Spore: an Action-Learning Support System for Incubating Regional Cooperative Innovation Networks

Summary

This paper describes a pilot project for incubating cooperative regional innovation networks (CRIN) around three problematics related with regional sustainable development: water, housing and goat milk production and quality. Incubation was designed as a two-step action learning process named Problematic-Innovation Cycle (P-I Cycle). Participants collectively elaborated a set of increasingly complex set of representations, from ante-narratives and dynamic models to scenarios. Action group learning was facilitated in several settings where systems concepts and tools were applied. Four different approaches –Complex Adaptive Systems, SECI, System Dynamics and Model Based Agent- were applied to model the incubation process. The project took place in Coahuila, a northern Mexican State, with the voluntary participation of stakeholders of each addressed issue. Two types of results were obtained -knowledge systems on each addressed problematic and incubation models- which have being incorporated into a State action-driven policy making effort to strengthen the regional innovation system by enhancing social capital as a key stock to launch cooperative innovation efforts.

1. Introduction

Innovation is becoming a lever for sustainable development, economic competitiveness and social wellbeing. To reach its effectiveness, innovation has to unfold at the regional level taking many different interrelated paths, building new interfaces and communities, empowering agents, weaving regional and federal policies, adapting organization strategies, and stimulating learning, trust and cooperative behaviors among the institutional and local practitioners.

Traditionally approaches to innovation have been demonstrated to be a weakening strategy[1] (OECD, 2009), particularly in regions with low economic growth affected by a myriad of complex problematics and with low or missing linkages between the innovation actors. One of the many challenges faced is the transformation and strengthening of the local innovation policy process -making, enacting, evaluating and redesigning and the lack of policy organizations.

Until now the making of innovation policies has been a predominantly top-down process leading to fragmented strategies, with scarce consideration of the regional contexts and moved predominantly by the particular interest and inclinations of scientists, based on the assumptions that innovation is triggered by ideas nurtured within scientific laboratories, without enough concern for complex regional issues. This approach, from the lab to the market, has being effective in rich industrialized countries within high-tech fields such as biotechnology, requiring abundant financial resources to walk all the way through the market place. These resources are impossible to be deployed by developing nations.

For regional innovation numerous assets such as social and human capitals and physical infrastructure, are greatly needed. Nonetheless, the most important issue is the capability to combine and mobilize them strategically. This capability, frequently missed by policy makers, includes addressing the regional framework conditions, properly designing innovation strategies, mobilizing various necessary resources including political, financial, personnel and social support, implementing the agreed strategies, and evaluating their performances. To be effective and self-sustaining, these elements must be incubated regionally from local capacities and many cooperative forms -alliances, consortia, networks, communities- have to be experimented as part of the new regional interfaces that need to be created.

1.1. Innovation in Latin-American Countries

Innovation, whatever definition -open, networked, non-lineal- is adopted, has become a mantra for national development. Latin American Countries (LAC) are not the exception, facing the challenge to transform their traditional science and technology structure into a more sustainable development, social needs and market oriented network system.

From the sixties, countries as Argentina, Brazil, Chile, Mexico and Venezuela started to build-up their human capital and physical infrastructure that unfolded into a highly centralized structure, focused on scientific problems and with weak linkages between Science and Technology (S&T), industrial policies and development strategies. In all cases there is the urgency not only to increase S&T expenditures, presently, except Brazil, below 1% of GDP, but also to diversify their policies and institutional and organizational framework in order to speed up linking science and technology with their developmental needs and, at the same time, to become part of the global knowledge flows. To speed up this process, LAC will need to

[1] . Specialized literature on the transition from lineal and sequential models of innovation to a non lineal forms such as open, networked, sequential, cooperative and many other is abundant.

overcome their inclination to imitate the lineal and sequential innovation model, characterized by developing first the infrastructure and human capital and later on to find out how to link them with the context.

1.2. A New Innovation Paradigm

For LAC, being part of the dynamics of the global economy implies transforming their still dominant lineal innovation models. However, evolution should not be a gradual improvement of existing approaches, but a dramatic change on the collective perception about innovation and its relations with the regional context. This implies looking into innovation beyond a codification process of information emerging from the labs, seeing it instead as a change in its epistemological foundation, leading to develop and articulate the social capabilities not only to transfer a new goods to a global market but to incubate the social perceptions of the critical regional issues, perceptions that should be in continuous change as a consequence of collective learning. Perceptions must mobilize knowledge into actions. A new language has to be not only locally adopted but shared meanings have to be collectively nurtured. It is at the local level where concepts such as openness, no-linearity, governance, social capital, tacit knowledge, systemic, networks, cooperation and trust can be converted from buzzwords into policies and daily practices.

1.2.1. Governance and Epistemology

Moving from a S&T system to innovation implies deep transformations no only in the policy making and funding mechanisms but primarily, and simultaneously, on the local culture requiring a more comprehensive, long term, participative and systemic approach. The transit to regional innovation systems implies radical cultural changes; moving from hierarchical structures centrally governed to governance[2] is one of them and constitutes a challenge to coordination, leadership, commitment and vision (Cappellin, 2007). Some studies (OECD, 2005) propose that governance is based on the agents capacities to achieve goals in conjunction with the normal government procedures, by strengthening the network of institutions both inside and outside of the government sphere. Governance accepts an intrinsic ambiguity of responsibilities to address social, economic and environmental issues, recognizing that the innovative power emerges from the relations nurtured in collective actions and in the autonomy of the networked agents. Governance fuses the top-down traditional policy making process with the bottom-up effort based on a different epistemology that relies on the strength of the regional collaborative mechanisms such as alliances and innovation networks.

Recent studies on LAC (Souza, 2009) have emphasized that the new approaches to innovation must start with the acceptance of a new epistemology, as an effort ingrained into the regional fabric, emerging at the local level not in isolation but in synchrony with federal and state policies. The new epistemology should consider some basic principles: (1), a contextual and historical vision shared by the agents; (2), interaction as the main ingredient for understanding relevant innovation; (3), collective commitment as the basis to tackle complex issues; (4), emotion (desires, values, motivations) as the source for action but reason as the guide for regulating the action; (5), to accept the multiple realities emerging from the agent perceptions and their contexts; (6), to understand that scientific practice is a human activity impregnated of values and interests; (7), reality is socially constructed and it can be transformed; (8), the whole (problematic) is dynamic and emerges from its parts and their dynamic relations; (9), ethical and aesthetic values must be negotiated; (10), physical, chemical and biological process must be understood and are independent of human interpretation; (11), relevant social knowledge is the product of interactive process taking place in the application context; (12), problematics are complex research challenges embedded in the context; (13), to interpret and to transform reality is an outcome of shared visions and meanings distilled from a dialogue between the scientific knowledge and the tacit knowledge and wisdom of the agents.

Under such considerations innovation can be conceptualized as a learning constructivist paradigm that interweaves concepts from systems thinking, complexity, organizational learning, action learning and many other social, economic, and management and behavioral sciences.

1.2.2. Investment, Social Capital and Regional Interfaces

A regional innovation system (SRI) is a deliberate dynamic process leading to link the agents around common efforts and interests to bring prosperity through change. Although normally considered technological, a SRI also embraces other interrelated forms and can be considered as a complex web of transactions and joint learning aligned by common goals and outcomes and reinforced by cooperative relations based on trust and communication.

A SRI is composed of stocks of tangible and intangible capitals and their interrelations, stimulated by policies and social behaviors that induce flows of knowledge, information and financial resources. Some stocks such as R&D infrastructure are

[2] . Governance can be considered as the social ability to interpret the complexities of a regional system, to define its problematics and to establish a common innovation agenda that empowers the innovation agents to coordinate their actions and to implement the designed policies, to learn from the gained experiences and to get feedback and lead an adaptive policy implementation process.

tangible while others, such as intellectual and human, have being considered within a broad category of intangibles. Intangible stocks pull together the SRI elements, one is the social capital and others are innovation and other related policies. Social capital, governance and policies integrate the core that relates market and regional sustainable development problematics with innovation strategies.

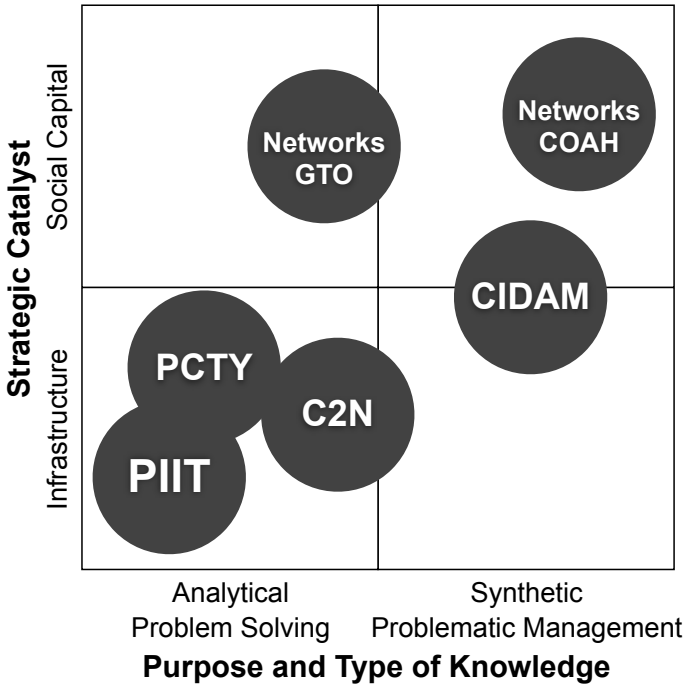
During the last decades the emergence of SRIs has been promoted by a diversity of policies based in a variety of approaches. Most of them emphasize the creation of regional interfaces, bringing together the innovation agents and, as a consequence, reducing geographic, technical and social distances. Interfaces can be classified within two broad extreme categories: one (infrastructure) is focused on building up infrastructure for R&D activities, and it depends on top-down policies and heavy government investments and intervention; the second (social capital) focuses on improving social relations as a catalyst and it relies on a strong emphasis on a bottom-up approach and governance. On-going international cases cover an ample spectrum of interfaces, from science cities, scientific and technological parks, consortia, alliances and innovation networks. All these approaches are based on different sets of policies, goals and approaches to innovation within the regional context.

1.3. Regional Interfaces in Mexico

The approval in 2002 of the Mexican Law of Science and Technology brought a variety of new policies to strengthen not only the physical infrastructure but also the social capital, inducing cooperation among innovation agents. Some of the new policies took the form of new funding schemes to support projects among research groups and regional industry and to create interfaces and a new regional infrastructure. Public Research Centers have being playing a central role both in decentralizing R&D and also in building-up regional learning networks (Casas. 2000; Vonortas, 2002) based on their scientific and technological orientations.

Some of the regional interfaces –science parks, innovation networks, and other cooperative forms- that are being constructed in Mexico in the last decade are shown in the quadrants of figure 1 formed by two dimensions, the catalyst strategy and the purpose of knowledge management.

