"Nuestras tierras tradicionales se caracterizan por ser muy fértiles y por ello hemos sido presionados permanentemente por concesionarios, colonos, el Parques Nacionales y, actualmente, por grandes productores agrícolas, "pools de siembra" y por el propio gobierno provincial"

Comunidad Qom, Formosa Argentina.

Understanding Agricultural Change

Nancy Guadalupe Arizpe Ramos

Understanding Agricultural Change: Integrated analysis of societal metabolism at different scales

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Quotation

Nosotros decidimos qué comemos, podemos elegir si seguimos comiendo petróleo o cambiamos nuestros hábitos alimenticios porque somos lo que comemos.

La manía por el crecimiento es la actitud de la teoría económica que empieza con el supuesto teleológico de las necesidades infinitas y el primer mandamiento es producir más y más bienes para más y más gente en un mundo sin fin. Y esto no solo no es posible, sino que tampoco es deseable. (Daly 1977, pág 51)

Abstract

The industrialization of rural systems and integration into international markets are commonly proposed as rural development strategies in the South. Technologized agriculture has driven changes in land use and human activity. These changes generate severe negative impacts (socio-cultural, ecological, and biophysical) associated with malnutrition, migration, poverty, and lack of food among others. In addition, it also induces changes in monetary flows and energy inputs, such as machinery, oil products, fertilizers and genetically modified seeds, which result also in negative social and environmental impacts.

In this sense, and in order to address concepts such as food security and sustainable agriculture, it is essential to focus on the restrictions that the requirement of land, soil, water and other natural resources impose on the possibility of generating an adequate food supply. Therefore, it is important to visualize the trends of technical progress in agriculture at a global level in order to be able to contextualize the discussion of alternative techniques in agricultural production and rural development.

The inspiration of this thesis is the complexity of the crisis in the agricultural sector in developed and developing countries while its principal purpose is to contribute in the understanding of environmental and socio-economic issues involved in agricultural changes. The research considers both empirical analysis and field work through the integration of different theoretical frameworks and methodologies such as the analysis of time and land use (Land Time Budget Analysis - LTBA), characterization of typologies in the context of societal metabolism, and multi-scale analysis. The Multi-Scale Integrated Analysis of Societal and Ecosystem Metabolism (MuSIASEM) framework is applied from a local scale, through a community to a regional one. This allows grasping the biophysical drivers that induce conflict in the study areas. Finally, the research is completed with an analysis of the decision making processes found in the study cases.

Keywords:

Agricultural change, multi scale analysis, societal metabolism, soy expansion, participatory processes.

Resumen

La industrialización de los sistemas rurales y la integración en los mercados internacionales son estrategias de desarrollo rural comúnmente propuestas en países del Sur. El modelo tecnificado de la agricultura ha provocado cambios en el uso de la tierra y en la actividad humana que pueden generar severos impactos negativos (socio-culturales, ecológicos, biofísicos) asociados a la desnutrición, la migración, la pobreza, la falta de alimentos, entre otros. Por otro lado, también induce cambios en los flujos monetarios y en el uso de energía, tales como maquinaria, petróleo, fertilizantes y semillas genéticamente modificadas, que tienen como resultado impactos negativos sociales y ambientales.

En este sentido investigar temas de la seguridad alimentaria y la sostenibilidad de la agricultura son fundamentales, por ejemplo centrarse en la restricción que el uso de la tierra, suelo, agua y otros recursos naturales conlleva a la posibilidad de generar un suministro adecuado de alimentos. Por lo tanto, es importante visualizar el panorama de las tendencias actuales del progreso técnico en la agricultura a nivel mundial, con el fin de ser capaz de contextualizar la discusión de las técnicas alternativas de la producción agrícola y el desarrollo rural.

La complejidad de la crisis del sector agrícola tanto en países desarrollados como en desarrollo es la inspiración de esta tesis, así mismo se profundiza en el conocimiento de las problemáticas ambientales y socio-económicas implicadas.

Esta tesis considera tanto un análisis empírico como trabajo de campo a través de la integración de diferentes marcos teóricos y metodologías como son: el análisis de usos del tiempo - suelo (Land Time Budget Analysis - LTBA), aplicación de tipologías en el contexto del metabolismo social, Análisis Multiescalar del Metabolismo Social y Ecologico (MuSIASEM). Esta integración de marcos téoricos y metodológicos a diferentes niveles permite entender los desencadenantes biofísicos de conflictos agrícolas. El estudio se completa con un análisis de los procesos de toma de desiciones en las zonas de estudio.

Palabras clave:

Cambios en la agricultura, análisis multi-escalar, metabolismo social, expansión de la soja, procesos participativos.

Preface

Thesis tries to reflect and integrate science with traditional knowledge. This is an important premise of inspiration, particularly in the context of my education which has been developed in a globalized world immersed in neoliberalism, coupled with the deep Mexican reality (*México profundo*), where it appeared that time did not pass and modernity would never come.

I still remember the day when, studying science at UNAM, our zoology professorasked us to exemplify a taxonomic classification. My answer built on a traditional taxonomic classification that I had learned in the degree of Physical Anthropology. Logically, the teacher did not accept this *non-scientific* answer. This experience led me to think about the long distance that existed between exact sciences and social sciences and more far away to the traditional knowledge. The previous statement inspired me to always seek a path that includes different views and areas.

Thus, I believe this thesis is not a theoretical contribution but deals with understanding what is happening in the real world and in indigenous communities, focusing more specifically in the agricultural systems and their importance for Latin America.

