Opening up Natural Resource-Based Industries for Innovation: Exploring New Pathways for Development in Latin America

SECTORIAL REPORT | Agriculture in Argentina

Anabel Marín and Maximiliano Vila Seoane

June 2011

Index

I- INTRODUCTION

This sectorial report has two main aims. The first one is to describe the main characteristics of the dominant system of production utilized in the agricultural sector in Argentina, paying particular attention to the challenges/problems faced by this system to satisfy three goals: economic growth, social inclusion and sustainability. The second is to identify niches (spaces of alternative systems of production) that address these challenges faced by the dominant system in different ways. These niches can be more or less radical. The more radical ones will be truly *path- breaking*, in the sense of proposing to transform the whole system and eventually taking it in a different direction of change - or pathway. The less radical ones, instead, will be only *path-repairing*, aiming to provide feed backs into the dominant system to improve it. In order to achieve these two aims a number of methods were used to gather preliminary information that will be used to plan and execute the future in depth fieldwork. The report is organized as follow. Firstly, following this introduction, we discuss very briefly the main elements of the theoretical framework that is in the background of our analysis, a socio-technical transition framework (for full descriptions of this framework see background paper 1). Secondly, we describe the methods utilized to collect information for the elaboration of this report. Thirdly, we describe the main characteristics of the agricultural system in Argentina using the main concepts of the socio-technical transition framework, highlighting its positive and negative impacts in Argentina. Fourthly, in section IV we mention the detected path repairing and path braking niches, suggesting cases that could be studied in more detail in the next phase of the project. Finally, in section V we conclude by summarizing the main tendencies found in this sectorial report.

II -THE THEORETICAL FRAMEWORK

As it has been described in more detail in background paper 1, the study will use the Socio-technical transitions framework (Geels, 2004; Geels, 2002; Rip & Kemp, 1998; Smith, 2005). Within this framework, societal problems are solved in particular ways at particular times, shaping what is called a Socio Technical (ST) regime, which refers to the semi-coherent set of rules carried by different social groups that provide orientation and co-ordination to the activities of relevant actor groups[1]. These ST regimes, however, face challenges that arise both from macro conditions, which are known as the landscape[2], and also from problems derived from the very way the regime work.

[1] Its stability is of a dynamic kind, because innovations still occur but they are of an incremental nature. Geels has separated the ST regime into 7 dimensions: Technology, Markets and user practices, Culture and the symbolic meaning of technology, Infrastructure, Industry structure, Sectorial policy and Techno-scientific knowledge. Every dimension has its own internal dynamic, and may be linked and co-evolve with the other dimensions. These differences may lead to tensions in which links between them get weaker.

[2] It is constituted by a set of heterogeneous factors, such as oil prices, economic growth, wars, emigration, broad political coalitions, cultural and normative values, environmental problems, techno-economic paradigms (Such phenomena as globalization, hyper-segmentation of markets, hyper segmentation of activities and technologies, the spread of information technologies and the move towards alternative energies are part of the paradigm shift that shapes the landscape and enables the use of alternative pathways without fundamentally disrupting the "system").These factors change very slowly and make up the external structure where the actors of the regime interact.

Some of these problems are addressed in what is known as niches, which are spaces that have protection and insulation from the normal selection conditions that exist in the regime. This allows radical innovations to be generated inside them, since the give the needed protection to new technologies that usually have low technical performance in their initial phases and are also more expensive. Moreover, niches are also important because they foster learning processes and the space to build the social networks that support innovations. These niches sometimes manage to challenge the dominant regime, providing feedbacks into the dominant system helping to improve it. Whereas in other cases, the niches may entirely replace the ST regime (Geels, 2002).

Also, there are different types of niches that can be classified according to the same dimensions that can be used to characterize the ST regime. In this way, one will find different levels in development regarding: exposure to markets; diffusion or importance with respect to other industrial structure, scientific and technological distance with respect to the dominant ST regime, among others.

Changes within the regime, and from one regime to another are explained by the interaction between the characteristics of the landscape, the ST regimes and niches. The relations and interactions between them is known as a multi-level perspective. The main characteristics of this perspective are summarized in Figure 1, which exemplifies how these three dimensions are interrelated. One way of interaction is for instance, that changes in the landscape can put pressures on the socio-technical regime, which in turn, might allow for the emergence of new niches that modify the development path.

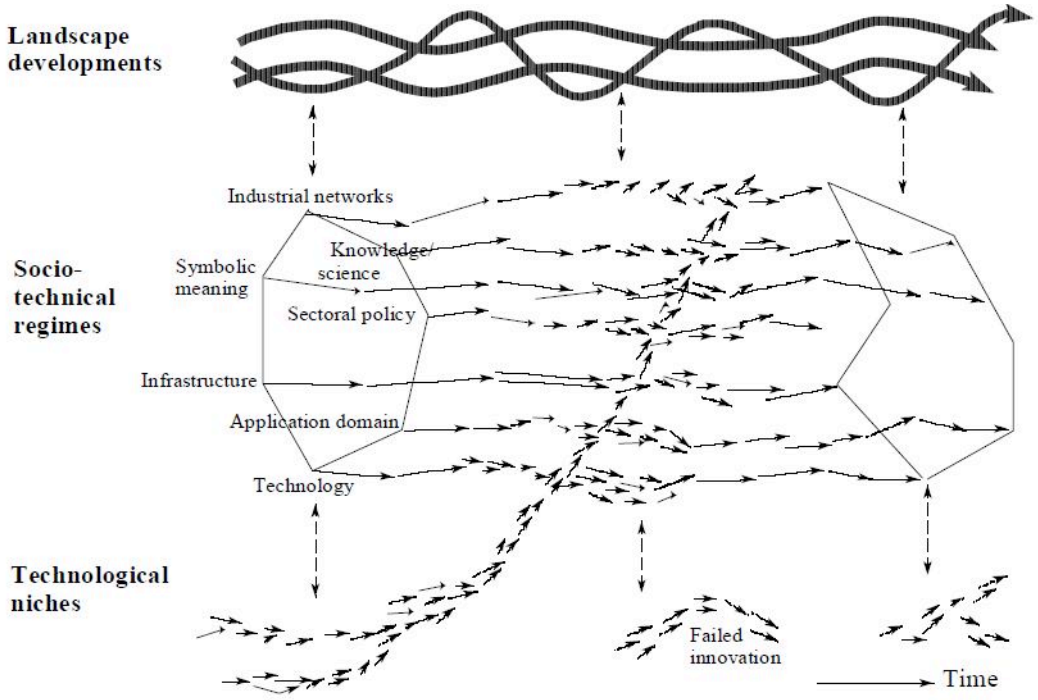


Figure 1: A dynamic multi-level perspective on Technological Transitions (Geels, 2002).

III- METHODOLOGY:

In order to characterize the ST, the landscape conditions and the existing niches, we mainly used the following three types of information sources.

The first one were documents available in the web, such as previous research papers, newspapers articles or books that talked about the advantages and disadvantages of the industrial agriculture system in Argentina, with a focus in the soybean production model, and those that also considered solutions to the detected problems. We studied several reports written by international organisms, research projects and technical research papers on the advantages and disadvantages of the regime.

The second one, based on the identification of key actors that are related to the study or are producers in the socio-technical regime and its associated niches, consisted in conducting in depth interviews. In this way, following a snowball method, we elaborated a list of people to interview so as to find out which were their opinions as regards the sustainability of the regime and on possible niches that could solve the problems that the regime brings. In total, we interviewed 10 actors[3], which had both positive and negative perceptions about different dimensions of the dominant ST regime, and who recommended different niches to study in more detail.

The third type of source, following the recommendations realized in the second background paper of Argentina, consisted in looking for projects that were financed by the FONTAR[4], Argentina's innovation fund that could follow path repairing or path breaking trajectories within the regime. In order to do this, after we had identified the key elements of the dominant regime and some niches mentioned by the interviewees, we built a keyword list that could identify projects that are related to the ST regime or the niches. Notwithstanding, after we consulted with experts in the sector, we were suggested that this type of information will not representative of the innovation activities in the sector, because the model for the introduction of technology has a different origin than local innovations funded by national funds, for example, the introduction of the technology by multinational firms who develop their products or processes abroad.

Subsequently, based on the different information sources, we characterized some aspects of the landscape situation that motivates, sustains but also puts some pressure on the dominant socio-technical regime. Following this, we summarized the main points in favour and against its use in the mid to long term in Argentina. And based on the negative points, we selected and described a couple of niche agricultural production systems that challenge the socio-technical regime since

[3] We thank the following interviewees: Msc. Roberto Bisang (Professor at the "Universidad Nacional de Buenos Aires"), Alejandro Carrizo (Alternative crops), Miguel Teubal (ST Critic member of "Grupo de Estudios Rurales"), Hernán Giardini (Greenpeace campaign leader against deforestation), Claudio Lowy (Regime Critic), Jorge Rulli (Regime critic and Permaculture promoter, member of "Grupo de Reflexión Rural"), Remo and Enrique Vénica (Biodynamic farmers from Guadalupe Norte, Santa Fé), Walter Pengue (ST regime critic and professor at the "Universidad Nacional de General Sarmiento").

[4] The Fondo Tecnológico Argentino (FONTAR) is the Argentinean fund in charge of promotion technological innovation in the country through different instruments (Peirano & Gordon, 2010).

they apply farming practices that negate the most damaging points that the socio-technical regime has. Also, we included alternative crops that were mentioned in the interviewees.

IV-THE DOMINANT AGRICULTURAL SYSTEM IN ARGENTINA: MAIN FEATURES AND CHALLENGES

In this section, we first describe the main features of the dominant agricultural system in Argentina using a multilevel perspective. We focus on the landscape and the main characteristics of the existing socio-technical regime. Second, we analyze the challenges of this system. The idea is to develop a clear understanding of the factors that might be contributing or limiting a potential change in the system. In section V we concentrate on the existing alternatives or niches identified, which can drive this change.

IV.1 The main Features of the dominant agricultural system in Argentina using a multilevel perspective

IV.1.1 The Landscape

Among the factors contributing to the expansion of the prevalent intensive system of agriculture we found:

The expansion of intensive/industrial agriculture in the world: Since the Second World War, a transition from extensive towards intensive or Industrial agriculture, which uses agricultural machinery, petrochemical fertilizers, herbicides and pesticides, took place and expanded throughout the world, process known as the "Green Revolution". Its methods try to replicate the way an industry is operated, with highly standardized equipments, and an intensive application of technology. The advancements have allowed an undeniable increase in food productivity that many argue it permitted to sustain the great growth of population. Biotechnology is usually seen as a modification to this paradigm, that keeps some elements in common, but that adds others that are so new that some even consider it as a completely new agricultural paradigm. The father of the Green Revolution, the Nobel Prize winner Norman Borlaug, has called it as the only possible solution to feed the increasing human population (Borlaug, 1970) that many estimate it will almost reach 9 million around 2050 (FAO, 2006).

The spectacular growth of many south eastern Asian countries: In particular China and India, which both overpass a thousand million of citizens, have shown a continuous economic growth that has produced an increase in the economic conditions and welfare of a considerable part of their population. As a consequence, there has been an increased demand for food from this classes who have increased their economic power. Many say that this is one of the main motives why there is an increasing demand for different applications of the soybean harvest from south-eastern countries, and statistics seem to justify the argument. For example China accounts for 30% of soybean demand in Argentina.

Oil scarcity: The famous Hubbert peak, which preludes a forthcoming world oil reserves insufficiency, will hack entirely the way in which the world economy works. Advanced economies are already taking measure to promote alternatives energy sources that could replace the domineering world oil economy. Within the alternatives, biofuels have already been selected as a very promising one by many countries. In particular, the European Union has already approved legislations to reach certain minimum consumption levels in the following years. But, in order to achieve such levels, they will need to acquire biofuels from abroad, since they are produced based on crops, such as soybean or corn, since they are not harvested in abundance in Europe. As a result, a big pressure has been put on Latin American crop producers, such as Brazil and Argentina, to produce crops that will serve as raw material for biofuels production. The main danger with this pressure is that crops for fuel will be competing with crops for food, creating a paradox between harvests for oil or food.

Other economic reasons for soybean increasing prices: As if this was not enough, a recent policy brief (OECD, 2008) shows that there are many other reasons why many agricultural commodities, such as wheat, rice, corn, soybean and others, show an increase in price. Among them they mention the recent global economic crisis that might have produced a substantial increase of in speculative interests in agricultural future markets, and the fall in value of the US currency, due to the fact that in most cases the value of these commodities is expressed in US dollars.

In any case, the result has been an increasing demand for soybean production that has shaped high soybean international price which is the first and most important signal that attracts farmers towards its making. These factors push forward the use of biotechnology to produce GM crops and to extend the agricultural frontiers, which is just what is taking place in Argentina (Peiretti, 2007). In this context, a socio-technical regime has emerged in Argentina to respond to the external demands.