Figure 1 displays in the quadrants formed by the intersection between purpose and type of knowledge and strategic catalyst some of the interfaces in development in Mexican regions: Parque de Investigación e Innovación Tecnológica in Monterrey (PIIT), Parque Científico y Tecnológico de Yucatán (PCTY, Merida), Ciudad del Conocimiento Nayarita (C2N, Tepic), Centro para la Innovación Agro-Alimentaria de Michoacán (CIDAM, Morelia), Innovation Networks of Guanajuato (GTO) and Coahuila Cooperative Innovation Networks (COAH). Some of these Mexican regional projects shows several weaknesses[3]: some lack coherent strategies while others lack managerial capacity; some are requiring global connectedness to expand markets of their main industries while others need an effective linking of their research outputs to commercialization. However, until now no formal evaluation has been performed on the outcomes. Diversity makes it difficult and ineffective to introduce a single best practice or approach, so that in-house problem-solving and problematic-management expertise are required to respond properly to local problems. Specific cases should rely heavily on social design and adaptive strategies reinforced by a systemic approach.



Regional interfaces created

3. Observations obtained as part of the Spore Project collected in a field tour done in 2011 by the author in cooperation with scientists from the STEPI (Korea).

1.4. Coahuila's Social Capital Approach

The case described in this paper took place in Coahuila, a Mexican State bordering with the United States that is facing many challenges for sustainable development and climate change such as water, housing, and the obsolescence of some traditional production chains. Scientific research and technology development are fragmented, performed by federal research centers and universities. Industry involvement and other innovation agents are just emerging. In spite of having several federal research centers, their involvement is mainly along those scientific issues of interest to the scientists. Several Federal Research Centers located in the state are oriented to advanced scientific topics with scarce relation with state problematics.

The State has several production chains and clusters: automotive, dairy products, manufacturing associated with the global automotive clusters, agriculture, mining and coal. In addition, it faces environmental problematics associated with the arid zones and climate change impact on drought. Fragmentation makes it difficult to design and implement innovation policies and strategic projects; due to this weakness it is difficult to assemble and align resources to regional problematics, thus inhibiting the elaboration of sound and effective policies promoting funding, portfolios and large scale strategic projects (recently the automotive project). Another barrier is the low level of cooperation and trust among the agents, which brings as a consequence a small number of large-scale, strategic innovation projects. Small industries having low technology content but abundant tacit knowledge are rarely considered by external innovation programs.

In 2007 Coahuila (through COECYT, the State's Council on Science and Technology) opted to follow a social interfaces strategy. Considerable effort has been placed on networks as a component of social capital development, and building social capital is a deliberate learning process around regional issues. Since then, several initiatives have been launched promoting the creation of collaborative mechanisms between regional agents and practitioners.

Promotion of innovation networks has been a central component; initially, networks created can be considered as communities of interest (Wenger, 2002), later on some of them can be transformed to communities of practice. In the coming years networks will be the basis for designing the large investment projects represented by Technological Parks. Social capital has been the basis of ideas for interdisciplinary projects already in process on regional issues.

Some lessons have been gained from those efforts: (1), the market is not the only source or destiny, it is entangled with social and environmental problematics; (2), innovation is a system of interrelated functions, not only of R&D activities; (3), it is a social process between many agents and not only a set of relations among clients and suppliers; (4), innovation is more than an agglomerate of fragmented problems and projects, it is instead the continuous updating of the social perception of the problematics, social and technological scenarios and portfolios; (5), museums, parks, laboratories, pilot plants and demonstration units are just one part of the learning and knowledge transfer spaces, others must also be developed; (6), independently of their scientific credentials, individuals have limited capacities to interpret the complex problematics, but those limits can be expanded with proper environments that provide conditions for cooperation and dialogue; (7), nowadays cooperative networks are the dominant innovation strategy in high technology sectors but also can be a leveler for addressing regional issues bringing opportunities for spillovers.

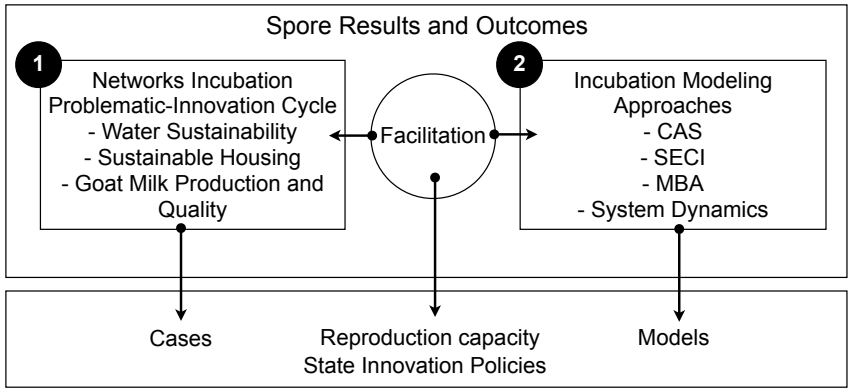
The remaining part of this paper is devoted to describe a project whose aims where to explore an incubation model of innovation networks to reinforce state policies to promote cooperative innovation.

2. The Spore Project

Incubation of Cooperative Regional Innovation Networks (Spore) was an action-learning project that took place from 2009 to 2011. Spore was part of a Coahuila policy-oriented effort to construct regional interfaces starting from building-up social capital as the platform for later on launching investment interface projects. Spore responded to an open call from FOMIX, a matching fund formed by the Coahuila State Government and CONACYT.

2.1. Spore Objectives

Spore Project objectives



The main objective of Spore was to explore mechanisms on how to integrate state innovation agents in a process that brings together not only technical solutions but stimulate actors to elicit their knowledge through a collective, cooperative and guided learning process. This process should contribute to increase social capital by nurturing a regional networked community of practice (Wenger, 2002) capable to build not only a fragmented laundry list of problems and their possible technical solutions that normally respond to individual interests, but to assemble a multi-level knowledge construct about the selected problematics and then generating policy, strategic and tactical R&D recommendations. As a result, Spore would provide cases based on regional problematics claiming for innovation policies and, from the experiences, improve the understanding of the social cooperation process and synthesize experiences into an empirical model. Next figure shows the Spore Project objectives and outcomes.

2.2. From Problem Solution to Problematic Management

Spore was a social experiment designed to explore forms to move from a traditional innovation approach based on the solution of individual problems to a collective process of problematic management. Moving to regional innovation requires a policy making and evaluation process that equilibrates the prevailing analytical approach with a more systemic effort. Table 1 compares "problem solution" and "problematic management".

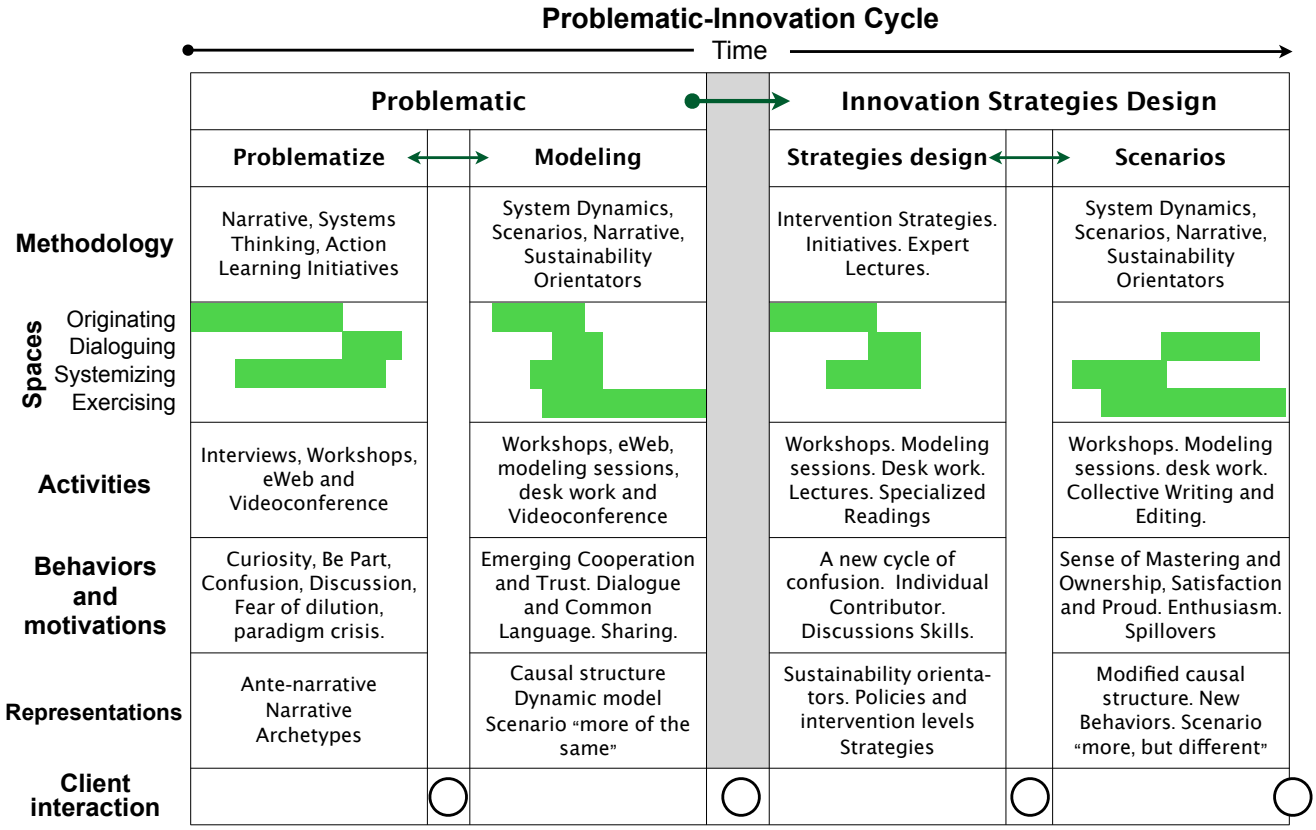
Structure	Problem Solution	Problematic Management
	Cause-effect	Causal loops
Decision makers and stakeholders	One or few	Diverse and numerous
Solutions Options	One, the optimal	Scenarios
Negotiation	Consensus, discussion	Conflict, dialogue
Product, outcomes and impacts	Certainty or calculated risk. Immediate	Unknowns
Probability	Quantifiable	Non-quantifiable
Time horizon	Short, event	Long term, behavior
Transfer	Solution, administration	Scenarios, management
Expert	Specialist	Network
Metaphor	Ockham's razor: solution is the simplest	Ashby's: only variety can destroy variety.
Client	One	Numerous and diverse
Result	Number	Behavior
Strategy	Implanting	Adapting
Context	Closed and controlled	Open
Thinking paradigm	Analytical	Systemic
Contingencies	Determinist	Adaptive

Table 1. **Problem Solution and Problematic Management**

The incubation of an innovation network is based not in an exhaustive and complete information concept but rather in an effort to integrate existing knowledge –explicit and tacit- socially scattered in a group of regional practitioners with the new knowledge catalyzed by cooperation.