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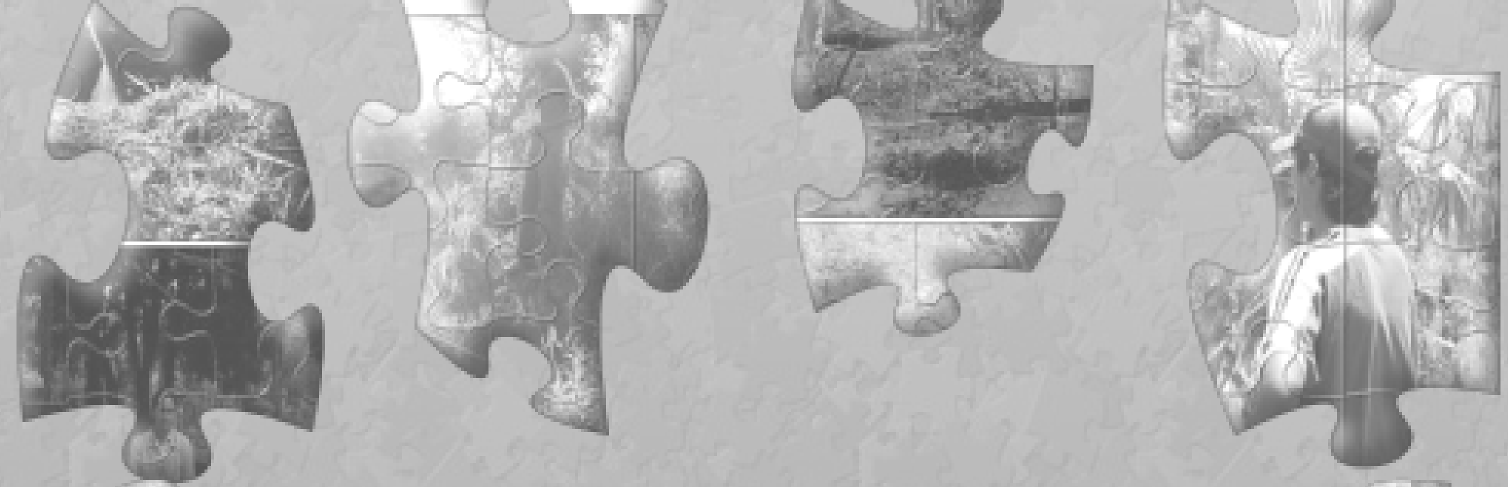
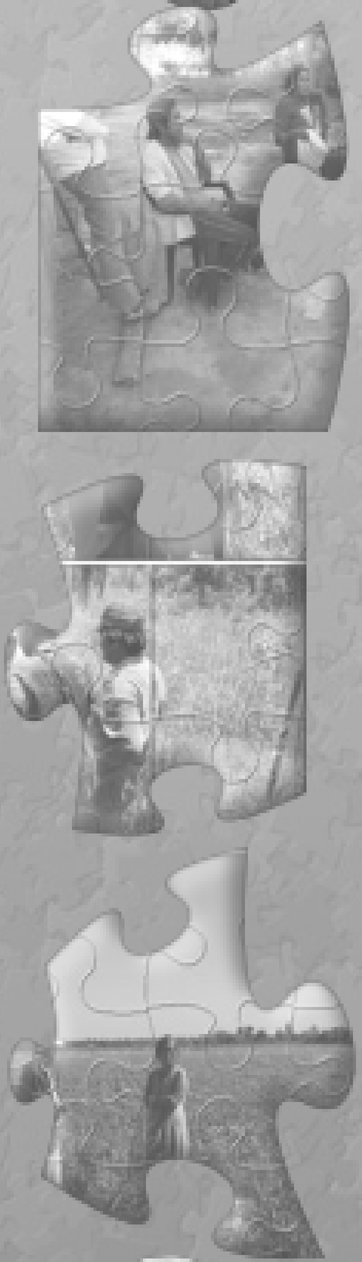
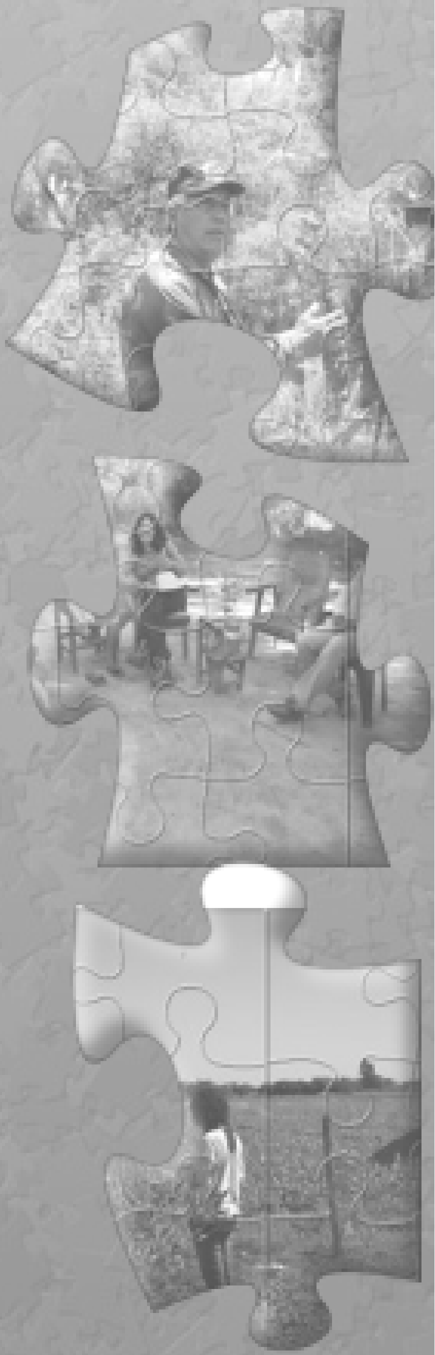
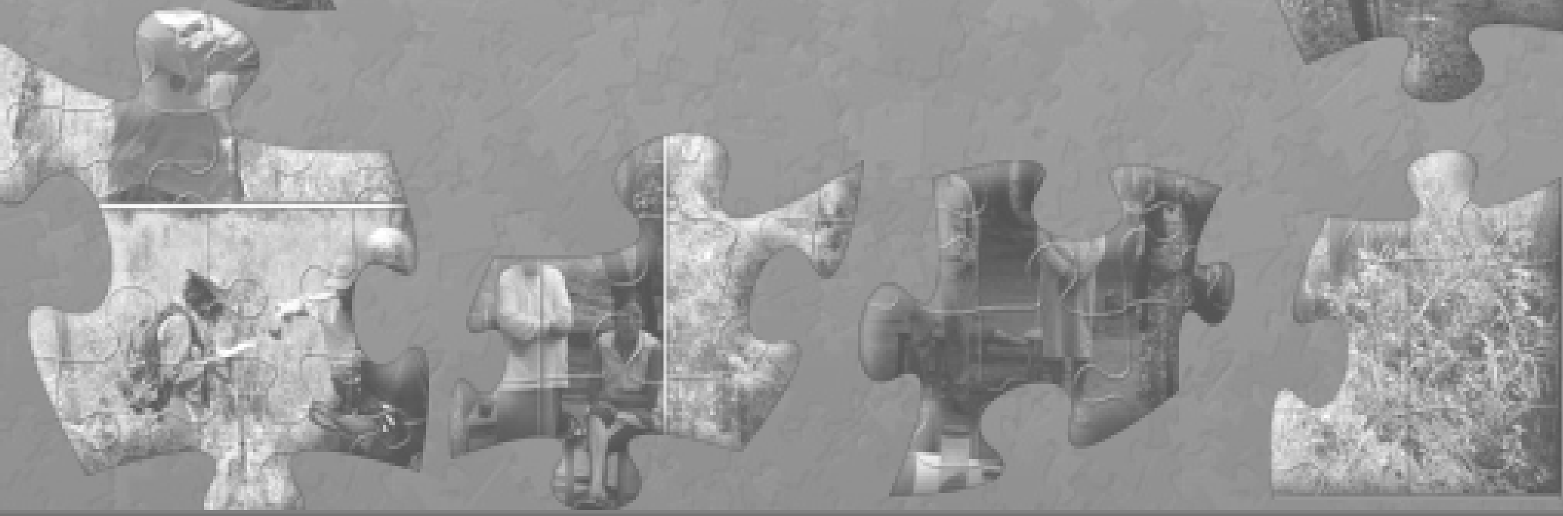






INTRODUCTION



Introduction

The rapid and large transformation of traditional farming systems into industrial farming is related to various consequences such as changes in the biophysical, ecological, socio-cultural, political and economic systems at different scales.

When considering biophysical constraints, the continuous increase in demographic pressure results in the requirement of a continuous increase in food production. Since the best arable lands are already in use, this translates into the need of converting virgin land into farmed land, applying '*Green Revolution'* technologies on marginal lands, as well as, in some countries the phenomena of '*Land Grabbing'*.

There is a huge variety of agricultural situations experienced by farmers operating in different countries. These differences are more evident with the existing trends of demographic and economic growth (Arizpe *et al.*, 2010) while agriculture does still represent one of the most important socio-economic activities in rural societies of developing countries.

The transition from the agrarian to the industrial socio-ecological regime is a historic and ongoing process (Fisher-Kowalski and Haberl, 2007). In general, developing countries would find it impossible to follow the "*Paradigm of Industrial Agriculture*" which has been implemented in developed countries. For example, the replacement of the work of farmers with machinery and technical inputs requires large amounts of capital (Giampietro, 2008). Economic development not only tends to reduce the number of farmers, but also to change the composition of food products in the diet of the growing urban population.

The mechanization of agriculture, although it did not incre the yield per acre, spread to every part of the world. The advantages of mechanization are related to the transformation of the nature of the agricultural sector, from an economic activity guaranteeing a livelihood to the people involved in it, it becomes a subsidiary sector of the rest of the economy within the goal of producing commodities required by modern socio-economic systems (Giampietro, 1997)

In developing countries there are different factors affecting agricultural systems, including i) international markets, which do not reflect the importance of most countries attached to maintaining food security; ii) the biophysical performance of agriculture, which plays a special role in alleviating poverty; iii) the effect of market prices of agricultural commodities, which undervalue the indirect effects of agricultural growth (Bresciani *et al.*, 2004).

Furthermore, agriculture does play other important roles. It significantly contributes to the management of a country's natural capital by providing the most immediate material and symbolic link with land, water, forests and biodiversity. It builds national social capital by shaping the social structure prevailing in rural areas. Moreover, domestic agriculture is an important source of knowledge, values, beliefs, recreation, creative inspiration and identity for national societies. However, agricultural activities are inherently very risky, depending on the weather, pests and other types of covariant and idiosyncratic shocks.

In the current global context rural populations are changing and evolving in complex and diverse ways in response to the challenges of globalization. Export oriented cropping poses significant challenges for a more mobile and diversified peasantry that remains the global poorest and hungriest inhabitants (Borras, 2009). Rural livelihoods have been incorporating new combinations of technological, discursive, commercial, and financial elements in the last decades (Hecht, 2010) together with the fragmentation of labor classes and migration flows in multiple directions between rural and urban, national and international, and in permanent and cyclical modes (Borras, 2009). For example, the technologized model of the expansion of soy has induced changes in land and time use that generate severe negative impacts (i.e. socio-cultural, ecological, biophysical) associated to malnutrition, migration, poverty, diseases, lack of food among others (Mora, 2006). On the other hand, there are also changes in monetary flows and energy inputs such as machinery, oil products, fertilizers and GM seeds, which result in negative social and environmental impacts (Altieri and Pengue, 2006, Holland *et al*., 2008; Pengue , 2008; RALLT, 2005, Palau, 2004). When dealing with issues such as food security and the sustainability of agriculture, it is essential to focus on the constraints that the requirement of land, soil, water and other natural resources entails on the possibility of generating an adequate supply of food (Pimentel and Giampietro, 1994).

Technological change becomes a first-order variable of change in the relation between available resources, energy and populations. In this sense, the unequal distribution of resources and energy has historically constituted a permanent source of conflict and search for what is now called “environmental justice”. This has become a powerful engine of the evolution of societies. In this sense the analysis of agricultural changes can be enriched by using the narratives of societal metabolism and post-political ecology insofar as the latter can draw attention on key characteristics of socio-ecological agrarian systems and shed more light on differentiated networked actors at different scales.

One of the main challenges in the thesis is to analyze the trends in agricultural change and provide data to answer important questions posed by Joan Martinez- Alier (Personal communication, 26/01/2011), to put in evidence: Is the study of the societal metabolism socially relevant for the study of the "agrarian question" i) to what extent are peasants resilient or will they disappear?; ii) are small peasants more productive per hectare than large farmers, and what is the relation of this to tenure systems?; iii) do landless workers want land (as the MST in Brazil) or do they want secure jobs?; iv) do the new ecological Narodniks (pro-small peasants) like *Via Campesina* have in some sense a valid argument when they say that modern industrial agriculture is not any longer a "*producer*" of energy but a "*consumer*" of energy and when they say that traditional peasant agriculture "cools down the Earth"?.