Notwithstanding, at the same time a couple of counter pressures or signals have raised that are pushing the regime towards new directions through a clear opposition against some of its most negatives aspects, which we briefly discuss below:

Increasing rejection of transgenic food: During the last years, there has been an increasing concern about the dangers that transgenic food might produce in health. It is still scientifically unknown which are the effects that this type of food might have on human and animal health systems. Thus, many organizations[5] advocate for a total ban of this type of food and promote instead a return to natural food, which does not have genetic modifications introduced by men through biotechnology.

Increasing segmentation of markets in advanced countries: Part in tune with the last point, there is a growing increase in the number of specialized markets in different advanced countries that are more conscious on the way and origins of the food the consume Markets have emerged which are characterized not only due to the organic food certification that their products have, but also due

[5] http://www.greenpeace.org/international/en/campaigns/agriculture/problem/genetic-engineering/

to the fact that the farmers who produced them have been able to harvest the food in basic and healthy conditions. In this way, the consumers are more responsible to stop the production of food through methods that end up damaging farmers or the environment in the original production territories.

Alternatives to soybean: During these years, many analysts have warned that one of the most profitable markets based on soybean, soybean oil exports, might be threatened by palm oil[6]. In particular, China has already decided to b buy more palm oil and reduce its soybean oil imports[7]. Possibly, these tendencies, if deepened, will contribute to put pressure on the amount of land dedicated to soybean harvest.

Increasing environmental concerns in the world, but also in Argentina: The dangers of climate change and global warming, plus others environmental concerns such as the upcoming world water and food crisis, are a signal of a growing environmental concern in the world. Argentina is not an exception to this international movement, and in particular, there are many exponents that fight against the expansion of the industrial agriculture which is heavily damaging many not renewable natural resources.

IV.1.2 The socio-technical regime

Main technical and social characteristics

The socio-technical regime that has emerged in the agricultural production in Argentina is very much like the one used in the soya bean production (which accounts for almost 60% of total Argentinean agriculture in tons and 25% of all exports), and is expanding to other crops such as corn and cotton.

The main technical elements of this regime are the following four, which are part of what is known as the Technological Package (Bisang, 2003) that is made up by the joint use of:

- **Transgenic seeds**: Most crops production in Argentina uses transgenic seeds. The appearance of biotechnology changed drastically the way in which seeds were improved, this was mainly due to the use of genetic engineering that allowed the production of a GM soybean seed that is resistant to the glyphosate herbicide. In this way the new genetic engineered soybean seed could survive the application of the herbicide that kills almost everything except it. These seed was originally developed by the multinational firm Monsanto, who licensed it to Asgrow, which was later acquired by Nidera. This last company introduced into Argentina the gene before it had been patented abroad my Monsanto. So the seed was already in commercialization in Argentina in the moment the American firm was trying to obtain legal property rights over it, and of course, this particular situation favoured the spread of the seed in the country. Statistics show the

[6] http://gestion.pe/impresa/noticia/aceite-palma-limitaria-demanda-aceite-soja/2011-05-04/31960
[7] http://ar.reuters.com/article/idARN1323724820110413?pageNumber=1&virtualBrandChannel=0

rapid expansion, for example, previous to 1996, the year in which GM soybean was approved in the country, there were no GM seeds, but just in 6 years, 91% of the seeds used for soybean production were transgenic (Bisang, 2003). Nowadays, this percentage is probably even higher.

- **Zero Tillage (ZT)**: This technology involves planting crop seeds in previously unprepared soil, without the need to till the land and other connected processes (levelling, sowing and necessary subsequent covering). This is allows planting the seed in a single process through the opening and subsequent flattening of a furrow where the seed is deposited and, if needed, fertilized. Farmers argue that No-till is a valid, realistic and applicable mechanism to improve productivity and profit, and at the same time reduce soil erosion produced by water and wind and degradation processes (Peiretti, 2004). But the technique requires fumigation in order to reduce competition from other species. So, the technique requires the use of herbicides, in this case, the glyphosate (Bisang, 2003). In 1990 the proportion of the area cultivated under ZT was almost negligible; in 2000 it was applied on 50 per cent of the total cultivated area; and in 2005/6 it had reached 70 per cent. The rapid and widespread diffusion of ZT technologies in Argentina in the 1990's provided new opportunities for the agricultural machinery sector, because new specific machineries were required, such as fumigation and zero tillage seed drill.

- **Biocides**: Widespread use of herbicides which are needed to eliminate every other type of grass, plague or insect that might compete or endanger the desired crops to harvest. In particular, it has been calculated that every year 300 millions litters of herbicide is used in Argentina for soya production. They are produced generally by the chemical industry, which in Argentina supplies a market of approximately US$ 700 million, of which 71% corresponds to herbicides. The appropriate for the soybean is the herbicide based on the chemical glyphosate that is offered by a number of international suppliers and a few local producers (Bisang, 2003). The GM RR Soy was originally designed to tolerate Monsanto's best selling herbicide Roundup, whose patents expired in 2000.

- **Fertilizers**: In Argentina, an accessory part of the technological package has been the massive use of fertilizers, whose use in tons increased around 8 times in the period 1984-2006, and the amount of kg used per harvested hectare increased approximately 6 times between 1993-2006. These numbers grow in tune with the expansion of the agricultural available frontier and the intensive application of ZT (Bisang, Anlló, & Campi, 2008).

The main social and organizational aspects of this regime are[8]:

[8] The list shows many points in common with the tendency also found in outsourcing practices in the manufacturing industry in the world. Thus, the social and organizational direction of the regime is not unique if analyzed under this more global optic.

- Who develops the activities is not necessary the same one who owns the land; This is a phenomena that results from a new actor which has entered the agricultural scene in the 1990s', the contractor, which owns machinery and knowledge, and rents big extensions of land to plant the crop;
- Service providers acquire higher priority;
- Contracts are the base of the different activities;
- The intensive use of certain technologies gain a prominence place in order to gain competitiveness, most of them are foreign supplied;
- The beans are demanded in quantity, quality and differentiation;
- Little state intervention in directing the trajectory, which almost completely shape by markets, but increasing state dependence on the sector for revenues;
- Little involvement of local consumers since almost all production is exported;

The combination of these characteristics shape a model of production that has been called a "Network coordinated model", which contrasts substantially with the traditional agro model in which the farmer owns directly the land and exploits it under his own risk, trying to dominate the greater amount as possible of processes with his own equipment. In this case, "to be from the farm" is to own land or machines and to control a substantial part of the production process (Bisang, Anlló, & Campi, 2008).

IV.2 Challenges of the dominant system: explaining the possibilities for change

The production system described above, and the associated expansion of the soybean production (and more recently of other crops) has brought in many challenges that have raised the voices of many people who cast doubt on the sustainability of the model. We have classified the critics in eight points which we now describe:

1. **Monocrop**: As a result of the transformations induced by the adoption of the technological trajectory described above soybean explains now 25% of total exports and 50% of all agricultural exports. This would put the country in huge economic risks since prices are highly volatile and demand, all external, is very sensitive to health and other moral concerns. Figure 2 shows the evolution of tons produced of soybean, and Figure 3 the evolution of hectares utilized with respect to other crops. Both show a higher growth of soybean production in comparison with the other following 4 more cultivated crops in the country, which seem to have stagnated in the analyzed period. This growth was permitted thanks to the expansion of the total amount of harvested land.

Figure 2: Total amount of tons for the production of 5 different crops. Source: Ministry of Agriculture, Livestock and Fishing.

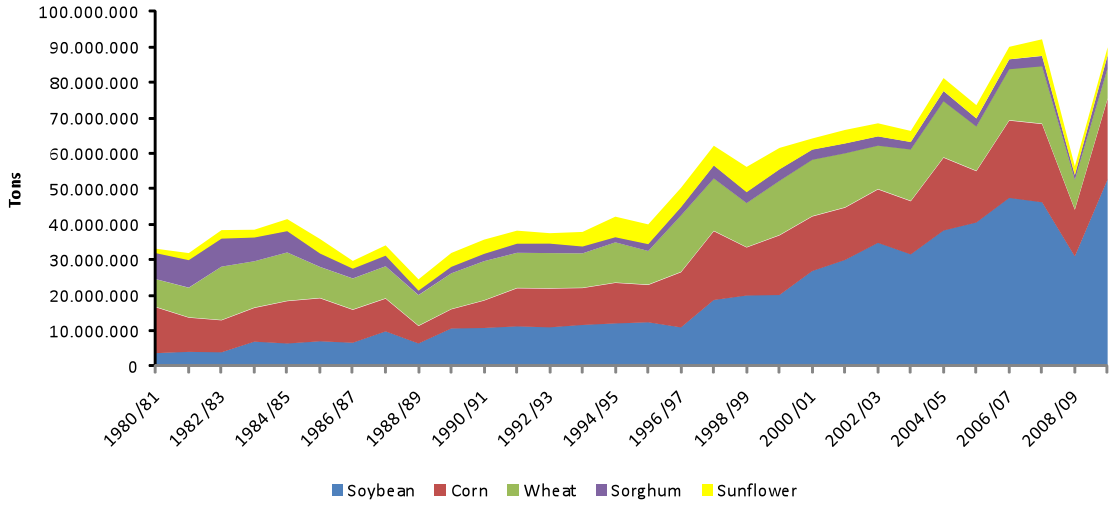
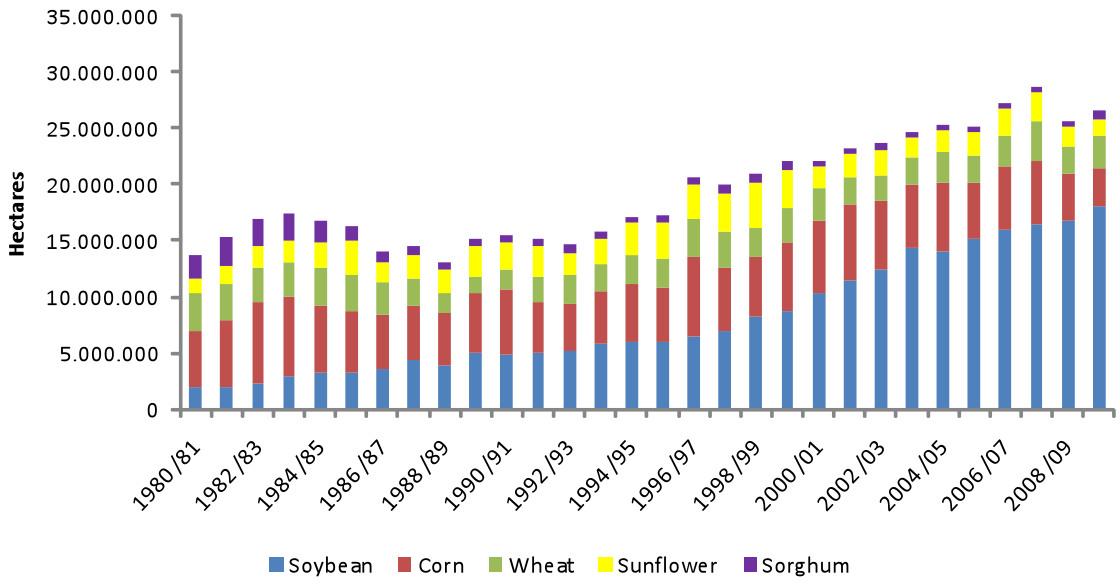
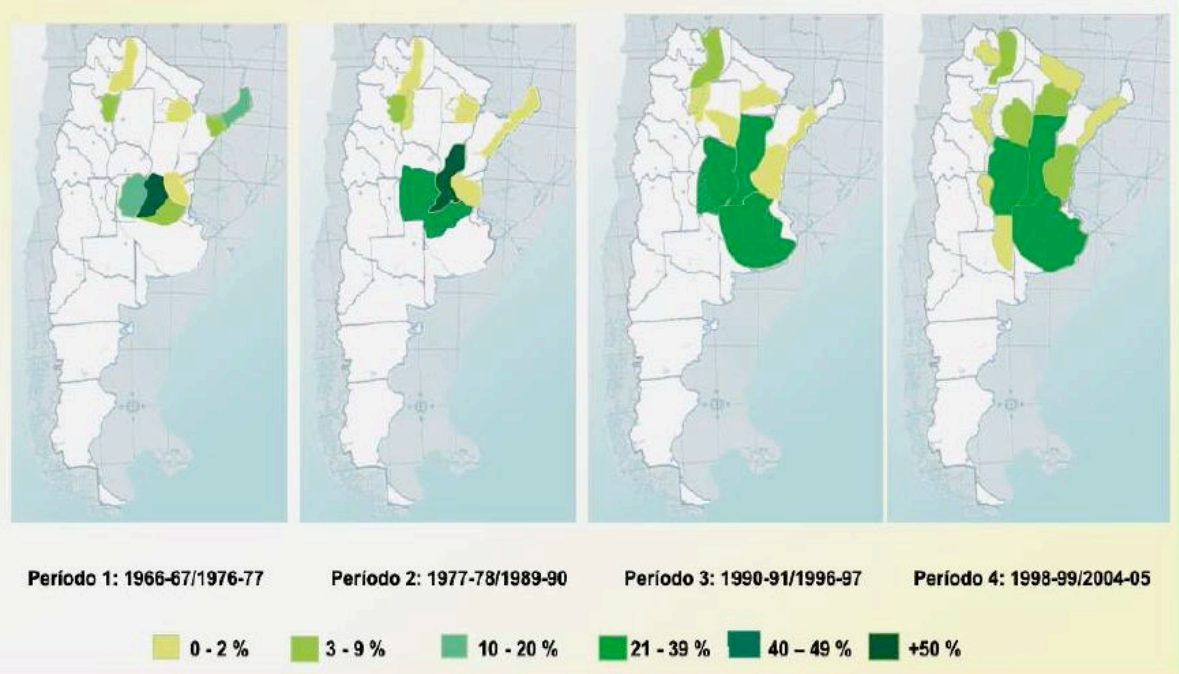


Figure 3: Total amount of hectares for the production of 5 different crops. Source: Ministry of Agriculture, Livestock and Fishing.