2.3. The Problematic-Innovation Cycle (P-I Cycle)

There are many different approaches to analyze the dynamics of inter-organizational collaborative innovation strategies such as alliances, consortia and networks. Approaches are predominantly *ex-post*, vastly using statistical modeling approaches (Doz, 1996;Doz, 2000) and some based in communication analysis (Browning, 1995). The advent of the knowledge economy brought the emergence of new paradigms on organizational learning (Senge, 1990; Nonaka, 1995) and cooperative innovation based on inter-organizational –formal and informal- configurations such as alliances, networks, and consortia. However, there are still few examples on performances and on the analysis and the incubation of new cooperative structures. This is a new phenomenon that is bringing the renaissance of approaches such as action learning (Lewin, 1997; Argyris, 1985) and fusing them with narrative approaches, metaphors such as the rhizome (Delleuze, 1987), systems thinking and other methods. Some experiences from the corporative world are starting to appear (Yu, 2006), and action research is now seen as an acting, modeling and adaptive process.



Problematic-Innovation Cycle (P-I Cycle)

Spore has been an effort to bring together several of these approaches into an experiment, aiming to incubate a set of cooperative networks whose mission is to address complex issues. Incubation is considered as an action learning process that takes place in two basic stages: problematization and innovation strategy design. The next figure describes the basic structure of the proposed P-I Cycle formed by two stages and five key ingredients: Methodologies, Spaces, Activities, Behaviors and Representations.

2.3.1. Problematization

The purpose of problematization is to create an explicit common perception of the problematic and to express it through different representations. The initial stage starts by building up an ante-narrative as a collection of individual stories and to assemble it into a more orderly narrative. The ante-narrative is thus transformed in a diverse set of representations ending in a scenario "More of the same, but worse". Participants are guided through an interaction process to build since the beginning social relations leading to trust, cooperation and dialogue. Activities are diverse, including workshops to elicit knowledge and

perceptions and, at the end, meetings oriented to modeling through several approaches. Documentation is an activity permanently performed. At the end, selected representations are presented to the client (COECYT) and other stakeholders.

2.3.2. Innovation Strategies Design

This second step pursues to identify intervention strategies on the problematic already modeled. Dealing with problematics endangering sustainability, a set of orientators (Bossel, 1998) is initially used as a way to induce discussion. Then, structural diagrams and stocks and flow models are used to locate points of leverage and intervention strategies (Meadows, 2008). At the same time, a new ante-narrative is composed as the starting point of the scenario "More of the same, but better". The intervention strategies are formed by technological, organizational and policy issues that are described with the participation of experts. Throughout the project only local experts participated. Dynamic model structure integrates some of the recommendations and a final scenario is documented. Lastly, a survey is conducted between the network participants in order to create a consensual analysis of the effect of interventions on the sustainability orientators. Results and representations are presented to the client and *stakeholders*.

2.4. Problematical Sustainability Issues

Three regional cases were selected, all of them related with sustainability. Selection came after a process of interaction with the existing "networks of interest" (NofI) promoted by COECYT in two state regions: La Laguna (Torreon) and South-East (Saltillo). Interviews and meetings took place with NofI's coordinators and members (Food and Agro-industry, Climate Change, ITCs, Furniture SMEs, Mining, Biotechnology, Metal Works SMEs, Water, Sustainable Housing, Renewable Energies, and Nanomaterials). Two conferences were organized for project launching: the first introduced Spore objectives, mechanics, and expected outcomes; invited experts presented basic concepts and methodologies to be used; in the second meeting selected NofI's presented their experiences. In both events surveys were applied to decide on the three problematics to be addressed through the P-I Cycles. Three problematics were chosen: Water Sustainability, Goat Milk and Sustainable Housing. Networks were formed by groups of different sizes, formed by scientists, farmers, consultants, government officers, and environmentalists.

2.4.1. Water Sustainability

This is a secular problematic in La Laguna, an important agricultural region formed by counties of Coahuila and Durango states. Concern for depletion of the regional aquifer is part of the regional culture and many policies exist at various levels (federal, state and municipal), however fragmented. Dairy (cow) agro-industry is one of the main economic activities and it is seen by society as responsible for water depletion. There are many actors and active NGOs but their perspectives are fragmented and there is no systemic approach that brings the actors together to improve governance; each actor has his own interest and own representation. In addition health problems in the region, originated by the increasing presence of arsenic in the water aquifer and its consumption by the rural population.

2.4.2. Goat Milk

This is a problematic also located in La Laguna. In spite of coexisting with a powerful dairy agro-industry (cow), which is the second largest in Mexico, goat milk production is an activity in extinction, due to the lack of dysfunctional performance to become a sustainable production system. The main restrictions are water availability and naturally produced feedstock. This problematic can be represented by a complex set of archetypes where, in spite of the high demand by the international market for goat milk products, the low quality of locally produced cheeses, the lack of small firms and local entrepreneurs, and public health problems associated with the manufacture of raw milk cheeses are entrenched with social organization issues and low levels of income among the local milk producers.

2.4.3. Sustainable Housing

Housing in Saltillo is a critical issue, not only due to the increasing demand but also because of climate change and its impacts on the population's well-being and health. This is particularly acute in housing for low-income families ("social interest houses") where government policy application is being managed by specialized federal-level offices. Over the years the quality of the houses has being deteriorating due to several factors: lack of enforcement of quality standards, smaller sizes, and designs that do not consider climatic elements. Recently, federal programs are promoting "green housing" aiming a better use of renewable energies, but there are still cultural, technological transfer and absorption and financial constraints. Besides, these incentives programs are mainly for new constructions and the stock of old and bad-quality houses represent the largest share.

2.5. Action-Learning Support System

Having presented the P-I Cycle, this section describes the elements that are considered as the network incubation support system. The following three basic elements -tools, spaces and facilitation- constitute the Action-Learning Support System (ALSS).

2.5.1. Tool Kit

Spore is an eclectic effort to integrate concepts, methods and tools scattered in several scientific fields, from sociology and narrative, to formal modeling approaches. Effort is placed in those tools that facilitate the cooperation of agents around complex issues, to create qualitative approaches that can gradually be transformed into more structured representations. The following table shows those that were used through the Spore Project; however it is not intended to describe a closed kit, on the contrary, an open one that could be enriched by new tools with improved advantages that improve elicitation and analysis and allow more effective participation and reduce time cycle.

Field	Basic Aspects	Application in Spore	P-I Cycle	Models on Spore
Complex Adaptive Systems (Browning, 1995)	Self-renewing and organizing, chaos and order, co-evolution with the context, emergence.	Interpretation of the incubation process.		Yes
Systems Thinking (Meadows, 2008)	Structure and behavior, to identify archetypes, learning restrictions and causal structure.	To assemble a collective perception by visualizing structures embedded in the narrative.	Yes	Yes
System Dynamics (Sterman, 2000, Rodríguez-Ulloa, 2011)	How the system changes with time and the structural causes and levelers	Problematic modeling and leveraging by interventions and scenarios.	Yes	Yes
Organizational learning (Senge, 1990;Nonaka, 1995)	Knowledge (tacit and explicit). Models, loops and learning fields. SECI concepts and fields.	Strategies for network integration. Interpretation from the learning perspective of the incubation process.	Yes	Yes
Action Learning (Lewin, 1997; Argyris, 1985)	Emotions, tacit knowledge, cooperative behaviors.	Induction of cooperative behaviors and trust. Metaphors for collective interpretation, framing and communication.	Yes	
Communication and Dialogue (Issacs, 1999)	Strategic conversation and creating shared meanings.	To improve communication, create a glossary and trust.	Yes	
Ante-narrative and narrative (Boje, 2011)	To integrate a story formed by multiple voices (polyphony).	Ante-narrative as the starting point of the P-I Cycle and scenario writing.	Yes	
Scenarios (Schwartz, 1991)	Optional futures collective writing.	Two scenarios: problematic unfolding & innovation .	Yes	
Case Study (Yin, 2008; Eisenhardt, 1989)	Empirical research of phenomena in its actual context, when the borders are unclear.	Integration and communication of each addressed problematic.	Yes	
Policy analysis (Roe, 2006)	Evaluation existing policy framework and its effects on the problematic.	Designing of optional frameworks and interventions to support innovation strategies.	Yes	Yes

Table 2. **Spore Tool Kit**

2.5.2. Learning Spaces

Spore is a multi-purpose process, from creating tacit knowledge and trust, to enhancing dialogue and analytical capabilities, both individually and collectively. It takes place in different milieus with the conditions that facilitate the emergence of the required behaviors. Knowledge is context specific in terms of time, space and relations between agents, Spore adopted the concept of Ba (Nonaka, 2003) consisting in the following four learning fields:

Originating. Tacit knowledge is generated. Emotions and experiences are shared by face-to-face interaction. Physical initiatives, games and simulation sessions are used. Tacit knowledge is socialized and perceptions about the problematic are shared and partially fused.

Dialoguing. Tacit knowledge is elicited. Concepts and relations are identified. Definitions are agreed in face-to-face or by video conferencing. As a consequence, an explicit knowledge system starts to emerge.

Systemizing. This field can be also virtual and synchronous. Concepts and relations are modeled. Problematic and innovation strategies are assembled and simulated. Scenarios are narrated.

Exercising. This is an individual and virtual, allowing the internalization of new knowledge through documents and other explicit forms (Brännback, 2003).

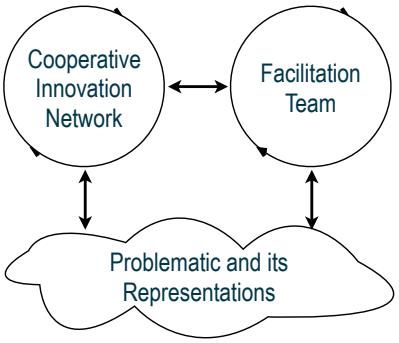
The fields were integrated by a variety of activities, as its shown below:

Type of activity	Effectiveness	Frequency	Type of field
Workshop	High	High	Originating, dialoguing
Videoconference	Medium	Medium	Exercising
Desk work	High	Very High	Systemizing. Exercising
Interviews	Medium	Medium	Dialoguing
Meetings and conferences	Medium	Medium	Originating, dialoguing
Internet, Blogs, others	Low, mainly e-mail	Medium	Exercising, Dialoguing

Table 3. **Events and Fields**

2.5.3. Facilitation Team

Any P-I Cycle required a complex facilitation process that was carried on by a group formed with individual with diverse backgrounds and skills that were enhanced through the cycle. The facilitation team became itself a social network whose relations –social, cognitive and technical- were are created and continuously strengthened. From this perspective, facilitation is not the administration of a series of activities through a predetermined route but instead the creation of an adaptive process that creates its own map through a continuous elicitation and group model building (Vennix, 1995). The aim is to promote the interaction process towards the required collective learning process; facilitation is considered as the process responsible to manage a structural and linguistic coupling (Maturana, 1987).

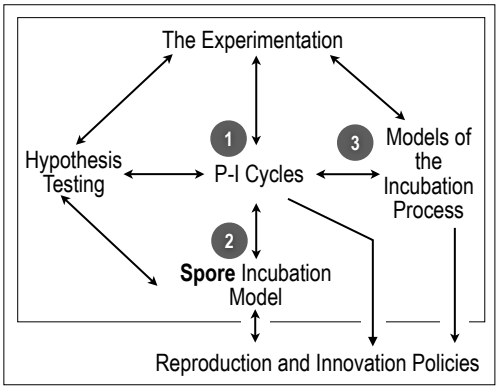


Facilitation as structural coupling

Experiences obtained from the Spore Project indicate that facilitation is a key element and should be a complex mixture of interrelated functions such as Project Coordination, Networks Coordination, Coaching, Modeling, Observation, Communication and Documentation. Team integration is done prior to cycle launching reinforced by continuous learning.