Aim and Structure

The chosen approach outlines the complexity of the crisis in the rural sector: north vs. south, developing vs. developed countries, local vs. global, strong vs. weak societies, peasants vs. agribusiness, as well encourages understanding trends in agricultural change with a holistic focus and integrating analysis.

This thesis applyies and test methodologies for analyzing the rural system through the analysis of the multi-scale integrated assessment and societal metabolism. This is an approach to the problem based on the development of information gathered at different scales and on a simultaneous evaluation of information referring to different dimensions (social, environmental, economic and political) by scaling up local insights. This means the reflection of the economic activity and natural resource management in parallel with 'socio-economic reading', 'political reading' and 'a biophysical reading', which are complementary and consistent with each other.

This thesis deals with the following research questions:

- Can we get a clear understanding of the nature and effects of agricultural change, specifically the movement from traditional agriculture to industrial agriculture?

The analysis shows: (i) A growing displacement of small farmers by large companies; (ii) a continuous fall in prices of traditional crops such as cotton, coffee and sweet potatoes in different regions; (iii) a great pressure to intensify industrial crops used for fodder, bio-fuels or industrial products such as soybeans and corn. In this situation, small farmers cannot compete with market prices and they are stifled along with their agricultural practices.

- What are the drivers of technological changes in agriculture and what are the implications for developing and developed countries in energy and demographic terms?

In particular this research question focuses also on the relation between the growing oil dependence of food security and the resulting implications of peak-oil.

The industrial farming model goes along with a technological package that depends on high energy inputs and increases economic costs of production. The need for this technological package is associated with changes in the demographic structure and the evolution of employment in different economic sectors (moving workers away from agriculture) following different patterns at the country level. It is important to note that in relation to this research question the benefit of a massive move toward a mechanized agriculture based on monocultures to feed the world is not evident, especially when considering the objective of rural development.

- What are the main socio-ecological changes in the transition from agricultural to industrial agricultural production? How are the smallholders in the transformation of agricultural land represented?

The paradigm change in agriculture has implications for the traditional rural system of smallholders in most developing countries. In this sense the move away from traditional agriculture had severe repercussions on the very existence of smallholder farmers. The majority of these farmers do not intend to transition to industrial agriculture, and in many cases such a transition depicts a less than derirable situation for the smallholder. As a result, a forced abandonment of traditional agricultural activities implies a severe impact on their socio-cultural development. In spite of this fact, the vast majority of governmental national secretaries of rural development have opted for a rural development based on industrial agriculture.

- What are the main socio-economical impacts in agricultural systems when moving to the industrial agriculture paradigm? What are the social and ecological impacts of monocultures at local and large scale?

In this thesis I assume that the change in the agricultural paradigm not only has important economic impacts, but also it involves a series of social, cultural, and ecological impacts. This premise is important to identify the positive and negative impacts associated with agricultural change from a holistic point of view, in order to make more informed recommendations at different levels (from the local level to the large scale level).

One of the main challenges the research seeks to deal with is a consistent methodological framework in order to analyze the agricultural changes in terms of societal metabolism. The approach outlines the integration of different voices around the main conflicts involved in agricultural re-conversion. The soy expansion is often used as a case study.

This thesis contributes to the Multi Scale Integrated Analysis of Societal and Ecosystem Metabolism (hereafter, MuSIASEM) framework through the generation of specific applications to the analysis of agricultural change, by scaling up local insights and ensuring the relevance of specific case study sites. The approach used at the local scale is the land-time budget analysis

The evolution of the thesis

The thesis is a compilation of small studies that have been developed since 2008. It tries to cover the understanding of recent changes in rural systems, seeking to personally develop methods to visualize systems as a whole and to provide understanding from the conflicts that have been analyzed.

This has led to a comprehensive analysis of literature, databases, and adaptive development methodology to societal metabolism approaches.

Chapter 1. Methodological Approach:

This chapter is a compilation of the different methodologies applied in this research to understand the agricultural changes across the scales.

Chapter 2. Global trends in Agriculture:

This chapter is based in a published paper[1] providing a synchronic comparison – e.g. comparing the use of technical inputs in 21 countries belonging to different typologies, at a given point in time – and a diachronic comparison – e.g. comparing the use of technical inputs in the same sample of 21 countries, over a time window of 12 years (1991-2003). The results confirm the conclusion of previous studies and include the following: (i) current pattern of inputs use reflects the existence of different typologies of constraints in different typologies of countries. Wealthier countries must have a very high productivity of labor, whereas poor and crowded countries must have a very high productivity of land. Different technical inputs are used for different purposes: irrigation and fertilizers are used to boost yield per hectare; machinery and infrastructures to boost the productivity of labor; (ii) when looking at the changes over the period of 12 years, a constant and worrisome trend is seen. The pattern of energy use in agriculture associated to the paradigm of industrial agriculture (High External Input Agriculture) has been simply amplified, by doing more of the same, with only minor adjustments in special countries. This represents a reason of concern for those looking for a major transition toward a different pattern of production more focused on rural development, ecological compatibility and quality food.

Chapter 3. Top-down / bottom-up participation in soy conflicts.

This chapter is based in a published paper[2] which analyses conflicts attached to soy expansion in Argentina and Paraguay.

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[1] Arizpe, N., Giampietro, M., Ramos-Martín, J. (2011): "Food security and fossil energy dependence: an international comparison of the use of fossil energy in agriculture (1991-2003)", *Critical Reviews in Plant Sciences,* Vol.30: 45-63. http://dx.doi.org/10.1080/07352689.2011.554352

[2] García-López, G.A., Arizpe, N. (2010): "Participatory processes in the soy conflicts in Paraguay and Argentina", *Ecological Economics* Vol. 70 (2): 196-206. http://dx.doi.org/10.1016/j.ecolecon.2010.06.013

Within emerging environmental conflicts, different participatory processes have developed as alternatives to the top-down models that have dominated policy-making. Three issues related to top-down vs. bottom-up participatory processes and how they affect the proposals coming out of these processes are analized: who counts as stakeholder (the role of social movements), what counts as participation (the role of mobilization), and who has power to select stakeholders and issues, make decisions, and influence others' preferences. To explore these issues, a case study of two parallel participatory processes in rural areas of Paraguay and Argentina is presented. One of these, the Roundtable on Responsible Soy, is top-down, created by large agri-business multinationals and international conservation NGOs with the support of the governments in the region, and has focused on establishing criteria for "responsible soy production". The other is bottom-up, self-organized by peasant and civil society organizations, and focused on stopping soy expansion and promoting food sovereignty and agrarian reform. The findings highlight the potential of bottom-up processes to promote true sustainability in agriculture while at the same time emphasizing the need for more research on grassroots participatory processes and their potential and limitations in different contexts

Chapter 4. Trends in agriculture at community scale in Formosa, Argentina..

An analysis of the metabolic patterns of two rural communities affected by soy expansion in the North of Argentina, is the base for a paper that has been recently submitted for publication[3].

The soy expansion model in Argentina generates different structural changes in traditional lifestyles, as well as different biophysical and socio-economic impacts.

In order to explore these issues, the MuSIASEM framework is applied to two communities in the Chaco Region, Province of Formosa, North of Argentina.

[3] Arizpe, N., Ramos-Martin, J., Giampietro, M. (submitted): "An analysis of the metabolic pattern of two rural communities affected by soy expansion in the north of Argentina", *Journal of Agriculture, Ecosystem and Environment*

These communities have recently experienced the expansion of soy production, altering their economic activity, patterns of energy consumption, land use, and human time allocation.

The results show differences (biophysical, socio-economic, and historical) between the responses of the two communities, highlighting important factors to guide the development of local policies in order to foster sustainable development.

Chapter 5. Scaling-up the analysis of societal metabolism: from household to community.

This chapter goes down in the hierarchy to analyze how different household metabolic profiles determine a particular community-level metabolisc profile dealt with in chapter 4. The outcomes of the study presented in this chapter have been already submitted to a journal[4].

Small and middle-scale agriculture has changed rapidly with the expansion of the industrial model (GM soy crop) in the North of Argentina. To explore and understand these issues, a characterization and analysis of the socioeconomic activities and biophysical variables at household level are proposed. The MuSIASEM framework is applied at household level to address socio-ecological change. The results show differences (biophysical, socio-economic, and historical-cultural) between the responses of the two communities, highlighting differences between the diverse farming systems and responses to soy expansion. The main impacts and important factors that may guide the development of local policies in order to foster sustainable development are identified.