The immense geographic expansion can be observer in Figure 4 that shows the Argentinean territory and how soybean spread as oil in water along the country.

Figure 4: Spatial distribution of soybean harvested land. Source: (Brieva, 2006).



As regards exports, the Soybean complex is the one that has the greatest amount of exports in Argentina. According to a recent report from the National Institute of Statistics, the sector contributes to 25% of all Argentinean exports[9], followed in a second distant place by the automobile industry, that just represents slightly half of the soybean complex, amounting to a total of 12,6% with respect to all Argentinean exports.

This statistics prove that soybean production has become very profitable in Argentina, and that the amount of hectares dedicated to its harvest has increased dramatically, creating an over concentration of land and resources on this activity (justifying the name that some have used to refer to the increase of this crop in the country, renaming it as "the Soybean Republic[10]").

Some of the side effects of this concentration include:

- **Soil erosion:** The expansion of soybean monoculture in Latin America has intensified agriculture in a massive scale, this has resulted in a strong decline in soil fertility and, at the same time, in an increase in soil erosion, turning some soils unusable (Altieri & Pengue, 2006). For example, the continuous nutrients extraction needed in the soybean harvest might lead to heavy nitrogen and phosphorus scarcity that will limit the soil productivity (Pengue, 2001). One

[9] http://www.ambito.com/noticia.asp?id=581385
[10] http://www.elpais.com/articulo/reportajes/Republica/Soja/elpepusocdmg/20100404elpdmgrep_2/Tes

solution to this problem that has been expressed by the model proponents is an even higher use of fertilizers, which will undoubtedly increase the dependence on them (Reboratti, 2010).

- **Deforestation**: The expansion of hectares dedicated to soybean production has produced a rapid increase of deforestation in Argentina. These effects have been generated by soybean both in a direct and indirect way. In the first case, deforestation is caused when forests are felled in order to cultivate soybean. In the second case, indirect deforestation takes place when the replacement of other types of production for soybean, like livestock or wheat, ends up being pushed to terrains that were previously forests (Pujol & Ramírez Torres, 2007). For example, in Chaco, Argentina, 118.000 hectares have been dismounted in 4 years (1998-2002) to produce soybean, 160.000 in Salta and 223.000 in Santiago del Estero (Altieri & Pengue, 2006). Many other cases have been documented and systematized by Greenpeace (Greenpeace, 2007). Moreover, the indexes that measure the amount of deforestation in Argentina are even higher than the overall ones of Africa (Menéndez, 2007). In addition, this point summed with the previous one is cause of an increase in potential desertification in Argentina.

- **Loss of species and biodiversity**[11]: Research suggests that the level of plant and animal biodiversity present in agroecosystems plays a key role in their internal regulation, since it performs ecological services such as: food production, nutrients recycling, microclimate regulation, hydrological processes, suppression of undesirable organisms, among others (Altieri, 1999). Fortunately, Argentina is a country with medium biodiversity that has the second largest South American ecosystem, the Gran Parque Chaqueño, which has a size of more than 1 million km^2. However, the soybean expansion has been shown to threat the country's biodiversity (Pengue, 2010). In a recent research, different diversity indicators were used and all of them agreed that crop diversity had decreased in 20% during the period of soybean expansion and dominance (Aizen, Garibaldi, & Dondo, 2009). The authors also state that there is evidence of a trend towards a homogenization of Argentina's agricultural landscape that will likely have consequences for remnant biodiversity, degradation of different ecosystems services, and a more vulnerable production structure.

2. **Knowledge and Land concentration**:

Another conflictive point of the soybean production model is that it has produced a strong knowledge and land concentration.

[11] Biodiversity is the degree of variation of life forms within a given ecosystem, biome, or an entire planet.

As regards knowledge, the GM seeds are produced through the use of biotechnology and are immediately protected by intellectual property rights, that is to say, patents impede the knowledge use by others who have not paid for the exclusive rights that the owner of the patent has during approximately the first 20 years after its submission. In Argentina a peculiar situation took place, since Monsanto did not have a patent in the country and the GM seeds where distributed by Nidera. However, that did not stop Monsanto from trying to collect royalties for the use of its technology, which in the soybean production accounted to the majority of seeds. Monsanto at first tried, without success, in national courts, and later changed strategy this time trying to file lawsuits against European soy importers in the Netherlands and Denmark, accusing them of illegal importing their technology from Argentina. Even though Monsanto's strategy failed, since it was rejected by Europeans courts, it was a clear example on how multinational companies could use their power to threat the Argentina's agriculture, economy and soy export market (Antoniou et al., 2010). Moreover, knowledge concentration is also present in the production of herbicides. For example, the market in Argentina has a strong presence of multinational enterprises that supply the farmers with the needed biocides that are a cornerstone of the model (Bisang, 2003).

As regards land concentration, some researchers argue that the technological skills and the needed productive scale to reach export markets has favoured large producers, forcing small and medium ones to leave the business, since they are not in a competitive position to acquire the needed technology (Teubal, 2006) (Giarracca, 2008). Moreover, there is a strong land concentration, since according to information derived from the last agroindustry census the largest 936 productive units control 35.515.000 hectares, whereas in the other extreme, 137.021 farmers only control 2.288.000 hectares[12]. The increasing concentration of land, is leaving most of the population out of the benefits created by the activity, and concentrating in a few hands key decisions regarding what to do and how to do it.

3. **Health problems**:

The so praised technological package has been accused of causing serious health problems. The research that tackles them can be divided according to the following two causes of the health problems, which can affect animals, humans or plants.

- Caused by the use of the herbicide: Manufacturers state that Glyphosate is not dangerous, since it works as a broad-spectrum, non-selective weed killer by inhibiting an enzyme in plants that does not exist in human and animal cells. However, there are many studies that show that the use of Glyphosate and Roundup have highly toxic effects. For example, the authors (Antoniou et al.,

[12] http://www.revista2010.com.ar/agricultura/En-el-reino-de-la-soja.php

2010) have identified 12 previous works in which they show, in some way or another, how the herbicides are toxic to many organisms and even human cells. Among the problems, they remark that the use of the herbicide: damages human embryonic cells and placental cells; causes human cell deaths at dilution levels far below those recommended for agricultural use; acts as an endocrine disruptor, damaging DNA; is toxic for amphibians. A recent example that showed the dangerous fatal effects of the herbicide took place in the town of La Leonesa in Chaco, Argentina. There, continuous reclaims on the toxicological effects that the fumigations with glyphosate and other herbicides had in the population of the town, pushed the government to limit the use of herbicides to no less than 1.000m away from houses and 2.000m away if the fumigation is practiced using airplanes. This decision was based on the correlation between the increase of herbicides use and the increase of health problems in the population, mainly the augment of cancer cases, intoxications and water contamination. What is more, a recent book has compiled an increasing number of cases that expose the associated dangers and effects produced to animal, human and plant health by the continuous, indiscriminate use of biocides in different parts of the country. This book was cited in a recent interview, affirming that more than 600[13] towns are affected by the use of herbicides which, according to estimates, cover around a quarter of Argentina's population.

Last but not least, the Argentinean professor Andrés Carrasco has found in a recent research that glyphosate causes malformations in frog and chicken embryos. According to the author, these results raise concern for human off springs in populations exposed to glyphosate in agricultural fields, because the experimental animals share similar developmental mechanisms with humans[14]. This type of research faces the difficulty, both in Argentina and in other countries, of raising severe criticism from GM companies and pro-GM scientists, who dismiss this type of research as unscientific, discrediting their authors (Antoniou et al., 2010).

- Caused by GMO food: In this case, the risk is associated with the technique of genetic engineering. According to its proponents, the technique is just an extension of conventional plant breeding, but its detractors state that this is not the case since the introduction of an artificial gene into the host plant's genome is a process that would never take place in nature. The argue that this process is imprecise and can cause widespread mutations, which could produce mayor transformations in the plant's DNA blueprints, sometimes leading to the production of unexpected toxic, cancer causing, birth defects causing or allergenic compounds (Antoniou et al., 2010). Also, there is evidence that GM seeds have

[13] http://tiempo.elargentino.com/notas/donde-se-fumiga-glifosato-viven-mas-de-13-millones-de-personas
[14] http://www.gmwatch.org/latest-listing/1-news-items/12509-interview-with-prof-andres-carrasco-on-his-research-showing-roundup-link-with-birth-defects

suffered unpredicted DNA changes, which could produce unnatural, unintended RNA combinations that give rise to new and unexpected proteins[15] that might affect health. Also, some studies show that GM RR soybean can be less nutritious than non GM soybean and it may even be more likely to cause allergic reactions (Antoniou et al., 2010). Among others, the main conclusion that Antoniou and others arrive to with respect to this point, is that GM soybean is not substantially equivalent, as some regulatory agencies have expressed, to non GM soybean. And so, some propose the use of the precautionary principle to ban the production of GM products until it is shown they are not dangerous for human consumption (Pavoni, 2010).

4. **Food security loss**:

Another very relevant negative point that analysts highlight is that the expansive use of Argentinean soil for soybean production has put in danger the food security[16]. For example, some say that Soybean area has increased at the expense of dairy, maize, wheat, fruit and livestock production, in particular in the 2003/2004 growing season, 13.7 million hectares of soybean were planted but there was a reduction of 2.9 million hectares in maize and 2.15 million hectares in sunflowers, among others (Altieri & Pengue, 2006). Moreover, the area before dedicated to cotton drop 12 times, the area dedicated to cattle lost 13.5 millions in the Pampas, and 30% of dairy farms disappeared. As an effect of these changes, the cattle production lost 3 million units, the potato harvest fell between 1997/98 and 2001/2 from 3.4 million tons to 2.1 millions, green peas from 9.000 tons to 1.800 tons, lentils from 9.000 to 1.800 tons. So, some authors state that the decrease in the amount of other types of food apart from soybean has triggered a raise in the price of food that was usually used in the diet of low resources sectors, and as a consequence, they are no longer able to acquire the most basic food to obtain a balanced nutrition. And in this way they arrived to the conclusion that the international demand of soybean from foreign countries, which is not used for consumption, might be a cause of the increased amount of poverty in Argentina.

5. **Low labour demand**:

In spite of the argument that those in favour of the model sustain of the number of workers that the soybean value chain requires, other actors argue the model has reduced the total number of jobs, entering an agriculture production system "without farmers" (La Vía Campesina, 2010). These arguments are based on an analysis of the decrease of agricultural establishments, more precisely, according to data obtained from the last agricultural census made in the country, in 1988 Argentina had 422.000 establishments

[15] It is defined as any of a large class of complex organic chemical compounds that are essential for life. Proteins play a central role in biological processes and form the basis of living tissues. They consist of long chains of amino acids connected by peptide bonds and have distinct and varied three-dimensional structures, usually containing alpha helices and beta sheets as well as looping and folded chains. Enzymes, antibodies, and hemoglobin are examples of proteins.

