NxN}$.

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