Finally, **Chapter 6** wraps up some conclusions both from a methodological point of view, and from the case studies analyzed. It also presents some additional

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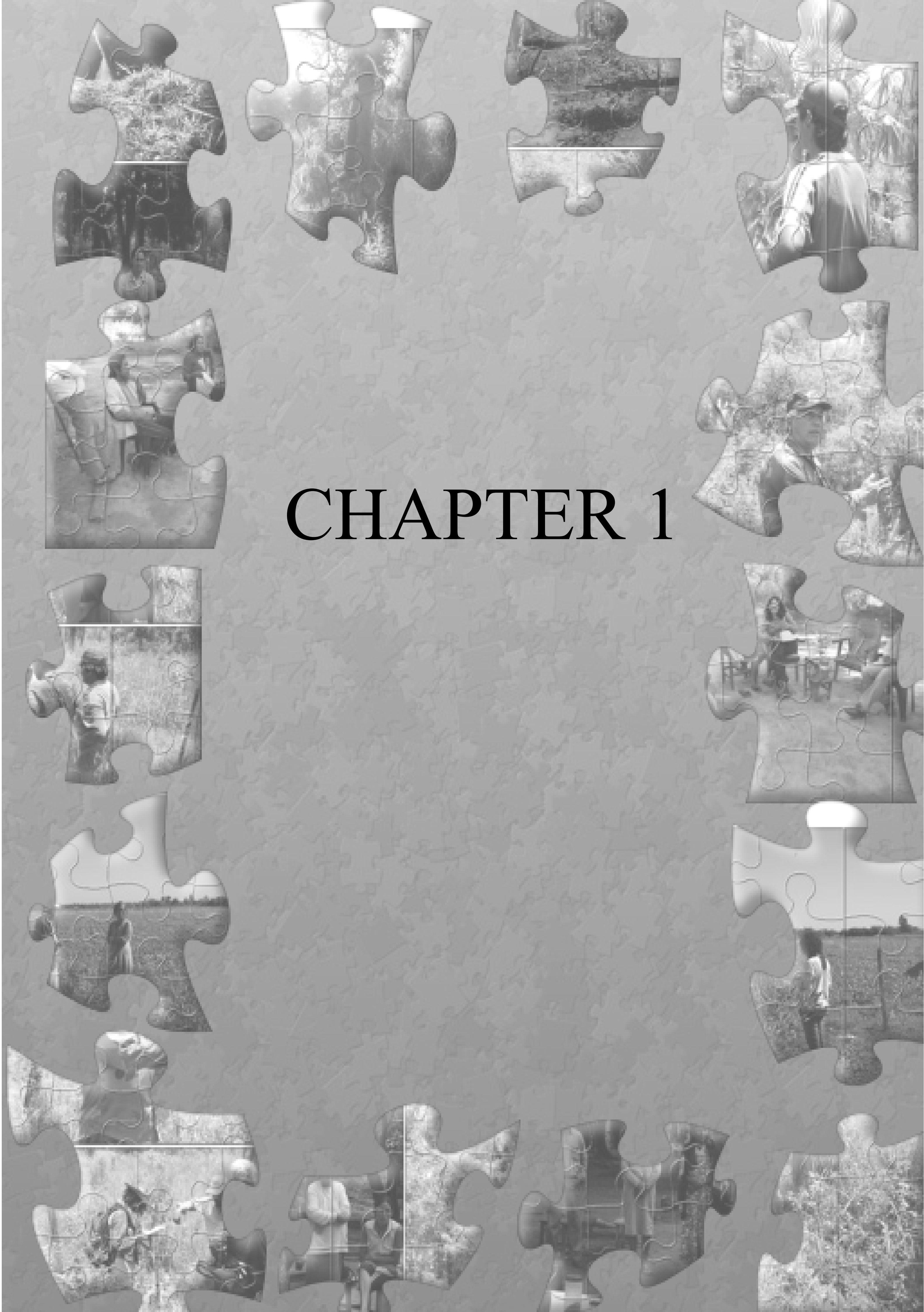
[4] Arizpe, N., Ramos-Martin, J., Giampietro, M. (draft paper): "Scalling societal metabolism: from household to community metabolism", *Land Use Policy*.

research I conducted on the topic. This research has allowed me to better frame the problems at hand, and gave me some hints of possible future research in the realm of building robust scenarios for sustainable development.



CHAPTER 1

Chapter 1. Study area and methods

This chapter presents the theoretical framework developed in the following chapters, the different methods applied and the study area. This thesis tries to reflect the implications of complexity faced when trying to study in a holistic way the relevant aspects of a particular conflict, what has been called technical incommensurability and social incommensurability (Munda and Giampietro, 2001).

Here, I describe the various methods used in the different chapters from global to local scale. At the Global scale (chapter 2) the method used is based on quantitative analysis, more specifically, data base analysis. At the country/regional scale (chapter 3) quantitative analysis and qualitative approaches (interviews) are both applied. At the local scale (chapters 4 and 5) quantitative and qualitative analysis, databases, interviews, and questionnaires are mixed together.

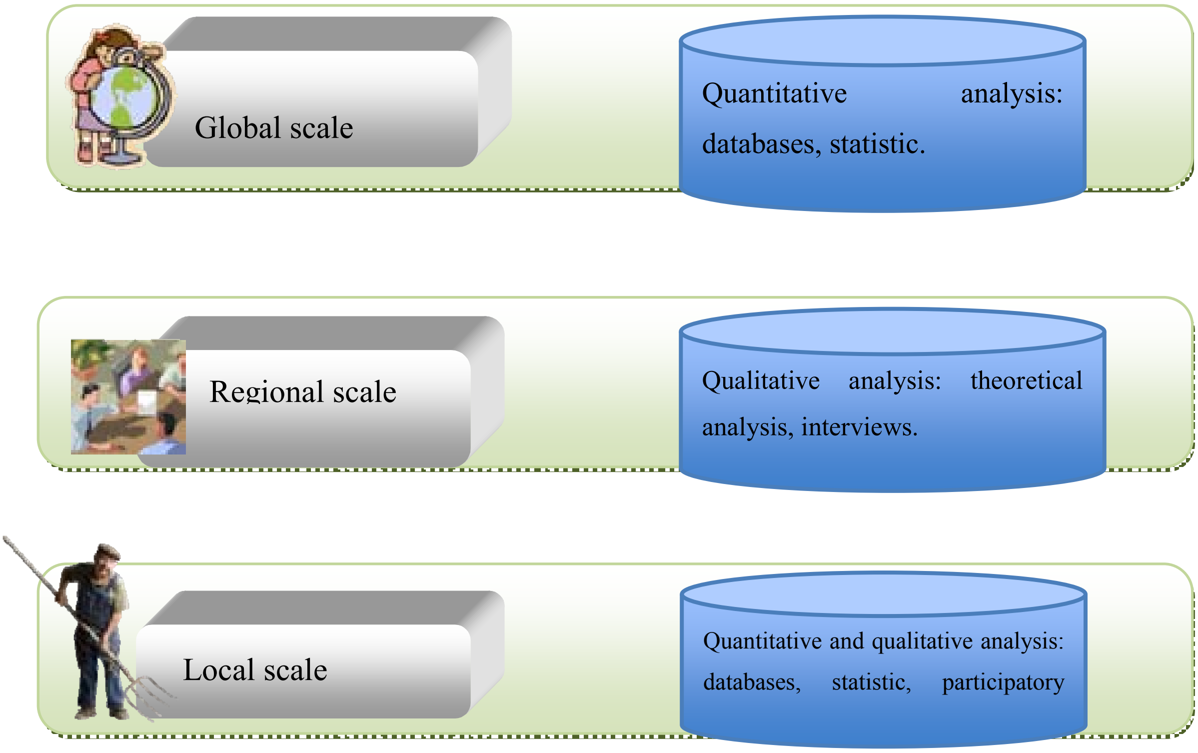


Figure 1 Methods applied at different scales.

1.1. Theoretical Framework of the thesis

In the last decade, developing countries are facing a growing process of land grabbing and intensification of extractive agriculture for consumption in industrial countries and commercialization in international markets (Huitze, 1999). This intensified commoditization of agriculture frequently originates socio-environmental conflicts in rural communities (Bebbington, 2008). Extractive economies are characterized by unequal trade balances, local disempowerment, and rates of production which go beyond ecological replacement rates (Guha & Martinez-Allier, 1997). In face of GMO's expansion and increasing intensification of agricultural production it is essential to develop bottom up participatory processes capable of generating new forms of governance alternative to the models that have dominated decision and policy-making processes. An example can be found in peasants (mobilization), indigenous and local narratives over the new rurality of industrial agriculture expansion.

Apart from tools aimed at generating a biophysical analysis of rural systems, I adopt also the theoretical framework of Political Ecology in order to understand the conflicts around monoculture expansion and the option to develop alternative paradigm of rural development in developing countries. Political ecology responds to the need of integrating political economy with the environment, due to the politicization of the latter (Peet & Watts, 1993). It emphasizes that "environmental problems are socially distributed" (Hornborg, 2001), involving "social, spatial, and temporal asymmetries or inequalities in the use by people of environmental resources and services, i.e. in the depletion of natural resources (including the loss of biodiversity), and in the burdens of pollution" (Martinez-Alier, 1995).

Conflicts originate from a growing impact of societal metabolism - because of the continuous increase of both the size and the pace of required flows. So an analyzis based on changes in societal metabolism can show how different actors and communities use different languages of valuation to confront these metabolic changes that involve the appropriation of a larger share of these flows by some at the expense of others (Martinez-Allier, 2001).

It is important to note the existence of two typologies of constraints that come from: (i) the different stakeholders operating in a society (internal constraints); and (ii) the environment embedding the society or a higher level (external constraints). A simultaneous consideration of these two typologies of constraints might lead to a more effective negotiation of viable solutions that involves understanding the perspectives of all social actors (including lobbyists), analyzing additional views, identifying where differences can be settled by "science" or not, where science and social action can bring innovative alternatives for understanding, and where social commitments are essential in order to move forward. In this regard it is considered that the socio-anthropological analysis of different perceptions can serve to improve the negotiation in conflict areas. In this sense the application of participatory methodologies as participatory mapping help to visualize graphically the results of different scenarios analyzed and strengthen communication technologies (video / photojournalism).