[16] Refers to the availability of food and one´s access to it.

whereas in 2002 that number was reduced to 318.000 (Altieri & Pengue, 2006). Researchers argue that the decrease coincides with the growth of land dedicated to soybean, so they blame it for the diminishment in the number of farmers. It is argued that this is in part caused by the restrictive effect of the activity, such as is organised under this technological package, to create employment. This is a very land and inputs intensive technology (extensive in land), which barely demands labour in a country with high rates of unemployment, particularly in the country side, where most poverty is concentrated. In GM RR soybean farms labour levels decrease between 28 and 37% compared to conventional. It has also been estimated that the activity demands only 2 workers per 1.000 hectares. This has meant massive displacements of people from the country side to the cities, and an increase in poverty in the rural areas. But, on the other side, researchers say that in spite that the high technology used in the technological soybean package demands few workers, it is arguable that it has caused the high exodus that Altieri & Pengue remark, since the process of replacing man force with machines has been occurring since the 19th century (Reboratti, 2010). This shows that the debate about this point is still open. Anyway, it seems to be inevitable that if the agricultural frontier keeps on expanding, the monocrop will definitely force many small farmers out from the activities that they have been pursuing, since their small structures does not allow them to keep up the pace of competition with large producers that handle the technological package.

6. **Glyphosate resistant weeds**:

According to recent research, the technological package that sustains the growth and application of GM soybean (Binimelis, Pengue, & Monterroso, 2009) is under threat. The menace is caused by the appearance and explosive growth of glyphosate-resistant weeds, also known as super weeds. These weeds have been detected in many countries, amounting to a total of 21 glyphosate resistant weeds according to the International Survey of Herbicide Resistant Weeds[17]. Their existence undermines the viability of the Roundup Ready farming model since the glyphosate is no longer able to control undesired weeds that compete with the soybean. For example, in Argentina the Johnson grass is resistant to the glyphosate and some argue that it is already causing serious agronomic and economic impacts in the northern part of the country (Binimelis, Pengue, & Monterroso, 2009). The environmental impacts are caused by the recommendations that farmers receive from agronomists to deal with the super weeds. Technicians do not hesitate to advise farmers to combat the super weeds using even more toxic and dangerous herbicides than the glyphosate, such as MSMA or 2,4-D, which of course increases the environmental and health impacts. From the economic point of view, the appearance of the Johnsons grass has increased the needed costs to control the weed, reducing the cost savings that the glyphosate package allowed. This is why researchers argue that the emergence of these super weeds completely hacks the technological

[17] http://www.weedscience.org/

package, sinking the pertinent use of the glyphosate that has been marketed as a key innovation by their proponents.

7. **Virtual water trade**:

The water that is used in the production process of a commodity is called the "virtual water" contained in the commodity, and as a consequence, the international flows of commodities imply international flows of virtual water (Hoekstra & Hung, 2005). It is a well known fact that water is a key element needed in the production of every agricultural commodity, and so the existing water scarcity in several countries of the world limits their capacities to harvest certain crops. In order to deal with such a problem, these countries import the crops from other countries, together with the needed water used for their production, producing a saving in the countries that have the scarcity and a decrease of water in those who have the surplus. Argentina is the fourth largest exporter of virtual water trade, mainly pushed by the export of soybean. Critics argue that this tendency will erode the natural water availability that Argentina has, which is being considered as if it were infinite, and of course it is not. These actions are summed to the soil erosion effects that the soybean production system produces, that if they continue with this tendency, they will endanger the capacity of local producers to use water for agriculture (Pengue, 2006).

8. **Regional expansion and negative consequences**:

The regime is not only present in Argentina, recent research shows how soybean has expanded to neighbouring countries (Pavoni, 2010), such as Brazil, that now is the second largest producer in the world, occupying 28% of the production in a global scale, with approximately 21 million cultivated hectares, and 61 million tons of grain in the cycle 2007/08. In overall, the MERCOSUR was the region that most grew in soybean production during the last decades. In the 1970´s the total production hardly reached 2 million tons of the 42 millions of the global production. But, in 2008 this number grew considerably, reaching a total production of 115 million tons of grain, covering a little more than half of the total global production which reached 218 million tons of grain. These numbers clearly show how large the soybean production is in the block. What is worse is the considerable amount of land that is used to satisfy this soybean demand. In Argentina, Brazil, Paraguay and Uruguay 53% of the 100 million cultivable hectares are used for soybean production. This shows a clear tendency towards a monocrop in the whole block, which brings with it the large number of negative effects already mentioned. But, as it has been expressed for Argentina's case, the commercial block occupies the second place as a world soybean producer, and the first place as a global provider in the international exports market. This allows the member countries to obtain commercial and fiscal surplus, which generates a strong dependence with the regime that dampens the direction change towards more sustainable models. Also, this regional dependence suggests that a change in the regime

cannot be conducted only in one country, but that coordination between the different most important countries will be needed, since they are all equally affected by the positive and negative effects of the ST regime.

These several problems could be addressed in two ways, by either repairing some of the damages provoked by the system or by encouraging a completely different system. Next section discusses these two possible directions of change open for the agricultural sector in Argentina.

V. POSSIBLE DIRECTIONS OF CHANGE: PATH REPAIRING AND PATH BREAKING ALTERNATIVES

V.1 Path repairing alternatives

Some analysts believe that most of these challenges could be tackled within the regime, with policies that limit some of the side effects of the particular pathway followed by the agricultural sector in Argentina, developing innovations that repair some of the damages created by the dominant system. In the following paragraphs we discuss some examples of these path repairing alternatives:

1) Diversifying products, regions and knowledge

According to some of the interviewees, government could reduce the strong dependence on a few crops if it applies policies that switch price signals to other types of productions. For instance, even though with the same logic of production, i.e. with the intensive use of inputs and land, one possible escape for some of the problems of the dominant system, such as monoculture, and lost of diversity could be to encourage diversification of production towards others products which are highly appreciated in world markets. We briefly outline some of the possibilities without entering into detail on the production capacities in the country, which in all cases are still scarce but incipient.

- **Quinoa**: Quinoa is a supercereal that originates from the Andean region of South America, domesticated by pre Columbian cultures around 5.000 years ago[18]. It is considered as one of the few cereals of vegetal origin that is nutritionally complete, and it has even been considered by the NASA (Schlick & Bubenheim, 1993) as a crop for space missions, especially due to its richness in proteins and a desirable proportion of important amino acids.

- **Amaranth**: It is also a supercereal that was cultivated by Aztecs around 8.000 years ago. Such as Quinoa, Amaranth contains large amounts of dietary fiber, iron, and calcium as well as other vitamins and minerals, which give Amaranth an outstanding nutritional value. Also, it is also very low in sodium and contains no saturated fat[19].

[18] http://www.fao.org/docrep/t0646e/T0646E0f.htm
[19] http://www.nuworldamaranth.com/content/answers/whyamaranth.asp

In both cases, the crops are produced in the northwest provinces of Argentina, and they lack developed commercialization channels, mainly due to the lack of well developed consumer markets[20]. So, if production is expanded, an important bottleneck that has been identified and that should be tackled is the lack of proper logistics.

- Stevia: Ii is a plant native to Paraguay that has been traditionally used to sweeten beverages and tea. It has been mentioned as a very promising crop, due to its capacity to replace sugar, since it is times sweeter and it does not impact blood sugar levels. In other words, it is a very low-calorie sweetener and may be advantageous to diabetics[21]. In this case, one of the interviewees said that there are three cooperatives already working in the production and commercialization of Stevia in the province.

The development of these types of alternatives will help to diversify products, addressing the problem of monoculture, and diversify geographical zone, since a lot of the alternatives can be produced in regions different to the Pampas. The sources of knowledge are also different since a lot of it, in the crops discussed, it is more based on ancient local one that takes advantage of the specific properties of crops and plants in the region, and less in formal knowledge from Universities. .

2) Switching the technology

- It has been suggested that the damages caused by the intensive use of herbicide could be repaired by switching to another one less toxic than the glyphosate but that can fulfill similar functions over the desired crops[22]. Another option is to switch to Integrated Pest Management principles that could reduce the side effects that herbicides are producing. This alternative approach is based on a set of ecologically based strategies to pest control, utilizing knowledge of pest-crop relationships, establishments of acceptable economic threshold for pest populations, and constant field monitoring for potential problems. In Argentina, the INTA has been promoting the method since the 1970´s.

- Another action that could be regulated or enforced in some way is the proper and needed rotation during crops harvest. The recommended agriculture with rotation has not been respected, and that is one of the reasons why soils are becoming depleted, since products are not always properly used.

- As regards GM, Greenpeace has argued that a more healthy way to select species would be through the use of molecular markers[23], so that a desired property of the crop is naturally obtained, avoiding the risks that a not always controlled or known process of genetic

[20] http://www.cofecyt.mincyt.gov.ar/pdf/productos_alimenticios/Quinua_y_Amaranto.pdf
[21] http://longevity.about.com/od/lifelongnutrition/a/stevia-extract.htm
[22] On this point, some authors (Pavoni, 2010) argue that a thorough toxicological study is needed both on previous herbicides to the glyphosate, and of course, on the proposed alternatives, so as to foresight possible adverse effects.
[23] http://www.greenpeace.org/raw/content/espana/reports/selecci-n-asistida-por-marcado.pdf

modification implies. But, others argued this option might not be recommended, since due to its selection mechanism it reduces even further biodiversity.

All these alternatives by proposing a different technology, address some of the problems associated with the well spread use of herbicides and GM, though leave the other aspects of the socio technical regime intact, such as the limited employment generation, the concentration of knowledge in a few hands, etc.. Next section analyses a number of initiatives aim to address several of these problems at the same time.

V.2 Alternative systems of production, path breaking alternatives

In our research in the different available sources, the main niches that have been detected are connected with a system of agricultural production that differs from the industrial agricultural system. In theory, we have detected that these systems can be collected within what is known as Sustainable Agriculture. Even though there is no consensus in the meaning of the term, in the literature it is recognized as encompassing a collection of new ways of farming different from those labelled as "conventional or industrial" agriculture, as the ones employed in the RR soybean production process (Rigby & Cáceres, 1997). Heterogeneous groups of farming methods are included, which is why it is also sometimes considered more like a movement, in which the aim of the farming systems is to maintain the productivity and usefulness to society of their production almost indefinitely. Rigby and Cáceres highlight that there are significant differences of opinion as regards the type of farming practices to select in order to reach sustainability, and they mention that part of the confusion that arises in the definition of the concept is due to the large number of alternative agricultural systems that are associated with it. Anyway, these sustainable agricultural systems seem to be the most direct niches that could challenge the paths that the socio-technical regime is following worldwide.

Among the sustainable production farming methods, we have detected the following niches: Organic farming, Agroecology, Urban and periurban agriculture, Biodynamic Farming, Permaculture. In addition, we have selected a couple of alternative crops that according to the interviewees might have good economic potential in our country if some existing production difficulties are solved.

a) Organic farming:

As it happens with the concept "sustainable agriculture", there are also great varieties of definitions of what organic farming is (Rigby & Cáceres, 1997). To avoid entering into details in the controversy, we will quote the definition included in the Argentinean law, which states that organic farming or food refers to "agroindustry systems: that make rational use of natural resources, that do not use products based on chemical synthesis and others with real or potential

toxic effect for human health, that produce healthy products which keep soils fertility and biological diversity, and that conserve nutrients for vegetable and animal life" (Brebbia & Malanos, 2003).

As regards international interest on this production system, a recent report by the Food and Agriculture Organization of the United Nations (FAO, 2007) has considered both certified and non-certified organic systems as a good alternative to the industrial agriculture production system. For instance, recent research (Cáceres, 2003) in the province of Misiones, Argentina, compared two types of groups of tobacco producers, those who use organic methods and those who employed industrial agriculture methods. The research analyzed 15 case studies of each type and arrived to the conclusion that organic agriculture producers doubled the other group in the amount of diverse harvest crops. Also, the research suggests that these types of organic producers are more probably more prepared to reach their food sovereignty.

In addition, the next several benefits have also been detected and discussed in previous research:

- Is proved to decrease use of fossil fuel-related inputs, for example the percentage was between 10-70% lower in Europe and 29-37% in the USA.
- Increases food access by increasing productivity, diversity and conservation of natural resources, by raising incomes and by reducing risks for farmers.
- Improves results from sharing of knowledge among farmers.
- Contributes to climate change mitigation through doubling soil carbon sequestration and by decreasing greenhouse gas emissions.
- Promotes rural development, because it requires a substantial higher amount of workers than widely spread industrial agriculture methods (Brebbia & Malanos, 2003).
- Restores functional biodiversity and conserves environmental services.
- Improves household nutrient intake.
- Enhances water security, since irrigation needs are decrease in organic soils and better yields can be obtained even from water-stressed soils.

The main recognized problem with organic farming is to obtain the required certifications, which tend to be too expensive for small farmers, so they are left out from the official commercialization channels, or are not always recognized as organic producers by their customers. This problem arises due to the heavy tendency to export most of what is produced without making a difference between the products that are aimed to foreign markets and those to inner markets. So recently the discussion in the community has been centred towards the implementation of different certificates according to the target markets. Foreign ones would keep the actual structure, whereas local ones could implement collective certifications, as the ones implemented in Brazil (Mateos & Ghezán, 2010), which could allow a vast number of farmers to produce certifiable organic food. Also, the debate has included the subject of deciding who will pay for the certification, the consumer or the producer, and so far, the community seems to be inclined to the first option.