3. The Results

As it was previously presented, Spore was a multi-objective project and its products reflect that condition. The results and outcomes can be considered in the three categories shown bellow and discussed hereinafter.



Spore Results

3.1. The P-I Cycles

Three cycles were performed around the problematics presented in point 2.4. Activities took place simultaneously in two different cities and groups with varying composition and number of voluntary participants. Incubation experiments lasted eight months, larger to the five months originally planned. Execution of the planned schedule faced various difficulties, as synchronizing agendas because all participants were involved under voluntary basis and during working days.

Features	Networks of Practice		
	Water in La Laguna	**Goat Milk**	**Sustainable Housing**
Problematic	Health, Aquifer Sustainability, Governance	Product quality, market failure, system viability	Quality housing, family wellbeing, and climate change
Participants and composition	46. Highly diversified: Users, NGO's, Government Officers, Industrial Managers, Scientists, Consultants	14. Highly diversified: Producers, Scientists, Consultants, Industrial Managers	26. Concentrated mainly in Scientists, Technologists, Architects and Construction Professionals and Consultants
Location	Torreon	Torreon	Saltillo

Table 4. **Cycles P-I Cycles**

3.1.1. Performance of Networks of Practice

Networks of Practice showed diverse performance patterns around collective behaviors that were considered relevant into its evolution dynamics, creativity and productivity. Initial integration of each network was the critical step to nurture the basis of cooperation and flexibility through the network ability to practice different conversation modalities. Group diversity and facilitators skills were key factors to move from a group of individuals centered in their perceptions to a network capable to create a set of collective representations embedding their individual perspectives.

Next table shows qualitative observations around a set of criteria used to assess networks performance. Table shows a final perception of network performance, however behaviors were dynamic in nature, unfolding through each P-I Cycle. Criteria were not part of the starting design but were emerging and identified through observations made by the facilitation team.

Criteria	Water	Goat Milk	Housing
Complexity (elements, relations y loops)	Very high	High	Regular
Identification of loops and Archetypes	Regular	High	Regular
Appropriate dialogue environment	Regular	Very High	High
Skills to identify and negotiate relations	Regular	Very High	High
Collective understanding of structure	High	Very High	High
Expansion of structure by participation	Regular	Very High	High
Spillovers leading to joint projects	High	Very High	Regular

Table 5. **Performance of Network of Practice**

From a more detailed perspective, the next Table presents how each network performed on deploying their activities. Seven operational elements were selected from which several observations can be inferred, such as the high effectiveness of the Goat Milk Network influenced by a manageable size, the coordinator expertise on the problematic and, at the same time, his facilitation skills, and the composition by a diversity of actors, many of them did not have previous relations but these were nurtured through the Cycle.

Performance	Networks of Practice		
	Water in La Laguna	**Goat Milk**	**Sustainable Housing**
Assistance	High. Normally groups with numerous participants (15-25)	High. Small group but activities attended by the majority (15-25).	Low. Highly fluctuating. At the end a consistent group of participants (6-15).
Participation	High. Most of the participants were well informed and emotionally attached to the problematic. However insistence to remain into their perspectives and discourses and initial reluctance to get involved in structured activities.	Very High. Group able to use several conversation modalities. Highly effective to use the different thinking and modeling tools.	Regular. Participants were usually centered in their common technical interests. Improved at the end, once the problematic started to be collectively perceived. Predominance of specialized technical information but difficulty to move beyond.
Coordinator's expertise, leadership and facilitation skills	Highly knowledgeable about the problematic. Highly capable to induce participation. Regular facilitation skills.	Highly knowledgeable about the problematic. Capable to induce participation. Very high facilitation skills.	Regular knowledgeable about the problematic. Regular capable to induce participation. Poor facilitation skills.
Use of Web and Internet tools	Weak. Concentrated in email for administration and transfer of information.	Regular. Concentrated in email for administration, transfer of information and incipient group work on collective documents.	Weak. Concentrated in email for administration and transfer of information. Sporadic use of videoconference.
Use and transfer of information	Very high transfer. Information overloading.	High. A good equilibrium with the problematic needs..	Very low. Reduced use of technical information.
Participants Cohesion	Participants with frequent relations around the problematic. Frequent conflictive perceptions. Gradual learning.	Initial conflicts due different perspective were surmounted. A group with a fast learning and highly integrated at the end of the first step (problematize).	A group interested in the broad issue of sustainable housing, with many local stories about how the future could be endangered by the climate change. Technical expertise but difficulty to expand the model complexity.
Openness	A group with a difficult beginning due to a predominant way of thinking focused on blaming and finding a responsible.	Participants capable to move beyond their mind-set and build up collective representations.	Difficulty to leave the technical space and to build up the collective representations. Coordinator required a full support from the facilitation team.
Thematic (problematic) evolution	Difficulty to draw limits and get a focused and shared perception of the problematic beyond the aquifer depletion and water quality and health problems. Gradually social learning and the lack of governance becmae the critical problematic components.	Since the beginning, the problematic was shared by network members, goat milk low quality as the hub. Having that agreed, network was able to move and build up a coherent narrative.	From the broad topic –social housing, wellbeing and climate change- problematic modeling move to a more technically focused cycle.

Table 6. **Network consolidation criteria**

3.1.2. P-I Cycle Results

The results obtain from each P-I Cycle is abundant and has been presented in detailed reports presented to the Client; each P-I Problematic document is formed by the set of representations already introduced. This section presents two tables synthesizing the basic constituents of the sustainability risks for each problematic. The next section 3.2.3, presents a Goat Milk cycle summary based on the representations obtained.

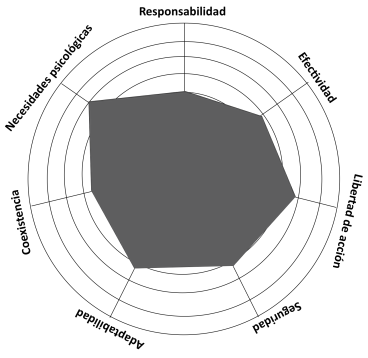
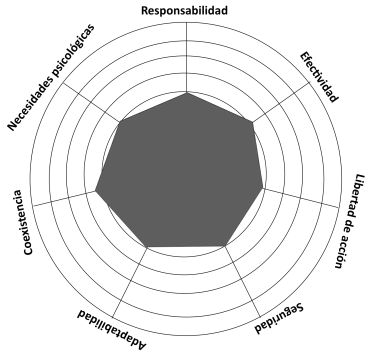
Water	Sustainable Housing
The Tragedy of the Unconsciousness **Sustainability at Risk**	**The Blocked City** **Sustainability at High Risk**
La Laguna's water system is a closed basin with its recharge in the high mountains of Durango state. Conflicts around the water use and management have being present since decades and lately increase it due to growth on the dairy (cow) production system, extracting without sustainable criteria water from the regional aquifers. Social and political concern on the aquifer sustainability is a source of permanent conflict that nurture a large network of individuals and organizations actively involved in pressing for a rational use. Actors claim that the legal framework is not respected and information is scattered among government offices. As aquifers deplete, the arsenic concentration in well extract water increases, with higher risks on rural population's health. The predominant culture can be defined with the systems archetype "tragedy of the commons" with a "shifting the burden" attitude, blaming the dairy production activities. Until recently a more systemic approach has being taken to include the recharge as part of the problematic and not only the extraction.	In Saltillo, the "social interest" houses are the most vulnerable to the climate change. They lack of a design that takes in consideration the environmental and climatic factors affecting not only the wellbeing and health of its inhabitants but also increasing the energy costs both in the winter as in the summer time. In addition to the bad design, the "social interest" houses are constructed with materials, predominantly cement blocks, lacking the insulating conditions required. Part of the problematic is the lack of local policies to promote "vertical" housing, people are culturally attached to the "land" and as a consequence city extended horizontally reaching the limits of its territory reserves. Innovation is not a driver, and transfer of new renewable energy technologies, and the improvement of local materials, such as adobe, faces with the construction and financial regulations restricting its use and improvement. R&D projects are fragmented and demonstration and transfer are just starting to appear as the outcome of innovation networks.
Sustainability Radar The larger the dark surface, less sustainaibility risks	
	

Table 7. **Problematic Synthesis and Sustainability Radar**

Orientator	Water	Goat Milk	Housing
A. Responsibility. The normative framework is known, accepted and enforced by the agents that contribute to its actualization.	Policies and plans are fragmented between government offices. The economic interests influence the policy making and enactment. Governance is absent.	Policies and related regulations are unknown by the producers, except some health requirements but this are not supported by good practices in the production of goat milk and derivatives.	Building regulations and standards are unknown by the owners and overwhelmingly the construction companies do not apply it. No social participation in the design and policy actualization.
B. Effectiveness. The context is favorable to the generation and sharing of information and knowledge. Availability of financial resources.	Incipient long term projects to improve system management and mobilize economic resources for conservation by payment for environmental services. Lack of an integrated information management system.	Low income does not motivate the small producer to improve his practices. Companies and producers do not cooperate, neither transfer technology or share information.	Incentives to invest in energy savings are recent, but generally unknown by the house inhabitant. Builders have few incentives to innovate.
C. Freedom of Action. It is possible a responsible and opportune participation in benefit of the individual, communal and resource system.	Incipient mechanisms. Lack of trust between stakeholders due that initiatives end up controlled by the government and the strong economic groups.	There are no mechanisms for effective participation between producers, dairy companies, scientists, consultants and government agencies. Conflicts are treated as symptoms.	The inhabitant does not have participation mechanisms. Negotiations are normally in hand of the unions.
D. Security. There are stability conditions in the availability of resources to satisfy the individual and collective needs.	Aquifer is in hand of the climate and those who exploit it for economic gains and beyond the limits. The presence of Arsenic is increasing; health and adaptation programs do not grow proportionally.	Environmental resources are normally used without sustainability considerations. Vulnerability is reinforced by producer's individualistic practices. Herds lacking genetic improvement.	Construction is done without considering of environmental contingencies and climate change. There is no policy inducing vertical construction and the city's land reserves are in disappearing.
E. Adaptability. There are conditions for education, learning and acquiring new knowledge, potentials, self-actualization and innovation.	Educational programs do not include the water sustainability among its topics. Lack of social consciousness about the systemic nature of the problematic and its relations with health. Research lacks articulation.	Programs are short term and symptoms oriented and no structural changes. Technical education does not include goat milk production. Research is fragmented and centered in herd management. Innovation is done by SME's on cheese production.	Fragmented efforts from researchers on materials and energy saving. No programs to improve inhabitant skills for energy management. Reactive coping of climate changes and lack of proactive programs. Incipient networks of professionals.
F. Coexistence. Spite their differences the Agents count with mechanisms to interact, create trust and participate.	Incipient social networks. Lack of governance mechanisms. Ineffective formal interaction mechanisms. Initial stock of social capital.	Conflicts and win-lose relations, short-term solutions. There are no continuous cooperative interactions between producers and dairy firms.	No social networks that share and exchange experiences, motivations, learning and demonstration and technology transfer projects.
G. Psychological Needs. Agents get involved under equality and express trust, and reciprocity. They face their conflicts in an environment of respect where they are able to share their visions.	Lack of trust between the agents. Prevailing unconsciousness on the problematic and risks. Finger pointing attitudes. Lack of collective capacity to build-up scenarios. Incipient steps towards governance are take it.	Lack of trust and antagonism. Producer on the margins with paternalistic relations with the government. Goat milk production is seeing as a sign of survival and poverty and new generations flee locking for new way of life.	Innovation agents focused on their technical areas. Inhabitant marginalized and lacking of information. Growing intra-family stress due to overcrowding and increasing effects of climate change.