This thesis focuses on agricultural premises written by Nicholas Georgescu-Roegen (1971). “The pressure of population on agricultural land the area of which cannot be appreciably increased, man can no longer share the agricultural low entropy with his traditional companions of work, the beast of burden”. This phrase explains why the agricultural mechanization spreads around the world. Instead, the Entropy Law allows us to observe rise in population and pollution.

Entropy can be used as an indicator of the quantity of unavailable or dispersed energy within a given formalization of a finite set of energy transformations. Therefore, the concept of entropy has been proposed by Georgescu-Roegen as a useful metaphor to study the biophysical nature of the economic process which consists of continued and irrevocable transformations of high quality resources into wastes. Human history can be interpreted using the Second Law of Thermodynamic, as an effort to increase the effectiveness of human labor. Technical progress has boosted the power supply associated with human labor because of the increasing used of new technologies, but this has required larger consumption of fossil energy and a consequent increase in the pace of entropy generation.

Nicholas Georgescu-Roegen (1971) gave us an illustration clearing up the transitions of how the man was *homo agricola* before becoming *homo faber*. Many years were needed for passing from hunting to agriculture and for changing the agricultural into an industrial environment, but only a short time was indeed needed for reaching the actual situation of near-depletion of the planet resources. In this sense, the demand on the environment has increased so much that a shift towards a new pattern of relations between humans and their environment is implacably necessary. This shift must go along with the development of a new type of technology and the formation of new social, economic, and political institutions. (Dragan and Demetrescu, 1991)

In the case of large resource extraction the conflicts multiply faster than their solutions, consequently new conflicts are harder to solve than old ones. In metabolic terms, the “environmental entropy” rises, while the available resources lower. In other words in a full world (Daly, 1994) it becomes difficult and costly to make and maintain the growing functional and structural complexity of modern social systems (Tainter, 1988). In this situation we can expect proliferating conflicts and expanding outbreaks of local collapses of social fabric.

Within this general framework, we can notice that modern agriculture characterized by its high-productivity is fully dependent on fossil fuels (farm machinery, synthetic fertilizers and pesticides). A type of energy that is not renewable. The food consumed nowadays in countries and produced by industrialized agriculture depends not only on soil but also on oil. (Dragan and Demetrescu, 1991).

In this situation an excessive intensification of the flow of biomass production can lead to an “entropization” of the characteristics of the soil implying: i) erosion (loss of the soil all together); ii) loss in organic matters; iii) destruction of the porous structure of the soil; and iv) accumulation of toxic chemical substances and salts.

Energy underlies human culture just as it underlies life. In a society dominated by rural customs, culture is involved in the improvement of the organization in processing available energy, together with its exchange and distribution in the various parts of the system as well as the elimination of wastes and residues of consumed energy.

According to the Roegenian theory of social conflict, people, as well as the other species, fight over the access to low-entropy sources. This bio-economic fight represents a major characteristic of economic growth and the context in which it goes on. The evolution of the role of exosomatic instruments[5] has created and further maintained not only the social division of human activities and the difference between the agricultural process and the industrial process. It has also shaped a permanent social conflict between the privileged classes of those who manage, direct and control human activities in society and the classes of those who are managed, directed and controlled. Last June 2012 this statement was corroborated in the Paraguayan conflict that finished with the death of a considerable number of small farmers and the destitution of the President, Fernando Lugo (Grimaldi, 2012). This conflict was spurred by Monsanto Corporation and other big farmers fighting against small farmers for the control and management of agricultural production.

The idea that industrialization as such entails economic development automatically is a myth, contributing in no way to the diminution of the social conflict. In order to mediate social conflicts, protect nature from degradation, defend consumer, provide social services, it is necessary to make increased expenditures at the level of the public administration and support a costly and, inevitably, ever rising bureaucratic apparatus. The efforts for delaying the advancement of entropic degradation in society are required to prevent the progressive loss of organization in social systems.

[5] Term introduced by Georgescu-Roegen (1971), "*exosomartic instruments enable man to obtain the same amount of low entropy with less expenditure of his own free energy than if he used only his endosomatic organs*"

This thesis embraces Georgescu-Roegent theory which integrates into bioeconomics the more comprehensive and significant system of life and of nature as a whole, including the problems of humanity in the perspective of this integration.

For this analysis to be complete, it needs input from the biophysical side of the economic process. Here the concept of metabolism is crucial. The ‘‘metabolism of human society’’ is a notion used to characterize the processes of energy and material transformation in a society that are necessary for its continuation (Martínez-Alier, 1987; Fischer-Kowalski, 1998; Duchin Cottrell 1955, Georgescu-Roegen 1971; Haberl (2006); Mayumi 1991; Giampietro ,2003). A social metabolism emerges when humans grouped socially appropriate materials and energy (input) and ends with the deposit of waste, emission of fumes or gases (output). Two kinds of energy: ‘‘endosomatic’’ and ‘‘exosomatic’’ can be distinguished. These were introduced by Georgescu-Roegen (1975) to identify flows of energy and material inputs transformed under human control within socio-economic processes ‘‘inside’’ (endosomatic) and ‘‘outside’’ (exosomatic) the physical individual bodies of the members of a given society (Giampietro *et al*., 2009; Margalef, 1993). This distinction is crucial to the foundations of the new ecological economics (Martinez-Alier & Roca-Jusmet, 2000). The metabolism of human societies is used to characterize the processes of energy and material transformation considering the cash flows and land and time use, in any society. The Societal and Ecological Metabolism is based on the idea that human societies have two different metabolisms: the endosomatic (relating to food energy converted in the human body to preserve and sustain physiological activity), and exosomatic (energy converted outside the human body and is associated with human activity) these two forms of societal metabolism interface with the set of energy and material flows associated with the maintenance and reproduction of ecosystem elements – the ecosystem metabolism (Giampietro *et al* 1997, 2003, 2007, Ramos-Martin *et al*. 2008, Haberl *et al*. 2002, 2005, Toledo *et al*., 2006;Toledo and Gonzalez de Molina, 2007; Tello et al, 2003).

Rural metabolism can be conceived as a set of socially motivated physical processes in which agricultural natural resources - by means of human work and energy - are transformed into products (Cifric, 2002; Toledo, 2008; Gonzalez de Molina, 2006). Furthermore, Toledo (2008) divides the process in five stages: appropriation, processing, distribution, consumption and excretion. Gadgil and Guha (1992) and Toledo (1994) distinguish three major modes of appropriation of energy and materials that correspond to three major types of organizing social metabolism: i) hunter-gathered societies do not transform the structure and dynamics of ecosystems as any other species in them; ii) traditional farming societies produce transformations with some limits on the dynamics of ecosystems, yet human domesticated species are manipulated and transformed. This system of production can be called Low External Input Agriculture (LEIA); iii) industrial societies use systems based on appropriation via fossil fuels or nuclear energy, which provide a high capacity of intervention in ecosystem dynamics, that renders them greatly expansive, subordinating and transforming. Within these societies agricultural production is based on High External Input Agriculture (HEIA)

The focus of the thesis, therefore, includes the construction of different typologies and scenarios to make explicit the trade-offs between different objectives of the communities. The methodology applied is MuSIASEM, whose main objective is to characterize, in terms of economic and biophysical, social and ecological metabolism at different scales. This is an analytical framework introduced by Giampietro and Mayumi (1997, 2000b, 2000a) and finally formulated by Giampietro (2003). This methodology combines monetary information (generation of value added), demographic (population, and use of human time), and biophysical, in particular the commercial energy used (or exosomatic energy), i.e. the one in the energy balances of the International Energy Agency, or endosomatic energy which we ingest in the form of food.

1.1.1. The conceptual basis of the MuSIASEM

Studying sustainability entails the challenge of how to properly perceive and represent a process which requires the simultaneous adoption of different dimensions and scales of analysis (Giampietro, 2003). For this reason, sustainability analysis requires the integrated use of non-equivalent descriptive domains and non-reducible models that have to be periodically updated and substituted (Giampietro *et al*., 2006a, 2006b, 2006c). This challenge calls for new conceptual tools of analysis capable of: (i) remaining ‘‘semantically open’’— i.e. to be adjusted to new meanings and tailored on an evolving issue definition and (ii) integrating quantitative descriptions—i.e. non- equivalent accounting systems—by establishing bridges across different dimensions of analysis and scales.

The methodology multi-scale integrated analysis of societal and ecosystem metabolism (MuSIASEM) has been developed to address such a challenge when characterizing the viability and desirability of patterns of production and consumption of socio-economic systems (Giampietro, 2003; Giampietro and Mayumi 1997; Giampietro and Mayumi 2000a, 2000b). The methodology integrates various theoretical concepts from different fields: (i) non-equilibrium thermodynamics applied to ecological analysis—Odum (1971, 1983, 1996) and Ulanowicz (1986, 1995); (ii) complex systems theory—Kauffmann (1993), Morowitz (1979), Rosen (1958, 2000), and Zipf (1941); and (iii) bioeconomics -- Lotka (1956) and Georgescu-Roegen (1971, 1975). Empirical analyses based on this approach have been conducted at a national level for countries such as Ecuador (Falconí-Benítez 2001), Spain (Ramos-Martin 2001), Vietnam (Ramos-Martin and Giampietro 2005), China (Ramos-Martin *et al*. 2007), Chile, Brazil and Venezuela (Eisenmenger *et al*., 2007), the UK (Gasparatos *et al*., 2009), Romania, Bulgaria, Poland and Hungary (Iorgulescu and Polimeni, 2009), Argentina (Recalde and Ramos-Martin, 2011), but also at the regional level (Ramos-Martin *et al*., 2009), and at the household/community level (Gomiero and Giampietro 2001).