In addition, other objections that are usually used against organic farming as a system to contribute significantly to the global food supply are that it has low yields and that there are insufficient quantities of organically acceptable fertilizers. Of course, these are still points for debate, since recent research (Badgley, y otros, 2006) suggests that organic farming effectively could produce enough food to sustain the actual population and even a larger one, without increasing the agricultural land base, and that there exists enough sources for the use of organic fertilizers.

As regards foreign markets, the International Federation of Organic Agriculture Movements[24] estimates that in 2009 the global sales of organic food and drink reached a total of 54.900 million US$.

In 1992 Argentina was the first Latin American country to create a normative to produce organic food, and for this reason, it was the third country to be accepted by the European Union as an organic food producer and of course this motivated exports to the Union. To have a quantitative idea of what is produced in the country, according to recent research in 2008 4 million hectares were dedicated to organic farming, from which 90% is dedicated to organic livestock and the remaining percentage to organic agriculture (Grasa et al., 2010). Concerning Argentinean exports, Grasa et al (2010) state that 95% of what is produced in Argentina is sold abroad. The European Union is the largest customer with 68% of exports, followed by the USA with 24%, while the remaining 8% that includes countries such as Japan, Canada, Ecuador and others from South America. Measured in dollars, the study estimates show that exports reached around 150 million US$, which made Argentina the leading export in Latin America during the 90s. But according to the authors of the study, this has recently changed because as they show in their report, the high growth in exports that has taken place in countries such as México (400 million US$), Brazil (200 million US$) and Peru (100 million US$) has displaced Argentina from the first place in total amounts of exports.

The legal pioneering activity in Argentina did not come out of nowhere, in 1983 the Argentinean organic movement was formally initiated when 30 organizations with an ecologist and ecological agriculture trajectory met in a national event (Grasa et al., 2010). Since then, and in tune with the emergence of the international organic movement, many organizations and institutions were created in the country that fostered the development of the movement and its associated practices. For sure, the existence of organizations of this kind that brings together actors in the organic food sector with similar interests put forward the development of the sector, and they are also a clear sign that the niche shows certain level of development. Among the most important organizations within the niche we can emphasize the following ones:

- Organic Farmers Argentinean Movement[25] (MAPO, *Movimiento Argentino de Productores Orgánicos*): It was created in 1994 and it assembles the main actors from the Argentinean organic movement. The MAPO has been in charge of promoting the national organic law

[24] http://www.ifoam.org/
[25] http://www.mapo.org.ar/

and the national program for organic farming, among many other measures and activities to promote and certify organic production in the country.

- National Program for Organic Farming (PRONAO, *Programa Nacional de Producción Orgánica*): It was created in 2001 through the national decree 206/2001[26], but researchers state that it just entered into operation in 2008 when a loan from the Interamerican Development Bank was executed. The main objectives of the program are to promote organic farming in Argentina, to develop and improve commercialization of organic products, to strengthen certification and trust that customers have on these products, and to identify and diffuse different finance sources (Mateos & Ghezán, 2010).

- Argentinean Chamber of Certified Farmers (CAPOC, *Cámara Argentina de Productores Certificados*): The alliance brings together farmers that have already obtained a certification that proves they produce organic food according to the national law (Grasa et al., 2010).

- Argentinean Chamber of Certifiers and related (CACER, *Cámara Argentina de Certificadores y Afines*): This alliance groups the dozens of companies that are in charge of certifying that the food production by farmers in Argentina is done using organic methods (Grasa et al., 2010).

As regards legislation, in 1999 the law 25.127 that promotes ecological, biological and organic agroindustry production systems was established (Brebbia & Malanos, 2003). In addition, in 2003 a close public and private partnership started with the official establishment of an Assessment Commission of Organic Farming in the Agriculture Ministry of Argentina. This commission gathers the most important actors from the private and public sectors in the area, in order to advice the national ministry on policies related to organic farming (Grasa et al., 2010).

Even though the conditions seem to be promising, research on the sector highlights that there has not been a substantial increase in foreign exports during the last years. Moreover, local markets are scarcely developed and this is a strong barrier for the development of the sector (Grasa et al., 2010), since it conditions and limits the necessary learning skills to increase exports. These limits are in part due to the lack of help that farmers who decide to switch to organic farming have during the first years of their new production, where the costs are usually higher than in the previous applied methods. Also, there is lack of information on the several barriers and processes that must be fulfilled so as to export.

In spite of these barriers, a recent document (IICA, 2009) has recollected different successful organic farming experiences in the country, in order to foster similar models in other parts of Argentina. Below we have selected a couple of them that could be used for the next fieldwork phase, so as to study successful cases and organization methods within this niche.

[26] http://www.alimentosargentinos.gov.ar/programa_calidad/Marco_Regulatorio/normativa/prod_organicos/dec206_01.htm

- "Grupo Pampa Orgánica"[27]: It was created in 2003, and now it groups 12 organic farmers, summing a total of 17.000 hectares, with approximately 20% of that area dedicated to the production of crops such as sunflower confectionery, edible oil and high oleic corn, soybeans, millet, wheat, barley, rye, oats, and the remaining 80% devoted to beef production. The fields are distributed in four Argentinean provinces, (Buenos Aires, Santa Fé, Córdoba y La Pampa), and the group was the first organization in Argentina to obtain the certification for extensive organic farming. The case is not only interesting because of the cooperation between the different firms that are part of the organization, but also owing to the exploration they are doing with respect to new commercialization strategies and the different ways they have implemented to develop integrated productive systems. Moreover, they also have close contacts with the MAPO and receive technical assistance from technicians that belong to INTA.

- Stay "Las dos hermanas"[28]: It is part of the group Pampa Orgánica, and it is dedicated to agricultural and livestock production. They have 4.000 hectares and in particular, they rotate soybean, wheat, corn and sunflower and as regards livestock they are dedicated to the race Polled Hereford. Agricultural products are mainly exported to the European Union and USA.

- Rivara SA[29]: In 1997 the firm joined the organic market, and the first step for doing so was to certify the mill used to process corn. Nowadays, they have 1.000 hectares dedicated to organic production, of which they highlight wheat and corn, and recently they have also started to produce organic soybean based on seeds imported from the USA. The firm exports to many countries, including USA, Germany, Denmark, Switzerland, Holland, Japan, among others. According to the report prepared by the IICA, the firm was successful in detecting markets demands. It also received technical collaboration from the INTI[30].

- "Cuyen"[31]: It is a family firm founded in 1993 in the province of Chubut, and is dedicated to the production of different varieties of organic certified fruits. The firm exports to the most demanding countries for these types of products, such as Great Britain and Japan.

- "Altos Verdes": It is an agricultural farm of almost 1.000 hectares dedicated to the extensive organic production of cereals, oilseeds and cattle. The IICA report states that they rotate sunflower, corn and soybean. The importance of the experience relies mainly on its location, since the farm is in the Northeast of the Pampean Region, in the heart of

[27] http://www.grupopampaorganica.com.ar
[28] http://www.lasdoshermanas.com.ar/
[29] http://www.rivara.com.ar/Htdocs2/index.htm
[30] Instituto Nacional de Tecnología Industrial, its Argentina national institute dedicated to research and development of technology applied in diverse industries. For more detail check Background paper 2 (Peirano & Gordon, 2010).
[31] http://www.cuyen.com.ar

the area most dedicated to the production of transgenic crops. The firm collaborates with MAPO and the INTA.

b) <u>Agroecology:</u>

Once again the term is not conceptually clear. A recent review (Wezel, Bellon, Doré, Francis, Vallod, & David, 2009) about its historical evolution shows that agroecology can be defined as a science, a movement and a practice, which of course means that its definition covers an ample spectrum that includes political institutions, social classes and the scientific community (Altieri, 1989). And even more complexity is added to the definition since it also depends on the country under study, for example the authors mention that in France agroecology is understood as a practice, whereas in Germany it has a long tradition as a scientific discipline. Different is the case in the USA and Brazil, where the three meanings are used.

The scientific definition dates back to the beginning of the 20th century, where agroecology was coined as the application of ecology in agriculture, a definition which still is maintained nowadays. In more detail, according to Miguel Altieri it could be defined as "*the application of ecological concepts and principles to the design and management of sustainable, biodiverse and socially just agroecosystems*"[32]. During the years the scale in which the scientific definition focused varied, passing from the agroecosystem scale to whole food systems.

The movements associated with agroecology often emerged in the 1960s due to the unexpected consequences of the green revolution. During these first years the movements not necessarily used the term to identify itself, but they did advocate for changes in the industrial agriculture paradigm. Only in the 1990s the term spread to movements, who use it as an alternative to the domineering industrial techniques (Wezel, Bellon, Doré, Francis, Vallod, & David, 2009). In particular, in Annex I we describe the Movimiento Campesino Indígena that advocates for the massive use of agroecology in Argentina.

As regards its significance as a practice, one of its origins emerged in the 1980s in Latin America, including a set of practical experiences that had the potential to develop a more environmentally friendly and sustainable agriculture, for example conservation of natural resources, adapted soil fertility management and conservation of agrobiodiversity were the practical basis for the different agroecological movements that emerged in Central America's countries, like México, and Brazil (Wezel, Bellon, Doré, Francis, Vallod, & David, 2009).

Among its positive characteristics, at the international level a recent report from the United Nations suggests that by scaling up agroecological practices it could be possible to increase farm productivity and food security, improve incomes and rural livelihoods, and reverse the trend towards species loss and genetic erosion (De schutter, 2011). All this characteristics are considered to contribute to the realization of the right to food in different dimensions such as availability, accessibility, adequacy, sustainability and participation. Moreover, agroecology combines

[32] http://agroeco.org/wp-content/uploads/2010/11/agroeco-ruraldev-slowfood.pdf

scientific research with the expertise of local and native communities, putting a strong emphasis on technologies and innovations that require an intensive knowledge use, which are low-cost and easily adaptable by small and medium size producers. Due to all this facts, in a summary on a recent international assessment of agricultural knowledge, science and technology for development (RAPAL, 2009), agroecology has been considered as an alternative that can give the solutions for the environmental and food crisis that the world will face in the 21st century.

Critics argue that these methods do not have good enough yields, but research casts doubt on such arguments, since agroecological practices have been found to have equal or even greater yields per hectare than conventional methods (RAPAL, 2009). For example, the cotton case in Brazil exemplifies this characteristic of agroecological practices, since in 2008-9, after intense rains during the harvest period, those who decided to use agroecological practices obtained a yield of $R 980 per hectare, whereas the farmers who were inclined to the more traditional, agricultural intensive practices lost $R 762 per hectare. Another example is mentioned where the evidence sustains that farmers from Guatemala, Honduras and Nicaragua who used agroecological methods showed a greater capacity to adapt to the effects of the Mitch hurricane. In overall, the study suggests that agroecology is specially suited for rural communities and development economies.

One of the reasons why agroecology has not been able to spread more widely is due to its specificity in its application (Altieri, 2002), since a creative application of the principles is needed in each of the agroecosystems, leaving out a one size fit all solution or technological package, which of course is due to the inherent variability and uniqueness of local systems. Moreover, the authors state that there is a need to enlarge the diffusion of the knowledge and practices associated with agroecology, and certainly, to redirect more efforts to research and development that are nowadays mainly used for industrial agriculture. If such conditions changed, the author suggests that the results obtained through these types of methods would be even better.

As regards agroecology cases in Argentina, since 1995 the NGO Center for the Study of Agroecological Productions from Rosario (CEPAR, *Centro para el Estudio de Producciones Agroecológicas Rosario*) is studying the application of agroecological principles in the northern province of Santa Fé. In particular, they have used a participatory action research methodology so as to study and promote the development of agroecological practices in the Chaco Santafesino. In order to achieve this, the CEPAR has organized several meetings between agroecological farmers with the end of generating networks between the different actors (Ottmann, Sevilla Guzmán, & CEPAR, 2006). Also, recent research written by CEPAR members argues that an agroecological movement is emerging in the province, *Movimiento Agroecológico Santafesino* (MAS), since they recollect a number of other experiences along the province, showing that agroecology can be an alternative to the industrial agriculture system (Ottman, Sevilla Guzmán, & CEPAR2, 2006).

In this context, to study the different cases that are described by CEPAR members, it is advisable to enter contact this NGO so as to select some of the aforementioned experiences to examine in detail the way in which this types of niches are evolving in Argentina. For example, the organic farm “Arroyo del Medio”, where the CEPAR has participated (Tapella, 2004) in the design,

technical assistance and management of the project that was financed by the W. K. Foundation. The aim of the project were to create an integral organic farming that would allow 10 families to live from its production and to create a technical center specialized in teaching agroecological techniques.