Table 8. **P-I Cycles Sustainability Orientators**

3.1.3. Goat Milk Case

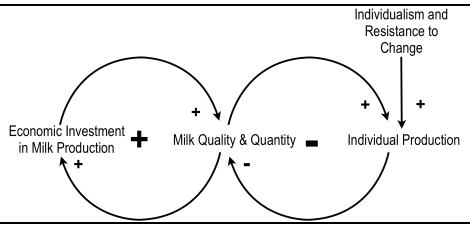
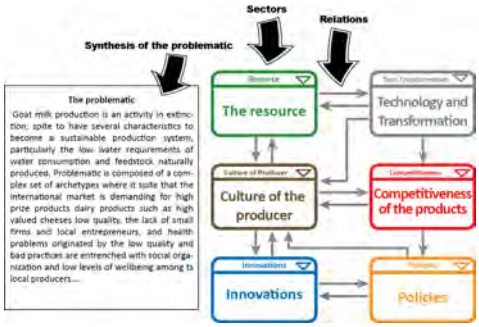
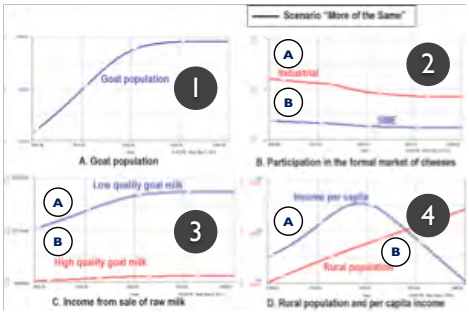
Milky Paradox
Unreachable Sustainability

Goat Milk Problematic: Initial Sustainability Radar.

Interweaved with the 5th world dairy (cow) corporate activities, the production of goat milk (GM) is extinguishing. Spite of a favorable global and NAFTA market, the production of GM is unable to reach the quality needed to export and to consolidate the regional markets. GM is produced by scattered goat's herds and sold to two big dairy corporate and candy manufacturers. Buyers prefer low quality GM because they pay lower prices. Old peasants produce low quality cheeses presenting high health risks. Young people are reluctant to work in the goat system leaving their communities; as a result GM is becoming a just for old people activity. Conflicts between agents are constant, a sign of social incapacity to reach win-win situations. The Government enforces reactive policies and programs creating an unhealthy dependence. Spite numerous opportunities for innovation, R&D activities are fragmented and oriented to improve comparative advantages.

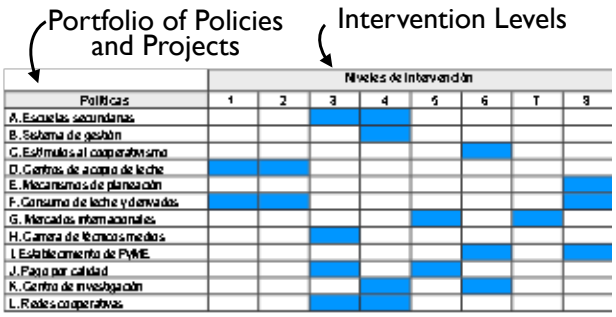
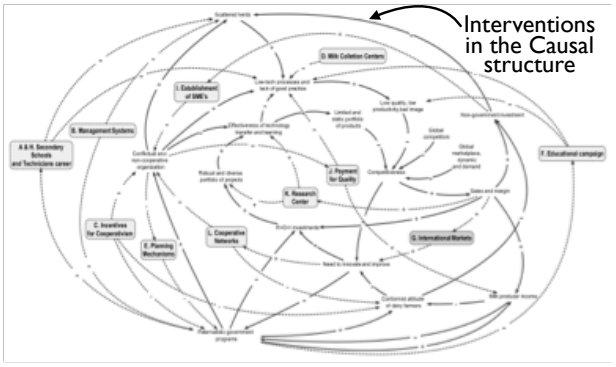
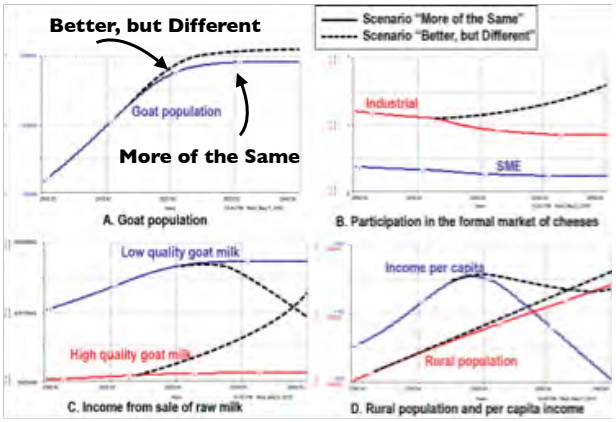
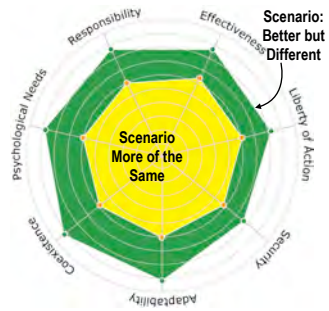
The two next tables present the representations obtained through the I-P Cycle. The first representations corresponds to the "problematization step", the second table shows the representations originated during the second step.

3.1.3.1. Goat Milk Problematization

Representations	
Archetypes • Limits to Growth • The Tragedy of the Commons • Growth with Underinvestment • Solutions that Fail	
Causal Structure and Loops • Loop. Paternalistic Governmental Programs • Loop. Seeding for the Future • Loop. Individualism and Lack of Competitiveness • Loop. Bad quality and Peasent's Low Income	
Dynamic Model **Sectors**: • The Resource and Environment • Producer's Culture • Products Competitiveness • Governmental Policies • Technology and Transformation • Innovations	
Dynamic Scenarios **System Behavior**: 1. Goat Population 2. Participation in the formal Cheese Market: Industrial A and SME, B 3. Income Producer: Low Quality Milk, A and High Quality Milk, B. 4. Rural Population, A and Per Capita Income	
Scenario: More of the Same If problematic persist without effective interventions, the scenario for the next three decades will reinforce the individualistic practices that will impede the emerging of collaborative schemes and establishment of market strategies such as payment for quality. The governmental policies will continue to be symptom oriented and the lack of a consolidated market will inhibit competitive innovations. The lack of cooperation and innovation networks will restrict the emerging of proactive programs and climate change will stress the producer's communities that will be unable to cope, among other challenges, with long drought periods, the starvation of herds and the irreversible emigration of youth and adults.	

Goat Milk Problematization Step

3.1.3.2. Goat Milk Innovation Strategies

Representation	
Interventions Regional technical schools. Regional geographic and climate alerting system. To fund cooperative reinforcing projects. To promote partnerships between producers and industry for milk management. To promote participation in innovation planning. Promote regional consumption of goat milk based in improving quality. Innovation on new products (powder milk, candies, cheeses) for national and global markets. Regional specialized technical school on goat system management. Cooperative SME's to transform and commercialize goat milk. To improve quality through strategies such as payment for quality. A regional consortium for cooperative innovation. Governance and participation practices.	
Modified Causal Structure Policies and intervention levels are located in the causal map.	
Dynamic Scenarios Dynamic model is changed by introducing some of the relevant policies in order to compare: **System Behavior**: 1. Goat Population 2. Participation in the formal Cheese Market: Industrial A and SME, B 3. Income Producer: Low Quality Milk, A and High Quality Milk, B. 4. Rural Population, A and Per Capita Income	
The Annual Board's meeting of the Regional Council for Innovation and Competitiveness of the Goat System has finished. Their members approved investments for the creation of a new firm for fabricating protein concentrated products obtained from the goat milk serum. This new products will be targeted to markets of high value food products. Now, the regional goat innovation system is a well known competitor in the international markets, continuously diversifying its portfolio with high value products with high knowledge content. Is the 2025 year.	

Goat Milk Problematization Step

3.2. The Spore Model

This part presents the Incubation model that emerged from the experiences obtained through the cycles presented above. Results are presented in three parts: Hypothesis, Representations and Model's Process.

3.2.1. Hypothesis Observations

Initial cycle design was based on assumptions originated in several sources: (1), the COECYT program of network of interest; 2), experiences by the facilitation team members in previous similar project experiences (Campos, 2011) and 3), readings of closely related cases from the specialized literature. Next table shows in the first column some of the assumptions considered for the design of the Spore project, the second column presents qualitative observations realized through the project realization.

Assumed	Observed
Interest does not exist in abstract but around the perceived problematic.	It was observed particularly through the evolution of the representations.
The network configuration and the number and composition of its nodes is dynamic.	It was observed as continuous adjustments made due to a variable participation.
Creativity and effectiveness are seeded at the beginning with the cooperation attitudes.	Observed. Weak manifestation in the water network with strong cultural inertia.
It evolves in a short period to an entity capable to generate complex patterns of innovation strategies.	The average time needed for incubating was 70 hours, this time does not includes time needed by the facilitation team.
Learning starts with tacit knowledge.	Confirmed by using initiatives from adventure earning and simulation games.
Innovation strategies showed an equivalent complexity to that presented by the problematic.	Limited observation due to the lack of formal methodology.
Learning starts with the perception of the problematic.	Learning requires an initial stock of social capital.
Portfolio is a complex information and knowledge system.	Weakly observed. Lack of evaluation tools.
Incubation requires a diverse and adaptive communication.	Absent in the various fields and activities.
Facilitation is a straightforward application of a set of activities and tools.	Continuous adjustments Were required. The facilitation team learned together with the network.
The participants have the needed basic technical and communication skills.	Heterogeneity impedes communication; reduced shared meanings increase the resistance to create shared visualization forms.
Networks members understand the difference between learning and to be informed.	An initial way of thinking that information should be complete and learning was not needed.

Table 9. **Spore's assumptions**

Observations collected by facilitation team members were synthesized by group consensus and complemented with interviews performed with network participants. Observations were qualitative in nature and no formal evaluation tools were used.

3.2.2. Learning by Representations

Spore's Representations are images collectively generated by the network of voluntary participants on the problematic of interest. Representations are explicit forms to communicate the articulated knowledge and express the evolution of the collective perception. Each representation is build from the previous, showing an increasing complexity. Next table describes the Representations used through P-I Cycles.