The work in this Thesis builds on Gomiero and Giampietro’s work, along with Land-Time-Budget Analysis (Pastore *et al*. 1999; Giampietro 2003; Grünbühel *et al*., 2003; Grünbühel and Schandl 2005), and compares the societal metabolism of two rural communities in the North of Argentina (Chapter 4) and their household typologies (Chapter 5), with the main objective of providing sound information that will allow the comparison of various attributes relevant for the sustainability of the models of development. That is, the resulting integrated analysis makes it possible to explore the farming household's interaction with natural resources in order to identify economic and ecological constraints and development opportunities. With this study a better understanding of the ongoing process of soy expansion in the region is wanted, as so are its repercussions in traditional farming practices and standard of living.

A key theoretical concept of the MuSIASEM approach is the incorporation of the flow-fund model proposed by Georgescu- Roegen (1975) for representing, in biophysical terms, the socioeconomic process of production and consumption of goods and services. The flow-fund model makes it possible to carry out quantitative analysis of complex systems organized across different hierarchical levels and scales. In fact, following Giampietro *et al*. (2011) according to the chosen representation of the process flow coordinates can be said that are elements that enter but do not exit the production process (e.g. an input used in production) – in the time horizon of the analysis - or, conversely, elements that exit without having entered the process (e.g., a new product). Flow coordinates refer to matter and energy in situ, controlled matter and energy, and dissipated matter and energy. Fund coordinates (capital, labour and Ricardian land) are agents that - in the chosen time horizon of the analysis - enter and exit the process, transforming input flows into output flows. Put in another way, the identity of the fund elements remains the same during the analysis. Fund elements require a given overhead for their own maintenance and reproduction and do entail a constraint on the rate of their associated flows. That is a range of value for the pace of conversion of the flows they control can be defined.

This thesis focuses on two fund elements:

(i) land – this makes it possible to study the interface between the colonized land (land uses whose characteristics depend on human agency) and non-colonized land (land covers whose characteristics depend on the identity of local ecosystems); and

(ii) human time – this makes it possible to study structural (demographic) and functional (socio-economic) changes in the allocation of human activity within the communities;

and two main flow elements:

(i) monetary flows – this makes it possible to interface the biophysical analysis with economic analysis;

(ii) biomass flows – this makes it possible to interface the biophysical analysis with both economic and agronomic analysis;

It should be noted that other biophysical flows (energy, water, and other key materials – e.g. soil erosion, cement for construction) are not included in this thesis for the characterization of the metabolic pattern, since they do not result relevant for the purpose of our analysis at the chosen level of analysis – the community level.

1.2. The different areas referring to the different studies

1.2.1 The study carried out in Chapter 2

Chapter 2 analyses energy use in agriculture at global level, including a comparison of the use of technical inputs in 21countries representing America, Europe, Asia, Africa and Australia. The chosen sample of countries covers different combinations of economic development (measured by GDP) and population density (measured by availability of arable land per capita).

Developed countries: United States, Canada, and Australia (important food exporters with low population density), France (net food exporter within EU), the Netherlands, Italy, Germany, Spain, United Kingdom and Japan (net food importers).

Countries with an intermediate GDP: Argentina (with abundant arable land), Mexico, and Costa Rica.

Countries with a low GDP: P.R. China, Bangladesh, India, and Egypt (all with little arable land per capita); Zimbabwe (net food exporter), Uganda, Burundi, Ghana. Case Study: The soy conflicts in Paraguay and Argentina

1.2.2 The study carried out in Chapter 3

Chaptern 3 analyses bottom-up participation linked to the conflict of soy expansion, it chaptern began with archival research focused on the expansion's impacts, the ensuing conflict, and the different participatory processes that have emerged to deal with the problem.

Fieldwork was then carried out between October 2008 and March 2009 in two regions, Northern Argentina and Eastern Paraguay (see Fig. 2), using participant observation and interviews. In Northern Argentina, the departments of Pilcomayo, Pilaga and Pirane were visited, focusing on the conflicts in the villages of Tacaagle, La Primavera and Lomas Senes

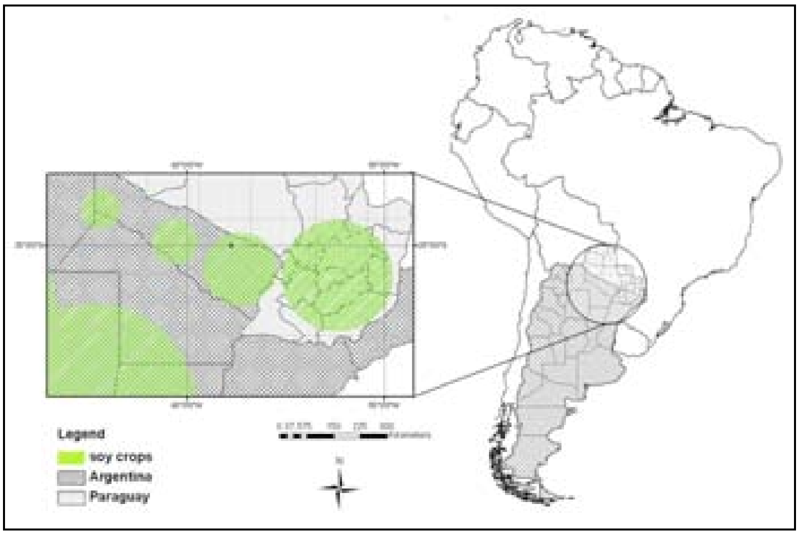


Figure 2 Map of Study

1.2.3 The study carried out in Chapter 4 and Chapter 5

The biophysical analysis at local level, case study research entails the detailed examination of one or a small number of 'cases'. Since our unit of analysis is the community and household level, in this study, we consider two rural communities that share similar problems such as the expansion of soy cultivation, and similar ecological conditions. A key difference however is the history and culture of the population. Tacaagle, that is located in the Pilaga Department in the Formosa Province, is populated mostly by non-indigenous people immigrated mainly from Argentina and Paraguay, whereas La Primavera *"Potae Napocna"* located in Pilcomayo Department has an indigenous[6] population, called *Qom,* although their popular name is Toba. Both communities are located in the Formosa Province in Argentina, and each of them has a surface area of approximately 5,500 hectares.

The Tacaagle's community is composed of two rural communities ("25 de Mayo" and Carpinteria) comprising 71 households. La Primavera *"Potae Napocna"* has *Qom* population and consists of 446 households.

Figure 3 shows the location of the two case studies.

[6] Argentina does not officially use the term 'indigenous', but rather 'aboriginal' population. We use the term indigenous, which is more frequent in Latin America.

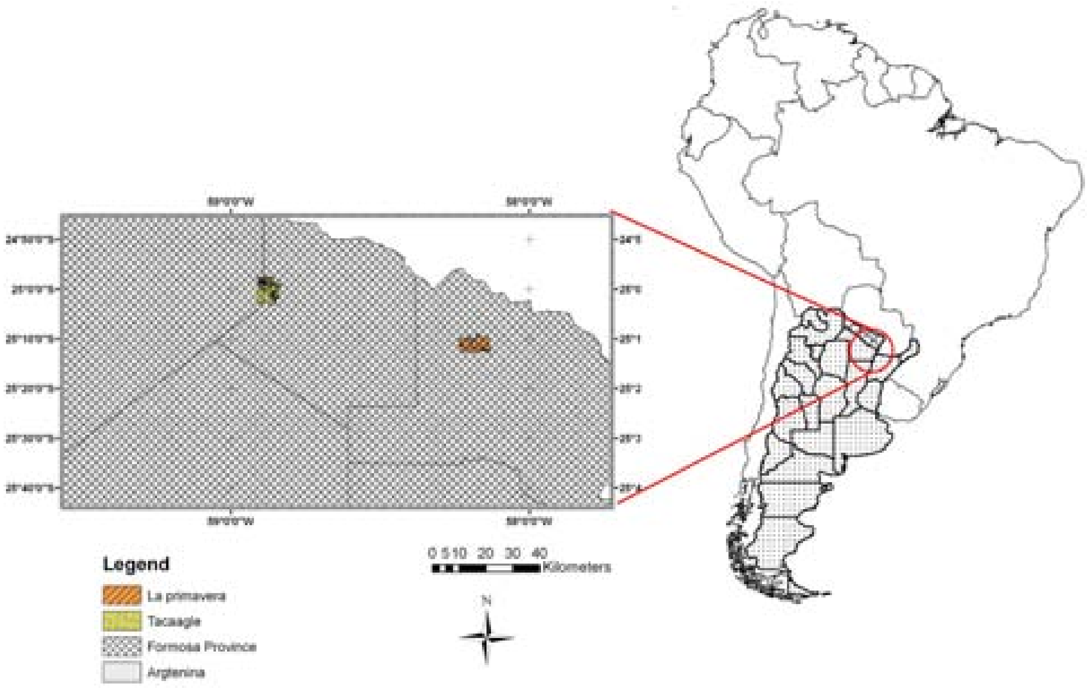


Figure 3 Map of the study area
Source: own elaboration.