As regards isolated projects, in 2006 the agronomist engineer Rodolfo Edgardo Timoni from INTA has put forward the project "Agroecological production for social inclusion"[33], which has the participation of 12 regional centres that belong to the INTA and that are distributed in different provinces. The project aims to gather information on existing agroecological practices, to create a network of agroecological systems of reference, to socialize and promote the diffusion of the generated knowledge, among others. Thus, it would be advisable to contact the project leaders so as to gather more information to study agroecological cases for the fieldwork.

c) Urban and periurban agriculture:

This niche is related with the previous agroecological concept, since one of its variants includes the possibility of applying the principles in orchards located in city zones or nearby ones.

Its worldwide importance has emerged due to the fact that there has been an increase of poor people in the cities, who are excluded from the production system and who do not have appropriate diets. In this context, supporters of this alternative state that urban agriculture offers a solution to these problems because it helps to improve food consumption both in quantity and quality (Reynaldo, 2004).

The most known example in Argentina is the national program ProHuerta[34], leaded by INTA that is promoting this type of agriculture. The program has been operative for more than 20 years and its main aim is to improve the food security of the country and to favour the participation and organization, in such a process, of vulnerable sectors of the society. In sum, it promotes self-sufficient food production, which includes the urban and periurban orchards in their actions. This is done through the promotion and adoption of alternative technologies of organic farming, the prohibition of the use of agrochemicals and other toxics which are replaced by a modern use and concepts of pest control, which are in all the process accompanied by the help of the technicians that belong to the organism (Pengue, 2006). According to Pengue (2006), the cornerstone of the program is the free seeds delivery it makes of the main vegetables and fruits to the producers, and also in the training it gives so that farmers can produce their own tools to harvest the land.

In the same sense, the city of Rosario has been a pioneer in this aspect, because since 1987 the city began with pilot projects with the creation of the first communitarian orchard. Some years later, after the creation and involvement of the CEPAR in the process (Lattuca, Sevilla Guzmán, Ottmann, & CEPAR, 2007), the amount of orchards was increased, and the growth continued even

[33] http://www.inta.gov.ar/extension/prohuerta/actualidad/boletin/boletin_html/BoletinProHuerta7/links/pnter3331.pdf
[34] http://www.inta.gov.ar/extension/prohuerta/

further after 2002 with the creation of the Urban Agriculture Program by the Secretary of Social Promotion under the city´s municipality[35] in part financed by the IDRC[36]. The program has a social aim, fighting poverty, fostering networks between producers and the distribution and commercialization of healthy food. To do this it promotes the creation of orchards in Rosario´s neighbourhoods. The official page argues they already have more than 640 orchards that produce for self consumption and 140 orchards whose production is sold in different fairs that take place weekly in the city.

In addition, on the 13th October 2010, Argentina's president, Ph.D. Cristina Kirchner, announced the creation of a National Program on Urban and Periurban Agriculture, which has as its main aims the promotion of food production, jobs generation, the strengthening of territorial capacities and the improvement of institutional links between the participating actors (Ministerio de Agricultura, Ganaderia y Pesca de la Nación, 2011). This initiative was boosted by a burgeoning amount of urban and periurban farmers that according to the Agriculture Ministry, rise up to 10.000 in the country. In particular, in the newspaper article they highlight the "green belt" in the zone known as "Gran La Plata", that produces around 30.000 annual tons of leaf vegetables, such as lettuce, tomatoes, eggplants, among others, that are destined for local consumption.

Considering the mentioned ongoing projects, for the field research a contact should be established with:

- Representatives and technicians that operate the program ProHuerta.
- As it happened with the previous niche, contact members of CEPAR to get information of experiences to study.
- Also, persons in charge of the programs that promote urban and periurban agriculture in Argentina, both at the national and provincial level, so as to gather information on which are the interesting cases to delve into.

d) Biodynamic farming:

It is an alternative agricultural system developed in Europe by the anthroposophist Rudolph Steiner in the early 1920s. As in previous niches, the biodynamic approach does not use synthetic chemical compounds, and what differs it from the other alternative systems is that its holistic view of agriculture requests to work with what it views as the spiritual dimension of the earth's environment (Rigby & Cáceres, 1997). More in detail, according to the Biodynamic Farming and Gardening Association[37], biodynamic is:

"*An impulse for deep social change rooted in the practice of farming. Biodynamics calls for new thinking in every aspect of the food system, from how land is owned to how farms are capitalized to how food is produced, distributed and prepared.*

[35] http://www.rosario.gov.ar/sitio/desarrollo_social/empleo/programa_au.jsp
[36] http://www.idrc.ca/uploads/user-S/11464968901UA_6_Rosario_sp.pdf
[37] http://www.biodynamics.com

A type of organic farming that incorporates an understanding of "dynamic" forces in nature not yet fully understood by science. By working creatively with these subtle energies, farmers are able to significantly enhance the health of their farms and the quality and flavour of food.

A recognition that the whole earth is a single, self-regulating, multi-dimensional ecosystem. Biodynamic farmers seek to fashion their farms likewise as self-regulating, bio-diverse ecosystems in order to bring health to the land and to their local communities."

In Argentina, the biodynamic movement started around 1985 with the initial meeting of experts and professionals interested in the subject. From then onwards, annual meetings were organized that fostered in 1998 the creation of the Argentinean Association for Bio Dynamic Agriculture[38] (or AABDA for its Spanish initials), whose aim is to develop and diffuse the principles of biodynamic agriculture developed by Steiner.

The AABDA states that there are 3.500 certified farms in the world that use biodynamic farming methods, which apply the principles for the production of diverse crops and livestock. The certification system, called Demeter[39] in honour to the Greek goddess of fertility, certifies that the farms production is based on the biodynamic principles. The AABDA is the organism in charge of giving the certification in Argentina, and so far they have approved 11 farms. Of course, they argue that many other farms apply biodynamic methods but that are not yet certified.

As regards successful cases to consider in the future fieldwork, the AABDA mentions the following four successful farms in Argentina that could be of interest for further research on biodynamic agriculture methods and techniques:

- "Naturaleza Viva": dedicated to agriculture and dairy, and situated in Guadalupe Norte, at the northwest of the Province of Santa Fe. We have made a first field visit to the farm in order to observe how the biodynamic farming method is applied. Prima facie, the experience proves that alternative methods can be used and that it is possible to obtain high yields. In particular, this farm exports varied products to most of the provinces of the country mainly to consumers who are aware of the better taste and natural properties that their organic production has. For sure, this case should be studied in more detail during the fieldwork, paying particular interest to the way in which the organization is managed and organized, contemplating the specificities that are needed to apply the farming techniques successfully.
- "El Rincón": situated in Villa General Belgrano, Prov. Córdoba.
- "El Hormiguero": that is dedicated to grow buffalos, situated Ruiz de Montoya, Prov. Misiones.
- "La Choza": dedicated to orchard and bakery, and situated in General Rodriguez, Prov. Buenos Aires.

[38] http://www.aabda.com.ar/
[39] http://www.aabda.com.ar/PHP-views/layout.php?IDSeccion=8

e) Permaculture:

The origin from this movement comes from Australia, where in 1975 Bill Mollison gathered principles of ecology, landscapes engineering and architecture (Martínez Castillo, 2004) to give birth to the concept. Also, it is argued that the movement has been inspired by the philosophy of Masanobu Fukoka, who created the concept of natural agriculture and who advocated for a holistic understanding of nature and humans in it, and so, for a radical change in the way that farming is made. In synthesis, permaculture aroused as a possible solution to two problems that modern urban areas have: The strong food dependence that cities have with rural areas and the high energy consumption based on non renewable sources. To tackle these problems, the movement advocates for the design of integrated agricultural systems, both in cities and in marginalized areas, in which groups of people decide to move to live in communities. In most of the cases, they are made up by urban people decided to dedicate part of their time to agriculture to become self-sufficient in food production.

In the literature, research (Martínez Castillo, 2004) affirms that the problem with this conceptualization is that it is considered as a post-industrial and computerized design of production landscapes that is severely limited in places where there exists no rational integrated control of space, like in Argentina. So, projects of this kind tend to be out of reach from the social and political realities of rural populations.

Notwithstanding, there are a couple of examples of small communities that are applying these principles and farming practices in Argentina. Among them we have detected the following ones:

- Ecovila Gaia[40]: It is located in Navarro, in the province of Buenos Aires and around 120 km from Buenos Aires city. It has a surface of 20,3 hectares and the inhabitants put forward activities so as to achieve the principles of permaculture. Within the villa, one can find the Argentinean Institute of Permaculture, that research, promotes and diffuses how permaculture can help to live in tune with nature.
- Velatropa[41]: According to their webpage, it is an interdisciplinary center, situated in the city of Buenos Aires. They offer courses on organic agriculture, appropriate technologies, and they have a seeds bank.
- Permacultura Research, Development and Education Center[42]: It operates in the province of Río Negro, near the city El Bolsón. It has 12 hectares dedicated to the application of the principles of permaculture.
- Montecallado[43]: It is a farm located in Tandil that has been created by a follower of Fukoka´s principles, who has studied such techniques in Japan and Greece. In the farm they specialize in the production of potatoes, wheat, pumpkins, beef, lamb, quinoa, among others.

[40] http://www.gaia.org.ar/
[41] http://www.velatropa.com.ar/
[42] http://www.cidep.org/
[43] http://bahiadenoticiasalter.wordpress.com/2010/12/27/un-oasis-sin-agroquimicos-solo-cultivo-organico-y-autoabastecimiento/#more-759

f) Alternative crops systems:

The interviewees mentioned another type of niches that could gain scale and become important alternatives in a nearby future. The cases include crops that have specific properties that are or could have a high demand due to their potential benefits to certain social sectors of world markets. We briefly outline their main properties, without entering into detail on the production capacities in the country, which in all cases are still scarce but incipient.

- **Quinoa**: Quinoa is a supercereal that originates from the Andean region of South America, domesticated by pre Columbian cultures around 5.000 years ago[44]. It is considered as one of the few cereals of vegetal origin that is nutritionally complete, and it has even been considered by the NASA (Schlick & Bubenheim, 1993) as a crop for space missions, specially due to its richness in proteins and a desirable proportion of important amino acids.

- **Amaranth**: It is also a supercereal that was cultivated by Aztecs around 8.000 years ago. Such as Quinoa, Amaranth contains large amounts of dietary fiber, iron, and calcium as well as other vitamins and minerals, which give Amaranth an outstanding nutritional value. Also, it is also very low in sodium and contains no saturated fat[45].

In both cases, the crops are produced in the northwest provinces of Argentina, and they lack developed commercialization channels, mainly due to the lack of well developed consumer markets[46]. So, if production is expanded, an important bottleneck that has been identified and that should be tackled is the lack of proper logistics.

- Stevia: Ii is a plant native to Paraguay that has been traditionally used to sweeten beverages and tea. It has been mentioned as a very promising crop, due to its capacity to replace sugar, since it is times sweeter and it does not impact blood sugar levels. In other words, it is a very low-calorie sweetener and may be advantageous to diabetics[47]. In this case, one of the interviewees said that there are three cooperatives already working in the production and commercialization of Stevia in the province.

V-CONCLUSION:

NR based industries are problematic for development. The discussion in LAC, and other developing countries has been very much up to know about how to move away from these industries towards more knowledge intensive ones. In this work we adopt a different angle; we wonder how we can

[44] http://www.fao.org/docrep/t0646e/T0646E0f.htm
[45] http://www.nuworldamaranth.com/content/answers/whyamaranth.asp
[46] http://www.cofecyt.mincyt.gov.ar/pdf/productos_alimenticios/Quinua_y_Amaranto.pdf
[47] http://longevity.about.com/od/lifelongnutrition/a/stevia-extract.htm

transform them, so they can better serve development goals in the region, economic, social and environmental. Innovation studies have developed a number of concepts that are useful to explore the transformation of industries into better direction. We borrow some of the concepts of these studies to explore the possibility to transform the agricultural sector in Argentina. This sector has started to create a number of challenges for the country, in association with the massive diffusion of intensive methods and the use of GM during the last 15 years.

We analyzed two possible paths of transformation, path repairing, i.e. projects that propose to carry on with the same logic of production and socio technical regime, but addressing some of the challenges that have emerged, and path breaking, i.e. projects that propose a completely different logic for the system.