Representation	Use	Format	Activities
Ante-narrative, narrative	Integrates and communicates the collective image.	Literary	Interviews, individual stories, and editing
Archetypes	Identify deleterious persistent behaviors	Structural, reference mode and literary	Collective in workshops
Causal Structure	Visually displays complexity	Structural and visual	Collective, in workshops
Dynamic Model	Displays scenarios	Visual and structural	Deskwork and workshops
Scenario "More of the Same"	Thinking on futures risks	Literary and graphic	Deskwork and workshops
Policies	Effects of policy framework	Document	Deskwork and workshops
Intervention strategies	Identify forms to act and their effects on scenario	Structural and diagrams	Deskwork and workshops
Modified causal structure	Transform problematic structure	Structural and visual	Deskwork and workshops

Modified Dynamic Model	Integrates innovation recommendations and generates new behaviors	Visual and structural	Deskwork and workshops
Scenario "Better but different"	Describes a better future trough innovation	Literary and graphic	Deskwork and workshops and hearing

Table 10. **Representations in a Problematic-Innovation Cycle**

The first step (problematization) is dominated by systems ways of thinking, according the cycle unfolds a more technical and analytical thinking is permeating. Those representations related with innovation strategies are more deductive and problem solving and design.

3.2.2.1. Ante-narrative

Ante-narrative and narrative are a social construct formed by the participant's knowledge obtained through interviews and personal stories. It involves multiple perceptions and perspectives.

3.2.2.2. Archetypes

Problematic is formed by complex cultural behaviors (policy resistant), they are attractors that inhibit learning and change. Structural archetypes are identified within the narrative using systems thinking archetypes as templates. (Kim y Lannon, 1997).

3.2.2.3. Causal Structure

This is a visual representation of the narrated problematic. Narrative causal analysis follows techniques described elsewhere (Boje, 2001), is done by group and also individually.

3.2.2.4. Dynamic Model

The previous representations change over time. Using system dynamics a model is constructed integrating essence of causal structure and archetypes and describing reference mode in the time lapse selected, a modeling and simulation platform is used[4].

3.2.2.5. Scenario "More of the same"

This is a collective narrative about how it will look the future if things happen as it is expected. Scenarios are not predictions but perceptions, myths and beliefs about the future (Schwartz, 1991). This is the most effective representation in terms of communication.

3.2.2.6. Orientators on sustainable development

Once the previous representations are displayed a group reflection is done on the implication of problematic in terms of sustainable development. A set of orientators is used and displayed visually by using a radar template (Bossel, 1998). Once having this representation, network start to explore intervention options.

3.2.2.7. Levels of Intervention

Policies imply different forms to act on the system, some having local and immediate effects, others with long term structural consequences producing cultural changes. In order to systematize the collective work and improve the quality of the contributions from participants, a set of eight levels of interventions was applied (Meadows, 2008). Intervention levels and policies were considered equivalents.

3.2.2.8. Modified Causal Structure

Suggested intervention levels are inserted in the causal structure. Type of specific actions and effects within each level is identified and documented. Intervention levels can be (1), actions on specific structure element and (2), affecting the structure by cancelling or creating loops.

3.2.2.9. New behaviors

Once the modifications are introduced in the system dynamics model, several dynmic scenarios are created and one is selected as the basis for Scenario writing.

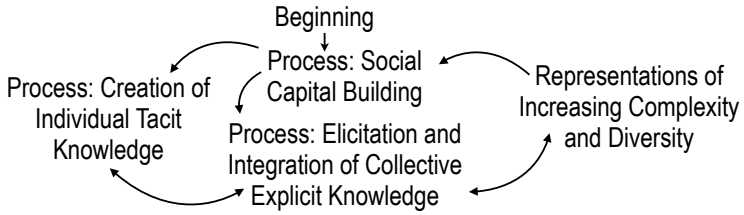
3.2.2.10. Scenario "Better but Different"

This is a literary representation marking the end of the P-I Cycle. Uses the previous representations and is collectively prepared. Generally imposes challenges to those participants lacking experience in future oriented thinking.

3.2.3. Incubation Model

Incubation cycle follows the mechanics presented in part 2, unfolding through three interrelated process whose purpose is the continuous generation of the representations by increasing interactions and closeness on, at least, three dimensions: social, cognitive and technical (thematic). These processes –social capital, tacit knowledge and collective explicit knowledge- are considered to unfold creating the conditions for incubating a collective learning process:

[4] . The system dynamic modeling platform used was ITinhk version 9.1.3. of ISee Systems.



Spore's Processes

Distance	Process		
	Social Capital Building **PICS**	Creation of Individual Tacit Knowledge, **PCITK**	Elicitation and Integration of Collective Explicit Knowledge, **PEICEK**
Social	Strong	Weak	Weak
Cognitive	Regular	Strong	Regular
Technical	Weak	Regular	Strong

Table 11. **Process and Closeness**

3.2.3.1. Process PSCB: Social Capital Building

Takes place in workshops that induce the interaction and the creation of tacit knowledge and its socialization. Several initiatives and simulation games are applied in promote behaviors as trust and to facilitate the framing of the problematic addressed. Process takes place in originating field.

3.2.3.2. Process PCTIK: Creation of Individual Tacit Knowledge

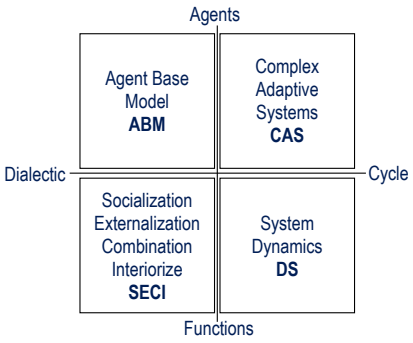
Through this process participants enrich their individual knowledge about the problematic and their mental models on cooperation. Narratives are the representations that play a key role in accelerating the learning and conversation reinforce the social ties and cognitive distance starts to reduce. Fields related are: originating, dialogue and exercising.

3.2.3.3. Process PEICEK: Elicitation and Integration of Collective Explicit Knowledge

This is the most critical and difficult to achieve the required effectiveness. Is in this process where the problematic and innovation strategies are made explicit and modeled. It requires considerable individual and collective effort to focus on the concepts and their relations. Fields related are: dialoguing, exercising and systemizing.

3.3. Modeling the Incubation

Spore pursued to improve the understanding of the process underlying the incubation P-I Cycle. It was considered that instead of a single interpretation, having a set of different approaches could contribute to have a diversified platform for better understanding and at the same time several options for communicating to the policy making level. Modeling approaches were selected considering that incubation occur under the light of two set of criteria: **(1), functions-agents**, **(2), dialectic-cycle** (Van de Ven, 1995). The intersection of these two criteria produced the quadrants shown in the next figure.



Modeling Approaches

Each modeling paradigm was chosen because is based in different assumptions the P-I Cycle, in this form is possible to diversify the interpretations that will be communicated, later on, for different purposes, from designing learning strategies to policy making.

Modeling Paradigm	What is observed	Contributions
SECI	Incubation as a rhizome process formed by numerous learning loops where tacit knowledge is transformed in explicit and then into representations.	An integral learning strategy.
System dynamics	The dynamics of the functions related with social capital accumulation and creation of knowledge.	Incubation as a learning curve.
Complex Adaptive	Incubation as a process facing the cultural	To understand the incubation as a non-

Complex Adaptive Systems	Incubation as a process facing the cultural resistance (attractors), the role of an initial chaos for increasing possibilities for aligning learning process. Representations as dissipative structures.	To understand the incubation as a non-linear process, accepting a chaotic beginning as the most critical stage.
Agent Base Model (ABM)	Network as an interacting assemble of agents	An model contributing to a better

Table 12. **Main features of the selected modeling approaches**

The results obtained by applying this approaches are described in the next four sections.

3.3.1. SECI

This model is inspired in the Nonaka's approach to organizational learning (Nonaka, 1995) and in the participative action-learning by (Lewin, 1998). It is complemented by ante-narrative concepts (Boje, 2011).

3.3.1.1. A Worrisome Image

The first step to the problematic is from the narrative perspective. The main purpose is to build-up an ante-narrative as a polyphonic ensemble formed by the participants and stakeholders individual stories. The ante-narrative is polished and a narrative is obtained, the antenarrative is the first collective representations and its purpose is to create a sense of risk and concern among the participants, narrative is the basis for a scenario of "more of the same, but worse" that will conclude the problematization step. Trough workshops, initiatives are executed to internalize the risk.

3.3.1.2. Learning by representations cycles

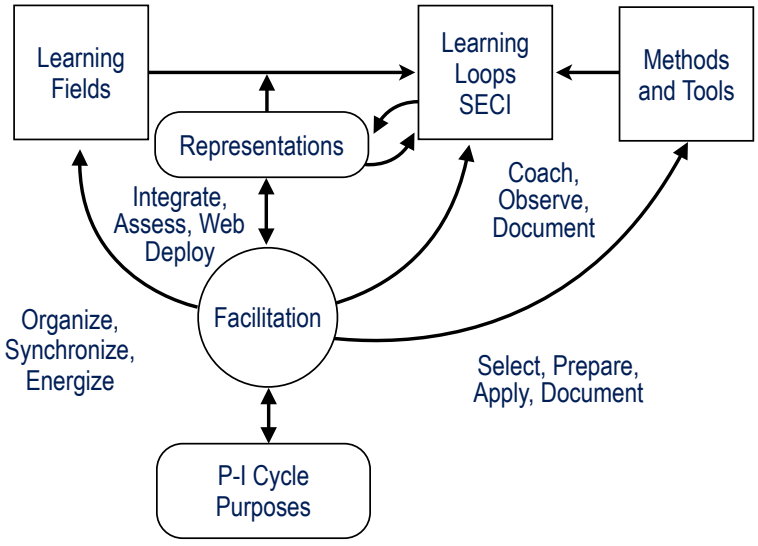
From that beginning the many representations already commented unfold, each one represents a learning loop that takes place following the SECI sequence. The number of loops is consensually defined between the facilitation team and network members, considering that a representation needs additional effort. In the SECI model the presentation and internalization of each representation is reinforced by group activities consisting of initiatives from adventure learning and operational simulations[5].

3.3.1.3. The process

To incubate is to transform the starting ante-narrative in a sequence of increasingly complex representations. The purpose is not to add more information, as an exhaustive bibliographical study but to qualitative transform the cognitive models of participant groups to a more complex forms (rhizome). The archetypes representation, spite its apparent simplicity, was one of the representations that represented more cognitive obstacles to be identified and elicited by the network participants.

3.3.1.4. The Structure

The next figure presents in a simplified form the central components, and their relations, of the SECI (Rhizome) model. The central part deals with the **representations** that emerge from a reinforcing loop with the learning SECI loops.



[5] . One of the most effective simulation games applied was the Fish Banks developed by Profr. Dennis L. Meadows. Fish Banks create the Group conditions and individual sensitization for introducing several systems thinking archetypes used as part of the representations.

3.3.2. Dissipative Structures

This approach is conceptually based on the Complex Adaptive Systems (Prigogine, 1984) and several of its applications to the study of the incubation of innovation cooperative structures, such as consortia (Browning, 2008; Campos, 2005). Applications focus on the observation of the interaction (communications) patterns among the participants and how individual behaviors are transformed leading to the emergence of collective patterns. Incubation start with a chaotic stage that is difficult to surmount, sometimes groups are not capable to solved and doom, but when they resolve it, qualitative changes start to occur and shared representations begin to flow.