The main economic activities of the Province of Formosa are related to food production and processing industries. The main crops are cotton, soybeans, wheat, rice, sunflower, sorghum, corn, and avocado. They also grow fruits, such as citrus, bananas, mangos, and pineapple. Forestry is also of major economic importance, with the main species under exploitation being: red and white quebracho, lapachos guayaibí, algarrobo, guaranine, urunday and rosewood. Apart from that, other relevant economic activities are livestock and bee-keeping, from which organic honey is produced. Finally, some oil extraction occurs in the west of the province (Ministerio del Interior, 2011).

The two case studies are found between the Glens Forest Chaco and the Lower Rio Paraguay. As an example of their ecological value, National Park Rio Pilcomayo (sharing land with La primavera community) hosts 49 species of mammals, 353 species of birds, 28 species of amphibians, 35 species of reptiles and 38 species of fish (Morello and Rodriguez, 2009).

1.3. Methods of qualitative analysis

The qualitative analysis is defined as not statistically orientated. This thesis makes use of methods applied in social sciences.

1.3.1. The archival research and literature review.

This archival analysis represents a relatively more formal process of topic review, with a more detailed and holistic analysis of the topics covered. (Johonson, 2004).

In this thesis I apply an extensive literature review on social, economic, environmental and political aspects associated to soy cultivations at the regional and global scale.

This method is applied in the different chapters. In chapter 3 in order to better understand bottom-up participation linked to the conflict of soy expansion, with archival research focused on the expansion's impacts, the ensuing conflict, and the different participatory processes that have emerged to deal with the problem was began.

1.3.2. Action Research:

Refers to a class of research methods where interventions are part of the research process. Involves collaborative research, education and action oriented towards social change, representing a major epistemological challenge to mainstream research traditions. Another important characteristic of action research is the strong role played by the researcher, because when the researcher intervenes, the researcherinevitably becomes part of the study – one of the study subjects. Since action research takes an interpretative approach, it involves qualitative data (Bryman, 1989; Baskerville, 1999; Kindon *et al*, 2007).

This methodology is used for field work as a useful tool to implement and enforce post-normal science as a form of integration of scientific and nonscientific knowledge. Fieldwork was then carried out between October 2008 and March 2009 in two regions, Northern Argentina and Eastern Paraguay.

Figure 4 Action research methods in Paraguay and Argentina.

This methodology can be seen in chapters 3, 4 and 5. Within the action research, other methods explained in the next section are applied.

1.3.3. Participant Observation:

Participant observation involves the researcher becoming part of the group being researched and reflecting on their experiences and the meaning systems they learn in the process. Participant observation is a key method used by ethnographers, but ethnography refers to a more holistic research approach which might also include, for example, quantitative methods or interviewing techniques (Rusell, 2000; Bryman, 1989; Walsh, 2009).

This methodology was applied for one side conducted meetings with different leaders and peasants in attendance at marches and events (e.g. conference discourses) related to the expansion of soy. On the other hand, I did extensive work of participant observation in the study communities in Northern Argentina.
This methodology is reflected in also Chapters 3, 4 and 5.

Figure 5 Internal meetings in Paraguay and Argentina.

1.3.4. Participatory Mapping:

This methodology is used to identify the different land uses associated with the perceptions and narratives of the locals.

Participatory GIS is a generic designation for the use of geo-spatial tools and methods oriented to represent people's spatial knowledge, using physical or virtual media, to help in the learning, discussion and exchange of information, in the analysis and decision-making process (Bernard, *et al*, 2011;Reyes et., al, 2011). Participatory mapping is typically assisted by the use of Geographic Information Systems (GIS), as the information retrieved in the field is geo-referenced and can be mapped and spatially analyzed with GIS software. (NOAA, 2009; FIDA,2009).

Existing maps were complemented with participatory mapping for the area under study. Participatory mapping was carried out to identify areas of soy expansion; this approach took more rigorously within the community of La Primavera, also collaborated with the identification of boundary markers around the land conflict.

This methodology can be seen in the maps of Chapters 4 and 5.

Figure 6 Participatory Mapping in La Primavera, Argentina.

1.3.5. in-depth interviews, semi-structured interviews, informal interviews and structured interviews

In-depth, semi-structured interviews are verbal interchanges where one person, the interviewer, attempts to elicit information from another person by asking questions. Even though interviewers tend to prepare a list of predetermined questions, in-depth, semi-structured interviews usually unfold in a conversational manner offering participants the chance to pursue issues they feel are important. In-depth, semi-structured interviews are a commonly used method in geographical research. Sometimes researchers rely upon in-depth, semi-structured interviews as a stand-alone method; sometimes they are used in conjunction with other methods. In-depth, semi-structured interviews are useful for investigating complex behaviors, opinions, and emotions and for collecting information on a diverse range of experiences(Longhurst, 2009; Bryman, 2008).

Informal interviewing must be done in an informal, relaxed, manner using 'semi-structured interviews' which are open-ended and interactive. They may be conducted with key informants or groups. There should be no formal questionnaires, rather a set of questions or subtopics generated with care so as not to incorporate previous assumptions. If necessary, the interviewer should repeat questions or rephrase them until the meaning is clear and connections become apparent.

Due to the lack of information at the local level (community of La Primavera and Tacaaglé), in-depth interviews were used to complement the data.

In-depth interviews were conducted with peasant leaders as key informants in the different communities and with government institutions and NGO's. In La Primavera the questionnaires were answered through in-depth interviews The in-depth interviews were the same number as questionnaires and lasted about 3 hour with key informants from both communities (Specific information in chaptern 3, 4 and 5).

Figure 7 Intervies in La Primavera, Argentina

1.3.6. Focus groups

Focus groups are group discussions designed to learn about subjects' perceptions on a defined area of interest. They involve as many as 12 participants and are conducted by a skilled moderator using a discussion guide. Focus groups rely on the dynamics of group interaction to reveal participants' similarities and differences of opinion (Rusell, 2000; Bryman, 1989; Walsh, 2009).

Focus groups were used to couple the two communities Tacaaglé and La Primavera. In both communities focus groups were conducted at job start and end. In the spring were conducted likewise 2 workshops to raise awareness of different tools and lead management practices to be used as tools mapping and participatory video and community awareness on the topic of soy expansion.

Figure 8 Focus groups in La Primavera, Argentina

1.3.7. Time use analysis, following families in their daily activities keeping records in diaries

With the aid of this analytical tool, information about daily activities of community members may be easily collected and analyzed. In using daily patterns different groups of people within the community may be compared, as well as seasonal changes analyzed. It is similar to a seasonal diagram in that it helps identify time shortages, problem areas and opportunities. The daily activity profile can be completed for an individual through interview, direct observation or both, noting that the information collected should be cross-checked. (Kapila and Lyon, 2006)

Monitoring activities in rural households was conducted to better understand activities within and outside the home. Therefore I lived in the home of key informants for a period of approximately one month in the community of Tacaaglé and 3 months in the community of La Primavera.

Important to note is that data collection is punctual. This methodology was emphasized mainly as a resource to meet the use of time allocated to different activities at home and to learn farming. In addition to the knowledge of the use of time the participatory video methodology was also applied, emphasizing the importance of women's time at home. This tool was later used by the community for recording conflicts that occurred.

Figure 9 Daily activies in Argentina and Paraguay.

1.3.8. Transects walks

Systematic walks with key informants through the area of interest can be used to identify different land use/type zones and their respective constraints and opportunities through observation, listening to, and questioning the informant. Transects can also be used to prompt historical information and where they follow a slope, can coincide with soil sequences. (Kapila and Lyon, 2006)

Figure 10 Transect walks in the communities.

1.4. Methods of Quantitative analysis

The quantitative analyses in general are referring to figures and statistics. This thesis focuses on methods from societal sciences and economics.

1.4.1. Database analysis

Chapter 2 presents the analysis of country databases to study agricultural change.

The quantitative assessments given in this study are based on the data-set taken from FAO Agricultural Statistics. Databases for world agricultural production are available at FAO web site (http://www.fao.org/corp/statistics). Data referring to 1991 and 2003 was selected. This database covers different aspects of agricultural production: (1) means of production – e.g. various technological inputs used in production (excluding data on pesticide use), (2) food balance sheets – accounting of production, imports, exports and end uses of various products, as well as composition of diet and energetic value of each item, per each social system considered; (3) data on agricultural production, and (4) data on population and land use. Data on pesticides have been estimated using data from literature. Assessments of pesticide consumption have been re-arranged starting from the estimates of Pimentel (1997) to fit FAO system of aggregation.
The set of energy conversion factors are taken from an overview of the available data in the specialized literature.

Energy conversion factors tend to apply generalized values, but at the same time to reflect peculiar characteristics of various socio-economic contexts in which agricultural production occurs (e.g. reflecting the system of aggregation provided by FAO statistics).

The conversion factors used to assess the amount of embodied fossil energy slightly different from those used in the original study of Giampietro *et al*., 1999, since some data have been updated. For this reason, the original data set used in the CRPS paper of Giampietro *et al*. (1999) has been recalculated using this set of conversion factors to obtain a better comparability of the two assessments presented in this paper referring to 1991 and 2003.