Among the path repairing we identified encouraging alternative productions to soybean, the crop that more has grown in the country, in alternative geographical areas to Las Pampas, such as Quinoa and Stevia in the North of the country, inducing the use of less toxic herbicides, and non GM technologies. Among the path breaking, the three more developed alternatives that we identified are: organic farming, agroecological farming and biodynamic farming. As it has been cited, the difference between the three of them is subtle, since there is still no consensus on the definition of the terms that define these agronomic fields. Anyway, different national organizations were identified in the three cases, and a couple of examples, which are recommended to be selected and studied in detail in the future fieldwork.

These alternatives are very promising in terms of addressing the main problems arising in association with the dominant regime, either by attacking specific problems or by creating diversity and resilience. However, these alternatives face substantial barriers to growth that are important to understand if they need to be promoted. Some of them are related with the importance that the agricultural sector has acquired, as it is, for the Argentinean economy, which make it difficult to "question" any of its aspects, others are related to traditional lock in processes which make it difficult change in any circumstance. We discuss some of these barriers bellow

The importance of the dominant system for the Argentinean economy

The dominant regime, characterized by the technological package described before, has induced an increase in production and productivity in the sector, with no precedents in history. During the 1970s and 1980s, the agricultural sector in Argentina performed poorly. It grew less than the rest of the economy, with the total volume of output in 1990 being little higher than it had been in the 1960s. Between 1990 and 2005 the production of the sector grew by 5.7 per cent per year on average (while GDP growth was 3.4 per cent p.a.), and the total production of grains (mainly soybean, maize and wheat) more than doubled, from around 30 million tons at the end of the 1980s to around 70 million. Some of the reasons that explain this incredible expansion include:

- It has turned easier to scale up production[48].

[48] http://www.inta.gov.ar/reconquista/crsantafe/docsoja.htm

- Farmers have become more efficient by specializing in one crop.
- It is allowing the earning of high yields.
- To harvest soybean using this technological package and organization methods is less risky and has less complexity than other crops.
- It allows the expansion of the agricultural frontier to other geographic zones with other types of soils which would, otherwise, not be used.

In addition the sector has encouraged substantial growth in other related activities, more advanced in the value chain both downstream, and upstream, that in some cases, export most of production, such as oil production and biofuels. Argentina has one of the world most modern industries processing crops: 80% of the crops are processed, in Brazil this share is much smaller. During last 4 years the biofuels production has grown 400%, 85% of which is oriented to external markets, and two knowledge intensive industries that have been promoted in association with the activity are:

- **SEEDS:** Although international seed suppliers drawing on innovation undertaken largely outside Argentina captured a large part of the seed market opened up by the growth of the agricultural sector in Argentina, a striking feature of the last decade has been the emergence of significant localized innovation in the seeds industry. Some of the companies that are good examples of this good performance are: Nidera, Bioceres, Don Mario, Buke, Cane, etc.

- **AGRICULTURAL MACHINERY**: The rapid and widespread diffusion of ZT technologies provided new opportunities for the agricultural machinery sector. It opened niches for the evolution of certain type of activities within the sector, the manufacturers of relatively specialized self propelled sprayers and seeding machines (or planters), as well as producers of other knowledge-intensive implements and associated inputs for agriculture.[49] In contrast, in the case of more generally applicable tractors and harvesters, the share of the domestic market held by local producers was substantially reduced in the 1990s. Having accumulated substantial capacities to satisfy the demands of innovative agricultural producers in Argentina, these companies that were pioneers in the massive adoption of ZT technologies are in a strong position to produce machinery adapted to other ecological conditions by setting up production in the context of those conditions in other countries.

Other processes that are promoting stability and perpetuating the dominant system are:

Existing Capabilities channel technical developments into restricted subsets of all possible directions (Kemp et al., 1998; Elzen et al., 2004). Innovative activities and investments are also

[49] For instance, one sector for which we do not have systematic data, but which is emerging and growing is the sector producing satellite software and hardware for precision agriculture.

constrained by existing beliefs and perceptions, routines and habits. The accumulation of capabilities around the use of Zero Tillage technologies in the agricultural sector in Argentina is a good example of how this mechanism operates. This is limiting explorations in other possible directions within the agricultural sector (such as ones involving for instance rotation between agriculture and cattle) but also in related sectors, such as the agricultural machinery sectors.

Economics. Existing technologies tend to be cheaper and more efficient in the short run because they have benefited from long periods of dynamic increasing returns (e.g. learning-by-doing and using, scale economies and positive network externalities). This puts them in advantageous positions compared with novel practices (Arthur, 1989); Dosi 1982), and explains why developing countries adopt them massively in most industries, particularly in the export-led industries. Thus, it is not surprising that developing countries face important economic barriers to move to uncertain alternatives, since this means departing from important economic benefits gained from investment in existing technologies. The adoption of GM in the agricultural sector in Argentina once again provides a good example of this economic barrier to change. GM soybean explains 25% of the country exports, and 8% of all tax revenues. Moving to alternative technologies in this sector would mean therefore that the government has to offset one of the most important sources of income at the moment, which is also being used to maintain the current exchange rate, and therefore the only industrial policy of the government.

Vested interests. Incumbents have sunk investments (in capital, competencies and social networks, for example) that they will try to protect. They therefore resist radical change that threatens them. Large, established industries may contain divisions and individuals with more radical ideas, but they are less often empowered to implement these if core business interests are thereby challenged.

Politics and power. Incumbent businesses, regulators and others enjoy important positions in the current system. Economic power bestows considerable influence; they have voices that will be listened to by innovation policy processes (Smith et al., 2005). Innovators outside this nexus rely on future expectations to make their case. 'Outsiders' need not be small players, for example large information technology companies can be outsider innovators, but have a potentially transformative role to play in a move to 'smarter' technologies that threatens some incumbents. However, 'outsider' innovators are often relatively weakly organised compared to incumbents. Whilst today's shareholders, workers and customers can invest, vote and exert influence in numerous ways, tomorrow's stakeholders in more sustainable systems are a constituency less immediately powerful politically or economically. The Argentinean agricultural system assures that the voices of big business are heard by providing companies, such as Monsanto, Syngenta, Dow and Bayer a place in the discussions of Conabia (the main body responsible for GM approvals).

Infrastructure. Existing technological devices may be embedded in dedicated infrastructures that make their substitution with alternatives difficult (Jacobsson and Johnson, 2000). A very good example in this sense are the existing programmes in degrees in Agronomic Sciences in Argentina

which increasingly only teach subjects and contents that support the use of Zero Tillage, transgenic, etc., with not mention almost to any other competing technology.

Institutions. Government regulations and subsidies, professional associations, and market rules have co-evolved as part of existing systems and tend to reinforce existing trajectories of development (Hughes, 1983); Walker 2000). In the case of Argentina, the way these different institutions have evolved together to provide support for the use of biotechnology in the agricultural sector has prompted some analysts to identify a Bio-hegemony in this country (Newell, 2007): "bio-hegemony has been produced and sustained by an alliance of interests which included powerful agribusiness producers and traders (such as Cargill), export-oriented elements of Argentine capital (such as Biosidus, Relmo, and Don Mario), multinational biotechnology firms (such as Syngenta, Dow and Monsanto), large commercial banks, and supportive elements within the Argentine state itself" Newell, 2009, p. 35).

These processes interact and mutually reinforce one another, thereby structuring the way industries commit to certain socio-technical trajectories rather than others (Geels 2002). Systems that have become 'locked-in' to these trajectories are difficult to unsettle and re-direct.

Developing highly novel, 'path-breaking' socio-technical configurations takes place in the context of the deeply embedded, substantially institutionalized and widely reproduced 'socio-technical regimes' characterised above (Unruh, 2000; Geels, 2002). At times, it can appear as though societies are 'locked-in' to certain regimes, such as the intensive GM soya bean complex in Argentina. However, inflexible path-dependent alignments can, under certain circumstances, become a source of fragility as circumstances change. For instance, in Argentina the highly concentrated benefits and dependencies under the soybean boom, and the inability of the soybean 'socio-technical regime' to address this problem through incremental reforms, is leaving this mode susceptible to criticism and growing dissent. In addition, internal misalignments, brought about by technical changes or shifts in ownership for instance, can combine with external processes, such as concentration of wealth, growing impoverishment, rising environmental awareness, demographic change, and resource shifts. Such processes can unsettle regimes and open windows of opportunity for alternatives to develop, and perhaps seed transitions towards radically different configurations

However, considerable social agency is required. Consider all the material, discursive and institutional elements and changes needed to make an organic food system succeed: specialized knowledge, reliable techniques, skilled workers, investment capital, supply and distribution infrastructures, maintenance services, willing customers, profitable markets, acceptable environmental impacts, and so on, and so on.

In this context, the current project will definitely add more detailed information on how these niches have developed, and its actual state, so as to explore new paths of development that could enhance innovation capabilities in the country based on an alternative use of natural resources.

Bibliography

Aizen, M., Garibaldi, L., & Dondo, M. (2009). Expansión de la soja y diversidad de la agricultura argentina. *Ecología Austral* .

Altieri, M. (2009). *Agroecology, small farms and food sovereignty.* Retrieved from Monthly review: http://monthlyreview.org/2009/07/01/agroecology-small-farms-and-food-sovereignty

Altieri, M. (1989). Agroecology: a new research and development paradigm for world agriculture. *Agriculture, ecosystems and environment* .

Altieri, M. (2002). Agroecology: the science of natural resource management for poor farmers in marginal environments. *Agriculture ecosystems & environment* .

Altieri, M. (1999). The ecological role of biodiversity in agroecosystems. *Agriculture, ecosystems and environment* .

Altieri, M., & Pengue, W. (2006). GM soybean: Latin America's new colonizer. *Grain* .

Altieri, M., & Pengue, W. (2006). La soja transgénica en América Latina. Una maquinaria de hambre, deforestación y devastación sociológica. *Biodiversidad* .

Antoniou, M., Brack, P., Carrasco, A., Fagan, J., Habib, M., Kageyama, P., et al. (2010). *GM SOY. Sustainable? Responsible?*

Arthur, W. B. (1989) Competing Technologies, Increasing Returns, and Lock-In by Historical Events. The Economic Journal, 99, 116-131.

Badgley, C., Moghtader, J., Quintero, E., Zakem, E., Chappell, J., Avilés-Vázques, K., et al. (2006). Organic agriculture and the global food supply. *Renewable agriculture and food systems* .

Binimelis, R., Pengue, W., & Monterroso, I. (2009). "Transgenic treadmill": Responses to the emergence and spread of glyphosate-resistant johnsongrass in Argentina. *geoforum* .

Bisang, R. (2003). Difussion process in networks: The case of transgenic soybean in Argentina. *Globelics.*

Bisang, R., Anlló, G., & Campi, M. (2008). Una revolución (no tan) silenciosa. Claves para repensar el agro en Argentina. *Desarrollo Económico*.

Brebbia, F., & Malanos, N. (2003). La agricultura orgánica, biológica o ecológica en la Argentina y su repercusión en los mercados mundiales. *XXII European Congress and Colloquium of Agricultural Law.*

Cáceres, D. (2003). Agricultura orgánica versus agricultura industrial. Su relación con la diversificación productiva y la seguridad alimentaria. *Agroalimentaria* .

De schutter, O. (2011). Agroecology and the right to food.

Dosi, G. (1982). Technological paradigms and technological trajectories. Research Policy, 11, 147-162.

Elzen, B., Geels, F. & Green, K. (2004). System Innovation and the Transition to Sustainability: Theory, Evidence and Policy, Camberley, Edward Elgar.

Esteve, M. (2009). "Tierra y Agua para poder producir y vivir": El Movimiento Campesino Cordobés. *Revista Theomai* .

FAO. (2007). *International conference on organic agriculture and food security.*

FoNAF. (2008). *Documento base del FoNAF.* Retrieved from http://www.fonaf.com.ar/documentos/Documento_base_FoNAF.pdf

García Guerrero, L. (2009). De articulaciones y resistencias: la experiencia de las ferias francas de Misiones.

Geels, F. (2004). From sectoral systems of innovation to socio-technical systems. Insights about dynamics and change from sociology and institutional theory. *Research policy* .

Geels, F. (2002). Technological transitions as evolutionary reconfiguration processes: a multi-level perspective and a case-study. *Research policy* .

Giarracca, N. (2008). *La argentina y la democratización de la tierra.* Retrieved from Lavboratorio/n line: http://lavboratorio.fsoc.uba.ar/textos/22_4.htm

Grasa, O., Mateos, M., & Ghezán, G. (2010). *Evolución de la producción orgánica argentina en la última década.*

GRR (2009). *Pueblos fumigados: informe sobre la problemática del uso de plaguicidas en las principales provincias sojeras de la Argentina.*

Hoekstra, A., & Hung, P. (2005). Globalisation of water resources: international virtual water flows in relation to crop trade. *Global environmental change* .

Hughes, T. P. (1983). Networks of power: electrification in Western society, 1880-1930, Baltimore, MD, Johns Hopkins University Press.