Emergence of dissipative structures in a Physic-chemical system	Analogies found in the emergence of Cooperative Innovation Networks
A particle system is in equilibrium. Experimented changes are small fluctuations and symmetry between them is preserved.	A group of agents is acting under agreed rules. No change is observed, and conflicts among them are rarely perceived.
Suddenly the system is under external action –pressure, energy, pH- that threaten to take the system out its equilibrium.	From the exterior arrives an instruction to address a problematic. Instructions are no well defined the agents get confused and feel uncomfortable saying that conditions are changing continuously and asking to return to the beginning.
Among the particles start to appear small fluctuations that threaten to breakdown the system symmetry.	Agents start to feel uncomfortable, they do not understand what is happening, do not know how to act and feel threaten.
As the fluctuations start to grow, the system generate respond by creating structures (attractors) whose mission is to neutralize those variations and to keep the threaten equilibrium under control.	The agents search for ways to mitigate what they feel is a disorderly situation. They claim that calm is needed and try to return to attitudes and management forms that in the past were successful.
The external action increases and the defensive structures (attractors) became ineffective to mitigate fluctuations that are now large and out of control. Then system arrives to a critical point (a bifurcation) where stability collapse and many options for transformation appear.	A growing pressure for adaptation imposing new ways to interact and to think on how to deal with the issue (problematic). Becomes clear the impossibility to stay in the same position. Agents start to generate new elements – images, ideas, proposals- taking them to perceive the issue in a different way, through a new representation.
In this bifurcation particles self-organize to follow the less energy path. Particles seem to communicate through long distances and a new pattern emerges between them.	The new representation stimulates and guides the agents to dissipate, momentarily, the pressure imposed by the problematic (the external issue). With the representation, agents start to communicate by new meanings and metaphors, and among the agents new relations are created. A new configuration emerges inducing new learning loops.
The new structure is the best option for dissipating influences from the context. The transformation is then a continuous process to improve assemble adaptive capacity to face the disorder-order continuous loops.	Each representation dissipates momentarily the problematic demands for new knowledge. Learning becomes a sequence of loops where knowledge becomes an assemble, new representations where threats from the problematic are transformed into innovation opportunities.

Table 13. **Analogy with dissipative structures**

3.3.2.1. Self-organizing capacity through incubation

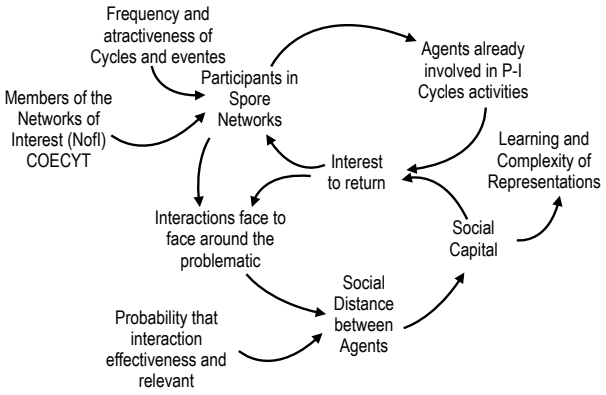
Self-organizing is a network capacity that evolves through the Incubation P-I Cycle, it is an essential functional attribute that can be observed and should be stimulated by using the Dissipative Structures model. This approach is a valuable guide for planning the P-I Cycle, in particular to face the challenges imposed by an inevitable chaotic beginning. Next table presents some of the observed behavioral aspects that were observed in the Goat Milk P-I Cycle. The three steps were adopted by previous studies (Browning, ; Campos,) are used to describe behaviors observed in Spore, Red color represents a full manifestation and gray an emerging condition.

Behaviors	P-I Cycle		
	Chaos and ambigüity	Cooperative network	Complex representations
Early confusion			
Mixed perceptions			
Previous relations			
Irreducible positions			
Productive discussions			
Participants actively involved			
Multiple contributions			
Commitment			
Interest in the results			
Sense of team and belonging			
Dialogue capacity			
Structure building			
Participation in virtual activities			
Sense of collective property			
Collective memory			
Spillovers and new projects			
Standards			

Table 14. **Behaviors and the Dissipative Structures Model**

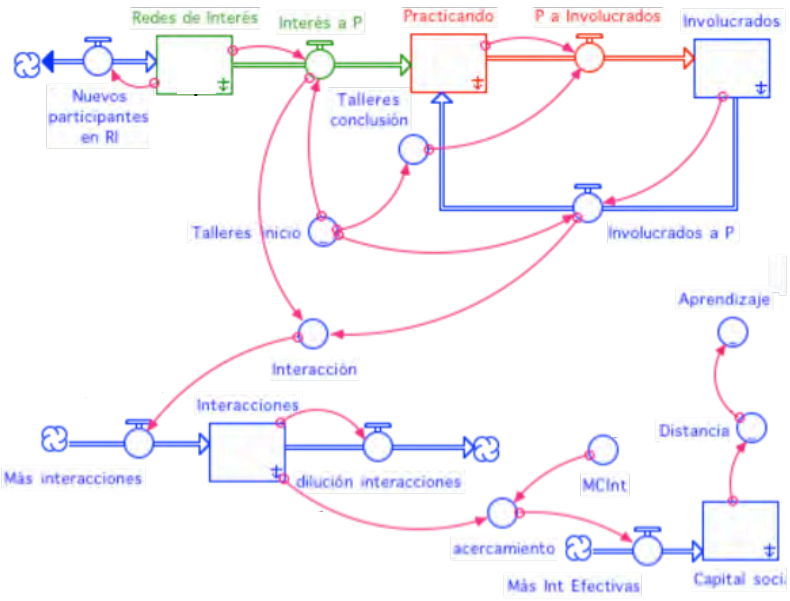
3.3.3. System Dynamics

Spore Causal Diagram.

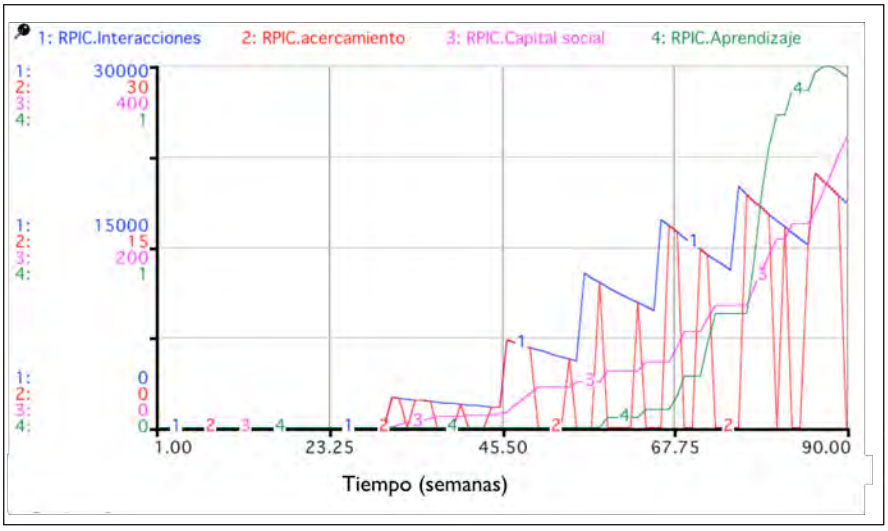


This model integrates the observations collected, in a dynamic and simplified interpretation of the P-I Cycle. The basic structure was based on the following causal logic: the realization of Spore's "learning fields" starts with the participants in the Network of Interest (NofI) respond to an invitation to a starting event. Once the P-I Cycles are launched starts an intermittent flow of agents, a fraction of them are motivated to return and new agents arrive in each activity. This reflux generates interactions face to face (those of virtual character are not considered), interactions are created in the several events, such as workshops. The interactions are accumulated, a fraction is instantaneous and dilutes. There is a probability that the interactions reduce the distance –social in the model- between the agents. Less social distance increases the network social capital and then its capacity to learn and to generate increasingly complex representations about the problematic and the strategies to cope through innovation.

The causal diagram was transformed in the system dynamics model whose structure is shown in next figure. Four main variables are considered: (1), interactions, (2), social distance (closeness), (3), social capital and (4) learning. The behaviors show the need to an early interaction through the activities performed in the "originating field". The social capital appears slowly and then accelerates its accumulation. As a consequence, productive learning emerges later and complex representations start to take form. Model consist of three types of agents: (1), participants in COECYT networks of interest: (2), participants in Spore networks activities and (3), motivated agents that return to the activities. Next two figures show model structure and dynamic behaviors. IThink 9.1.3 (Isee Systems) was the modeling platform.



System Dynamics Model



Incubation System Dynamic Behaviors

3.3.4. Agent Based Model

This modeling approach has being used in studying the mechanisms of learning and knowledge creation that play a central role in the emergence of innovation networks, particularly focused in industry (Gilbert, 2001). In Spore, an ABM was developed to provide the policy makers, particularly COECYT, with some insights about the importance to reinforce its effort on promoting "networks of interest" with the "networks of practice" (NofP) proposed by this project.

Basic questions that this model aimed to answer were the following: (1), what are the differences between both types of networks? (2), are they incompatible or by the contrary between them exist a reinforcing mechanism with a synergistic effect? (3), if this is the case, how this synergistic effect will improve the overall effectiveness of the network program to tackle emergent challenges? (4), how this interpretation (model) can be communicated and linked with the policy making process to promote cooperative innovation through networks strategy?

3.3.4.1. Interest and Practice

As it has been mentioned through the paper, the networks of interest (NofI) were the initial step and later on, the Spore project came to explore complementary forms to enhance the policy effectiveness by creating a platform for working together around the P-I Cycle. As a consequence, the ABM model was developed from two networking approaches described in the following table:

Features	Networks of Interest (NofI) Promoted and coordinated by COECYT.	Networks of Practice (NofP) Incubated by the Spore Project.
Motivation	To be informed and related, access to funding of individual projects.	To work together, to be part of a big project.
Membership	Coordinator and agents invited by him, normally from the same area of interest.	Agents from diverse networks of interest, invited experts.
Coordinator	Designated by the COECYT.	Leadership emerged from the process
Knowledge system and limits	Focus topic difficult to be defined. Diffuse borders, an agglomeration of individual interest.	Defined by the problematic, structure and borders emerge from the cycle.
Interaction modalities	Thematic, administrative.	Social, cognitive y inter-thematic.
Deliverables	Coordinator's Report.	Various collective representations.
Dominating behaviors	Interest in the scientific or technological topic. Waiting for instructions.	Changing cooperative attitudes, increasing interest in the problematic.
Duration	Undetermined.	A cycle, in Spore lasted 6-8 months.
Domain	Scientific topics: water, biotechnology, nano-technology, mining, food technology and renewable energy.	Problematic: Water and housing sustainability, Goat Milk Quality.
Work forms	Meetings, email, sporadic open events, interviews with policy makers.	Workshops, modeling sessions, email and Web, interviews, conference.
Learning paradigm	Not declared, normally not considered, complete information.	Action-learning approach and an eclectic collection of related methods and tools.
Management support methods and tools	Administrative support from COECYT.	Action-Learning Support System.
Documentation	Administrative follow-ups and proposals for R&D projects.	Representations, manuals and reports on network cycle performance.