IICA. (2009). *La producción orgánica en la Argentina.* Retrieved from http://www.iica.int/Esp/regiones/sur/argentina/Publicaciones%20de%20la%20Oficina/Prod_Org_Arg.pdf

Jacobsson, S. & Johnson, A. (2000). The diffusion of renewable energy technology: an analytical framework and key issues for research. Energy Policy, 28, 625-640.

Kemp, R., Schot, J. & Hoogma, R. (1998) Regime shifts to sustainability through processes of niche formation: The approach of strategic niche management. Technology Analysis & Strategic Management, 10, 175 - 198.

La Vía Campesina. (2010). *Sustainable peasant and family farm agriculture can feed the world.* Retrieved from http://viacampesina.org/downloads/pdf/en/paper6-EN-FINAL.pdf

Lattuca, A., Sevilla Guzmán, E., Ottmann, G., & CEPAR (2007). Hacia una agroecología urbana: crítica a la sociología de la agricultura desde la praxis del movimiento huertero de la ciudad de Rosario en el sur de Santa Fé. *Resumos do II Congresso Brasileiro de Agroecología.*

Martínez Castillo, R. (2004). Análisis de los estilos de agricultura ecológica. *Manejo integrado de plagas y agroecología* .

Mateos, M., & Ghezán, G. (2010). El proceso de construcción social de normas de calidad en alimentos orgánicos y la inclusión de pequeños productores. El caso de Argentina. *Innovation and sustainable development in agriculture and food.* Montpellier.

Menéndez, J. (2007). *Informe sobre la deforestación en la Argentina.* Secretary of environment and sustainable development.

Ministerio de Agricultura, Ganaderia y Pesca de la Nación (2011, 4 24). La agricultura próxima a las ciudades, una actiividad en desarrollo y generadora de puestos de trabajo. *Tiempo Argentino*.

Newell, P. (2009). *Bio-Hegemony: The Political Economy of Agricultural Biotechnology in Argentina.* Journal of Latin American Studies, Cambridge University Press.

OECD. (2008). Rising agricultural prices: Causes, Consequences and Responses. Retrieved 04 05, 2011 from http://www.oecd.org/dataoecd/1/36/41227216.pdf

Ottman, G., Sevilla Guzmán, E., & CEPAR (2006). Elementos para el análisis del desarrollo agroecológico en una provincia Argentina: el caso de Santa Fé. *Resumos do I Congresso Brasileiro de Agroecologia.*

Ottmann, G., Sevilla Guzmán, E., & CEPAR (2006). Estrategias agroecológicas en una provincia Argentina: el caso del chaco santafesino. *Resumeos do I Congresso Brasileiro de Agroecologia.*

Pavoni, J. C. (2010). *Oro verde en Sudamérica.* Retrieved 03 15, 2011, from http://www.vocesenelfenix.com/pdf/pavoniweb.pdf

Peiretti, R. (2004). The No-Till cropping system and its evolution toward the achievement of the MOSHPPA model principles. World Soybean Congress. Foz de Iguazú.

Pengue, W. (2006). "Agua virtual", agronegocio sojero y cuestiones económico ambientales futuras... *Fronteras* .

Pengue, W. (2010). *Agrocombustibles y agroalimentos: considerando las externalidades de la mayor encrucijada del siglo XXI.*

Pengue, W. (2001). Impactos de la expansión de la soja en Argentina. Globalización, desarrollo agropecuario e ingeniería genética: un modelo para armar. *Biodiversidad* .

Pengue, W. (2006). *La autoproducción de alimentos en Argentina. "Aún nos quedan las manos y la tierra" ...* Retrieved from http://www.redes.org.uy/2006/11/30/la-autoproduccion-de-alimentos-en-argentina-aun-nos-quedan-las-manos-y-la-tierra-2/

RAPAL. (2009). *Agroecología y desarrollo sostenible.* Retrieved from http://www.rapaluruguay.org/organicos/articulos/AgroecoBriefFINAl.pdf

Reboratti, C. (2010). Un mar de soja: la nueva agricultura en Argentina y sus consecuencias. *Revista de geografía norte grande* .

Reynaldo, T. (2004). *Experiencias en agricultura urbana y peri-urbana en América Latina y el Caribe.* FAO.

Rigby, D., & Cáceres, D. (1997). *The sustainability of agricultural systems.*

Rip, A. & Kemp, R. (1998). Technological change. In Rayner, S. & Malone, E. L. (Eds.) *Human choices and climate change. Volume 2: resources and technology.* Columbus, Ohio, Bateller.Schlick, G., &

Bubenheim, D. (1993). *Quinoa: An emergent "new" crop with potential for CELSS.* Retrieved from http://ntrs.nasa.gov/archive/nasa/casi.ntrs.nasa.gov/19940015664_1994015664.pdf

Smith, A., Stirling, A. & Berkhout, F. (2005) The governance of sustainable socio-technical transitions. *Research Policy,* 34**,** 1491-1510.

Tapella, E. (2004). Agroecología, seguridad alimentaria y desarrollo sustentable en Argentina: Sistematización de cuatro experiencias en el contexto de la crisis reciente. *Primer conferencia de seuimiento, evaluación y sistematización de América Latina y el Caribe.*

Teubal, M. (2006). Expansión de modeo sojero en la Argentina. De la producción de alimentos a los commodities. *Realidad económica* .

Unruh, G. C. (2000) Understanding carbon lock-in. Energy Policy, 28, 817-830.

Walker, W. (2000) Entrapment in large technology systems: institutional commitment and power relations. Research Policy, 29, 833-846.

Wezel, A., Bellon, S., Doré, T., Francis, C., Vallod, D., & David, C. (2009). Agroecology as a science, a movement and a practice. A review. *Agronomy for sustainable development* .

Annex I: Political movements

As the theoretical framework shows, changes in socio-technical regimes are influenced by political movements, and the regime under study is no exception to this. In the following section we briefly outline a couple of organizations that support the regime and others that are in favour of a change in the agricultural production system towards other systems that address the problems that the regime and its monocrop tendency have.

a. Peasant Agriculture:

The international organization, La Via Campesina[50], which gathers family and peasant organizations all over the world, believes that agroecological food production by small farmers is the agricultural model best suited to meeting future food needs (La Vía Campesina, 2010). They argue that truly sustainable peasant agriculture comes from a combination of the recovery and revalorization of traditional peasant farming methods, and the innovation of new ecological practices. Peasant movement fights for a transition towards these types of systems, and for doing so they agree that significant structural changes are needed in addition to technological innovations, farmer-to-farmer networks and farmer-to-consumer networks. Peasant movements are aware that strong political will is needed to dismantle and transform the institutions and regulations that block sustainable agriculture (Altieri, 2009), and that is the reason why they have emerged as a movement, having a cornerstone proposal of an integral agrarian reform, that would imply a redistribution of lands and the possibilities of their exploitation, the organization of cooperatives, local agroindustries, productive diversification and an adherence to the principle of food sovereignty[51]. And in this sense is oriented the fight that the Argentinean peasant chapter has, the National Indian Peasant Movement (*Movimiento Nacional Campesino Indígena*, or shortly MNCI). The MNCI[52] is made up by several sub organizations that act in different provinces of the country, like the MOCASE in Santiago del Estero, the MOCAFOR in Formosa, or the MCC in Córdoba. Despite its different units, the whole movement advocates for an end to the agribusiness, underlining the several negative points that this type of production has. As a counterproposal, they have in mind several alternatives based on agroecological methods, including urban and periurban agriculture, plus a return to an agriculture production system with large amounts of farmers in the fields, increasing the amount of work needed to harvest the land. Moreover, they promote what they identify as local development models that do not have as an aim infinite growth at all cost, but instead, that they allow the achievement of a better life quality, resolving the existing problems through the use of alternative pathways (Esteve, 2009).

[50] http://www.viacampesina.org/sp/

[51] Food sovereignty is defined as the right for each nation or region to maintain and develop their capacity to produce basic food crops with the corresponding productive and cultural diversity (Altieri, Agroecology, small farms and food sovereignty, 2009).

[52] http://www.mnci.org.ar/index.php?option=com_content&view=article&id=12&Itemid=9

b. Familiar Agriculture:

This movement is represented in Argentina by the Forum of Familiar Agriculture (FoNAF, *Foro Nacional de la Agricultura Familiar*), which was formally created in 2005 and that gathers over 100 organizations that represent the familiar agriculture sector. According to FoNAF, familiar agriculture is a lifestyle and a matter of culture, that has as its main objective the social reproduction of the family in fair conditions, where the management of the productive unit and every investment realized in it is done by persons who have a link within the family, the most part of the work is done by members of the family, the ownership of the production means belongs to the family, and the transmission of values, practices and experiences is done in its interior (FoNAF, 2008).

FoNAF highlights the importance of the sector based on a number of statistics obtained from the agricultural census of 2002. The results show that 71% of agricultural farmers belong to the group of small producers, which is related to familiar agriculture. As regards workforce, the small producers provide 53% of the total employment generated in the national agricultural sector.

As in the case of the MNCI, FONAF also believes that an integral rural reform is needed in the country, whose objectives are to reach a social equality, to allow the participation of up to day outcast sectors in political power and to look for a more egalitarian economic distribution.

Within this concept of familiar agriculture, a case that has been already studied in the literature (García Guerrero, 2009) is the "Ferias Francas" that have been organized in the province of Misiones. These are fairs that can be defined as small local markets sustained by groups of families farmers who get together twice per week so as to commercialize directly to the consumer the food they produce in their own lands. The authors say that in 2009 2.500 families participated in the organization in 40 fairs distributed along the province. The food is produced by each of the families in terrains that in some cases are located around 30 to 40 km away from the fairs. This is why some collective arrangements have emerged to share the transport costs. According to the research, the fairs have allowed an increase of varieties of harvest food by the participating farmers. Also, the consumers have benefited in the obtaining of a basic amount of proteins for their diets, thanks to the lower costs that the food sold in the fairs has. And a very important aspect of the experience has been the creation of "seeds fairs", in which the farmers freely exchange their varieties, which of course is in strict contrast to the owned seeds in the biotechnological production system.

As regards the cases, a contact could be made with the "Ferias Francas" and the researchers who previously studied the case, so as to deepen the analysis in the dimensions relevant to the ongoing project.

c. Some institutions of the dominant Sociotechnical regime

The dominant regime has many organizations of different kind that support the followed direction and that push forward new technological advancements. Among them, without being exhaustive

in our description which can be deepened in the results obtained in previous reports[53] and in the webpages of the relevant organisms, we can highlight the following ones:

Acsoja[54]: In this case, it is the organization that groups entities of the entire soybean value chain, gathering: science and technology organisms, different types of inputs providers, service providers, commercialization organisms, among others. Its website gathers information on events, congresses, workshops, and news related to the sector.

Prosoja: It's a nonprofit organization which gathers soybean breeders and researchers in Argentina. It was created in 1983 in the city of Tucumán. The organization has participated actively in the promotion of this crop, in the orientation of research and development plans, in the organization of technical events and congresses and in continuous educational activities.

AACREA[55]: the *Argentine Association of Regional Consortiums for Agricultural* Experimentation is a non-profit institution registered as such under Argentine law. According to its webpage, it was founded in 1960, and is the mother organization of about 200 CREA groups throughout Argentina, divided into 18 different ecological and productive regions. The CREA groups and their organization are commonly referred to as the CREA Movement, and its objective is to promote the technological and managerial development of its members, striving, through participative methods, to attain the all-round improvement of producers, technicians, and the rural community as a whole.

AAPRESID[56]: It is the Argentinean Association of No-Till Farmers, a non-profit governmental association comprising a network of agricultural producers who adopted and promoted the spread of the use of no-till farming techniques.

[53] http://www.inta.gov.ar/manfredi/info/documentos/economia/Libro_Giletta_2010/Publicaci%C3%B3n%20cadena%20soja%20nacional.pdf

[54] http://www.acsoja.org.ar/

[55] http://www.redcrea.org.ar/

[56] http://www.aapresid.org.ar/

Annex II: Preliminary innovation fund DB results

A preliminary analysis of the FONTAR innovation fund projects was done. The methodology used was based on keywords. Upon the main characteristics of the regime and the detected niches, a search was made in projects abstracts so as to detect those that might be related to the regime or the niches. For example, “no till” or “GM soybean” or “Glyphosate” were used to detect projects related to the regime, whereas “organic” and “agroecology” were used to detect projects that might be related to the identified niches. This preliminary search showed that this fund mainly finances projects that follow the direction that the dominant regime is taking, since 82 projects were found that are related to it. Whereas just 8 were related to organic production methods. Of course, a more in depth search is still needed summed with a case by case analysis of the projects that could be put forwards in the following part of the project.