Table 15. **Interest and Practice Networks**

3.3.4.2. The Model

Observations collected through the realization of the three P-I Cycles were the input for developing the Agent Base Model herein presented. In the ABM the agents are: Coordinators designated by the COECYT (in the figure represented by circles), the COECYT (big square), Participants (human shaped figures), and Clients (small squares representing opportunities to act together such as problems, challenges, projects). New Participants and Coordinators are continuously entering into the White Field (WF) and also some are leaving the system.

The Participants and Coordinators are able to interact in three dimensions: cognitive (ways to learn), social (behaviors creating trust and cooperation) and thematic (scientific and problematic related information exchange); the interactions show different degree of intensity derived of the type of interaction, frequency and time. The agents, except COECYT and Clients are able to move in two different spaces: (1), the White Field (WF) and the Blue Field (BF). Each field has different rules that oblige the agents to interact in different ways. In the WF there is a strong relation between COECYT and Coordinators and Participants interact predominantly through thematic relations. In the Blue Field the Participants and Coordinators interact in

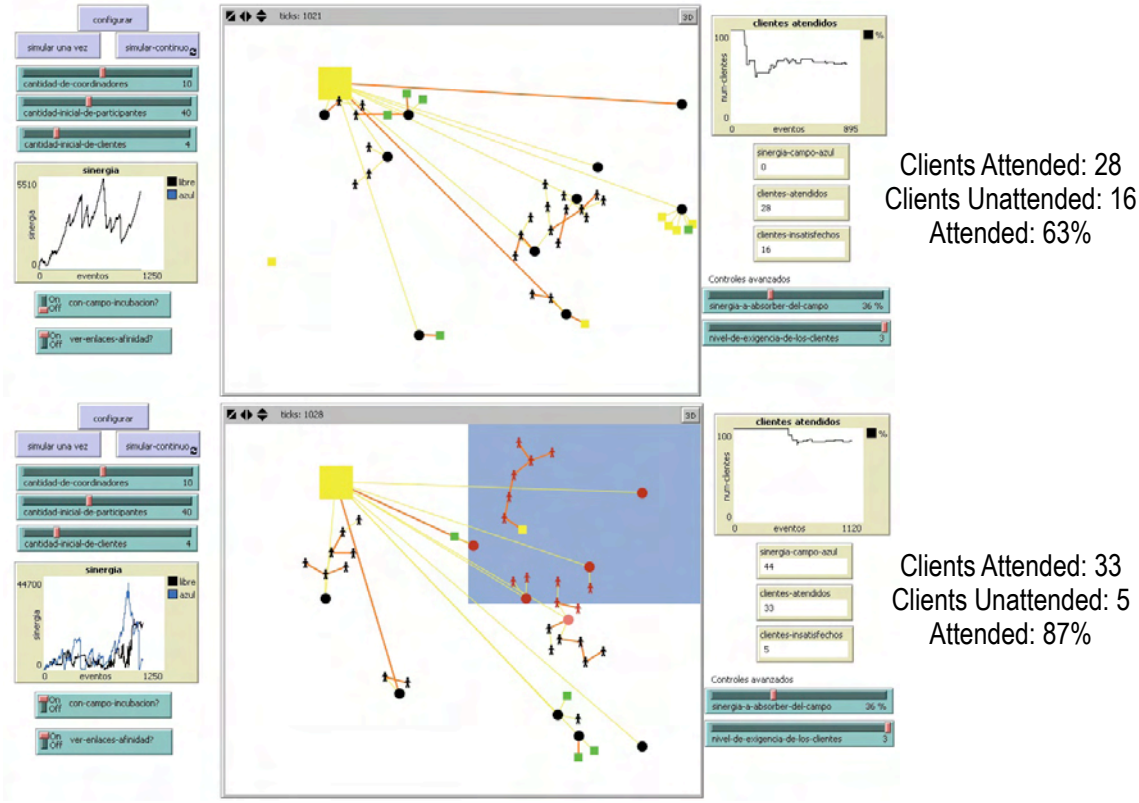
the three dimensions; cognitive (learning approaches), social (behaviors and attitudes) and thematic (on the problematic and scientific and technological related issues).

Features	White Field (WF)	Blue Field (BF)
Interaction Dimensions	Thematic	Cognitive Social Thematic
Generation of synergy	Look for guidelines, proposals, and clients.	Make narratives, dialogs and interactions to understand problematics and make proposals through shared activities
Networks	Thematics fade with time	Multidisciplinary, guided by shared by dialogue about problematics.
Coordinators relations	Strong and thematic with COECYT	Integrated with different participants and a wak relation with COECYT

Table 16. **White and Blue Fields**

Participants and coordinators move freely and continuously between the two fields. The strength of the relations is determined by the variety of interactions meaning that in the BF relations among the agents are stronger that in the WF. The strength of the relations present in each field is accumulated in a **synergy** effect. This synergy attribute can be considered as directly and positively influence the social capital. When agents move travel from the BF into the WF they move with energy carried on their relations, this energy is gradually disappearing during his residence in the WF. In the WF this Synergy influence positively the networks ability to attract and entrap the Clients during its flowing through the WF. Once entrapped, Clients are converted in potential common projects and policy recommendations, in this version of the ABM model there is no feedback between Clients attended and the frequency of Clients, they flow into de model independent of the field.

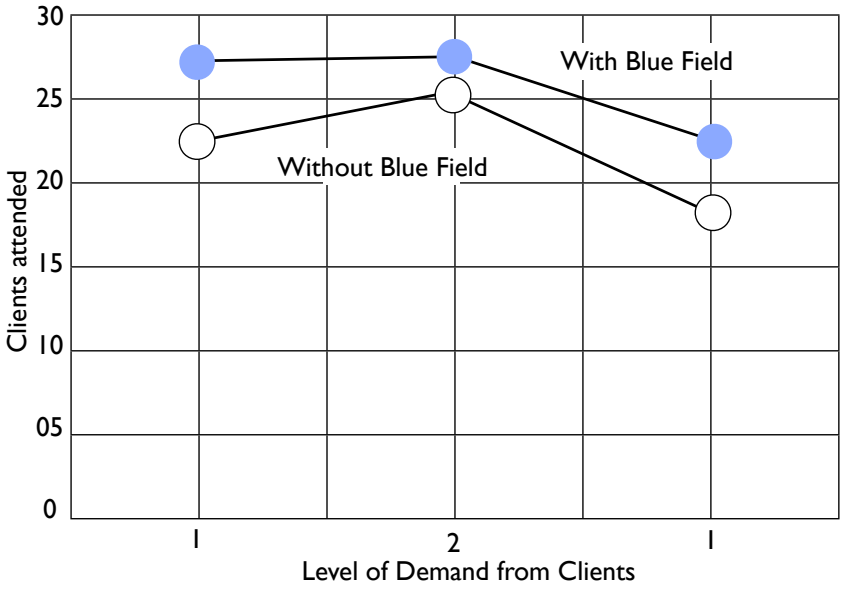
Next figure shows two model computer screens obtained by simulations run with 1000 ticks. The first display presents the results without the presence of the BF and the lower screen with the BF. In both cases the number of Clients attended are presented, showing the influence of the BF in WF effectiveness matter later discussed with more detail.



Fields and Agents

3.3.4.3. Results and Observations

The model was developed by NetLogo 4.0.4[6]. In order to observe the role of the BF in the performance of the overall networks system, a sensibility analysis was performed by two conditions: (1), having the presence of the BF and (2), in absence of the BF. In each condition simulations were performed in different lapses by adding 1000 ticks (arbitrary units of time) every period. In both cases the complexity of Client requirements was increased. The number of entrapped (attended) Clients was determined. Next figure shows the obtained results:



Sensibility Analysis by MBA

The dynamic behavior was observed by running simulations in various lapses. The presence of Agents, Coordinators and entrapped Clients was then determined. A cyclic behavior was detected, in the short term the number decreased, however in larger periods a cyclic behavior was observed with the population of both fields becoming to the levels initially determined. The voluntary basis of participation can be considered the source of the cyclic behavior, both in the virtual as in the actual networks. This observed cyclic behavior did not receive further attention, being a matter that later will be researched.

The results obtained through this modeling approach contribute to improve the understanding the role that incubation of the "networks of practice" experimented by the Spore project could have in generating a more systemic approach to the policy framework. Some of the relevant reflections are:

1. There are structural differences between the two types of networks. Administrative and coordination oriented NofI, being part of the present COECYT's policies should be complemented with the more horizontal and interactive possibilities offered by NofP.

2. White Field and Blue Field are complementary and mutually reinforcing. By one side Participants are attract by the interest to be part of COECYT´s activities, and by the other side learning occurred in BF and synergy (social capital) reinforce WF field effectiveness to deal with arriving Clients, problems and opportunities demanding network efforts.

3. The social capital is the triggering effect to increase the possibilities to address complex issues. Learning through the possibilities to couple social behaviors should complement the administrative approach to networks.

4. Synergy is an attribute emerging from the systemic interaction between the agents. Is a field property generated mainly in the BF, a field were Agents meet to play freely around specific problematics and in different field (discussed in previous sections). Accumulated synergy is predominantly used in the WF where the Clients enter into the system..

[6] Wilensky, U. (1999). NetLogo. http://ccl.northwestern.edu/netlogo/. Center for Connected Learning and Computer-Based Modeling, Northwestern University, Evanston, IL.

4. Outcomes

As regional competitiveness becomes more dependent of innovation, local institutions face the challenge to recognize, induce and monitor a high order institutional and agents learning. Agents reflexivity, learning by action and social participation are ingredients needed to replace inefficient restrictive practices with others based in improving the social capacity to adapt and culturally transform (Gertler, 2002). Spore Project, aligned along this challenges looks to sensitize local agents and institutions on the inevitability to improve governance through new collective learning approaches to face the imperative to tackle increasingly complex regional critical issues.

Spore simultaneously addresses several issues dealing with regional policies to nurture and buildup local interfaces reinforcing cooperative innovation. Results already presented are outcomes for different levels and address dilemmas challenging the traditional policy making process for an oriented practice-based process (Landry, 2012). The next table presents a synthesis in three outcome levels –policy, strategic and tactics.

Levels	Outcomes Spore's delivered products and experiences will contribute:
Policy	- To improve regional policy framework oriented to build-up social capital and cooperative interfaces as a prior step to design investment strategies on Science and Technological Parks. - To create new funding policies targeted not only to Public Research Centers but also to Innovation Networks. - To create regional "think-tanks" mechanisms that using networks approach, such as contributed by Spore, continuously address critical regional issues as the inspiration source for innovation.
Strategic	- To provide integral portfolios for designing new mechanisms for strategic funding and diversifying the traditional policies such as the regional FOMIX. - To provide a systemic framework for the participative design of specific strategic projects around critical issues. - To improve social and human capital by the creation of social networks sensitized both, in the problematic and on systemic and cooperative learning approaches.
Tactics	- To empower human resources in the facilitation of social learning process, normally not considered within the University curricula. - To integrate a set of concepts, methodologies and mechanisms that enhances regional cooperative innovation. - To create opportunities for technological development in the crossing field of ITC, social learning and innovation.

Table 17. **Spore's Outcomes**

Many challenges will be faced in order to transfer concepts and practices to the policy makers but also to the innovation agents. Conditions are favorable, the needs are enormous and learning and innovation are never ending entangled processes.

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