1.4.2. Quantitative indicators developed within the MuSIASEM approach: Demographic and Bioeconomic pressure in agriculture (Chapter 2).

The overall value of the output/input energy ratio of agricultural production refers to two distinct typologies of energy flows: (A) the energy output – which is food energy produced in the crops; and (B) the energy input – which is the fossil energy embodied in the technical inputs used in agricultural production. These two flows are not directly related to each other in terms of their relative value to society. When analyzing the energetic efficiency of agricultural production we face a paradox: "*In the last decades technical development in agriculture has led to a reduced efficiency of energy use, when assessed by the output/input energy ratio in agricultural production* (Pimentel and Pimentel, 1979; Pimentel *et al.* 1990) *together with a diminished use of biodiversity in food production* (Altieri *et al.*, 1987; Wilson, 1988*)*" - Giampietro *et al.* (1999). To explain this paradox it is important to understand that beside the energetic efficiency of the agronomic production there are a lot of other relevant criteria of performance determined by the strong conditioning that the socioeconomic context imposes on the technical choices made at the farming system level (Giampietro *et al.*, 1994; Giampietro, 1997a; 1997b; 2003; Conforti and Giampietro, 1997). In particular explaining the evolution in the pattern of use of technical input in agricultural systems requires establishing a relation between:

(i) changes taking place in the socio-economic context of the farm. For this task in this analysis two indicators are used: demographic and bio-economic pressure; and

(ii) changes taking place within the farm. For this task in this analysis the changes taking place in the pattern of use of technical inputs – the mix of irrigation, fertilizer, pesticides and machinery are checked.

The basic rationale behind this analysis is that technical progress of agriculture has been driven by two objectives (Hayami and Ruttan, 1985; Giampietro, 1997b): (1) boost the productivity of labor in the agricultural sector; and (2) boost the productivity of land in production. Therefore, technical progress (coupled to economic growth) has implied a continuous increase in the injection of technical inputs into the process of agricultural production in order to increase the net supply of: (i) food per hectare (in response to the growing Demographic Pressure); and (ii) food per hour of labor in the agricultural sector (in response to the growing Bio-Economic Pressure).

As explained by Giampietro and Mayumi (2009) "The priority given to these two objectives, under the alleged label of "technological progress in agriculture", has been driven by two crucial transformations that took place in developed societies in previous decades:

First, a dramatic socioeconomic re-adjustment of the profile of investment of human time, labor and capital over the different economic sectors in industrial and post-industrial societies occurred. This transformation required the progressive elimination of farmers to free labor for the work force in other economic sectors, initially the industrial sector and later the service sector;

Second, the demographic explosion that took place, first in the developed world and later everywhere, linked to the phenomenon characterized as 'globalization of the economy'. This explosion did, and still does require boosting the yields on land in production due to the progressive reduction of the available arable land per capita".

To study the different effects of these two pressures on the technical development of agriculture in the countries analyzed in Chapter 2 the following relations are assumed:

(i) the performance in terms of "land productivity" – the level of crop production per hectare (MJ/ha) – is correlated to differences in "demographic pressure". An increase in demographic pressure is defined as the reduction in available cropland per capita, associated with population growth. An increase in Demographic Pressure implies the need to boost the yields per hectare, to remain self-sufficient in food production;

(ii) the performance in terms of "labor productivity" – the level of crop production per hour of work allocated to agriculture (MJ/hour) - is correlated to differences in "bio-economic pressure". Increase in bio-economic pressure is defined as the reduction of the fraction of farmers in the work force, associated with economic growth. An increase in Bio-Economic Pressure (BEP) makes it necessary to produce more crops per hour of work in agriculture, to remain self-sufficient in food production. The main factor determining the increase in BEP is economic growth in the economy, rather than any "biological" factor. Using the jargon used in conventional development economics, the process of declining active population in agriculture is explained as follows. Labor productivity goes up in agriculture because of technical improvement (nothing is said about energy input), while production cannot increase at the same pace of productivity because of low income-elasticity of demand for agricultural products as a whole (Engel's Law). Therefore, economic growth implies that agriculture tends to expel active population.

This assumption of an existing relation between: (i) agricultural land productivity and Demographic Pressure (DP); and (ii) agricultural labor productivity and Bio-Economic Pressure (BEP); has been confirmed by the empirical analysis (Giampietro, 1997b; Conforti and Giampietro, 1997).

In this thesis changes in relation to these concepts are characterized as follows:

#1. Demographic Pressure (DP) and Bio-Economic Pressure (BEP) – seen as drivers of technical progress in agriculture

**** Demographic Pressure***- to quantify the demographic pressure on agricultural production, the level of agricultural productivity imposed by demographic pressure is calculated. This is defined as the productivity of land (yield of food energy per hectare) that would be needed to obtain a situation of complete food self-sufficiency in society (Giampietro, 1997b; Giampietro *et al.*, 1999). This threshold level can be calculated from:

• The aggregate requirement of food in society (considering the food system under analysis as closed), which is determined by the population size of society, food consumption pattern, and post-harvest losses. This information is available by consulting FAO Food Balance Sheet (total consumption of the population). In this study the energetic value of plant crops (consumed directly and indirectly) is cosidered, to account for differences in the quality of the diet, determined by the amount of animal products, requiring a double conversion of plant calories into animal product calories – for more see Giampietro (1997b).

• The land available for food production, which depends on availability of arable land, characteristics of this arable land, and alternative land uses (dependent on population size and technological development). This information is available from FAO statistics (arable land and permanent crops). High demographic pressure in society will invariably favor farming techniques and crop mixes that yield a high food production per unit of area (Boserup, 1981; Hayami and Ruttan, 1985). This implies that the higher is the demographic pressure - proxy: population divided by colonized land - the higher can be expected to be the productivity of land - proxy: the food energy yields of cultivated crops;

**** Bio-Economic Pressure in agriculture*** - the bio-economic pressure determined by economic growth can be described as the need of reaching high level of labor productivity in specialized compartments of the economy, which are in charge of producing the supply of critical inputs consumed by society (Giampietro and Mayumi, 2000; 2009). In relation to food security, the bio-economic pressure indicates the level of productivity of labor, which should be achieved per hour of labor in agriculture, to obtain a situation of complete food self-sufficiency in society. For example, in 1999 the entire amount of food consumed per capita in a year by a US citizen (the USA is among the countries with the highest consumption of food items per capita) was produced using only 17 hours of work in the US agricultural sector (Giampietro, 2002). In general, quantitative indicators of Bio-Economic Pressure correlate well with all the other indicators of development such as Gross Domestic Product or commercial energy consumption per capita (Pastore *et al.*, 2000).

In this thesis, Bio-Economic Pressure in Agriculture is defined as the level of agricultural labor productivity (yield of food energy per hour of labor in the agricultural sector) that would be required to produce the food consumed in a society. In this calculation the same overall energetic requirement of food calculated for determining the demographic pressure is considered. That is, the society's food system is considered as closed. Then, the aggregate requirement of primary food energy of the whole society in a year is divided by the labor time available in a year in the agricultural sector. The latter depends on the size of the labor force, the unemployment rate, the fraction of the labor force absorbed by the nonagricultural sectors, and the average work load (Giampietro, 1997b). A high bio-economic pressure in society favors farming techniques and crop mixes that yield a high food production per hour of work (Hayami and Ruttan, 1985; Giampietro, 1997b). That is, the higher is the bio-economic pressure in agriculture - proxy: total primary food energy consumed by the society (total food consumption) per hour of work in the agricultural sector (numbers of active workers in agriculture x 2000 hours/year) - the higher can be expected to be the productivity of labor of farmers - proxy: the amount of food energy produced per hour of work in agriculture.

As a matter of fact, imports and exports make it possible for modern societies to have a certain level of independence between: (a) the level of internal consumption of food both per hour of work in agriculture and per hectare of land in production in agriculture; and (b) the level of internal production of food both per hour of work in agriculture and per hectare of land in production in agriculture. However, as proved by the empirical analysis, these two distinct types of pressure play an important role in shaping the use of technical inputs across world countries.

#2. The use of technical inputs in relation to these two different pressures: (i) irrigation and fertilizers are required to deal with demographic pressure; whereas (ii) machinery is required to deal with bio-economic pressure.

Previous studies on the use of technical inputs in agriculture (Giampietro 1997b; 2002; Conforti and Giampietro, 1997; Giampietro *et al*., 1999) provided the following explanations in relation to the mix of inputs used in different typologies of agricultural production:

* Irrigation and fertilizers are used more in crowded countries, independently of the level of economic growth, since they respond to the intensity of the demographic pressure – they boost the production per hectare of land.

* Machinery is used, but in special niches, only in developed countries, independently of the level of demographic pressure, since it responds to the intensity of the bio-economic pressure – they boost the production per hour of labor.

These assumptions will be double-checked in this study. This is done by providing not only a synchronic comparison – e.g. comparing the use of inputs of 21 countries belonging to different typologies at a given point in time – but also by providing a diachronic comparison – e.g. the comparison over the same sample of 21 countries performed at two points in time 1991 and 2003, that is over a time window of 12 years.

1.4.3. Questionnaires

Questionnaires are important if statistics are needed or if there is a need to compare data. Care must be taken in the design of the questionnaire.

At the local level, questionnaires and in-depth interviews were used to complement the data. The software used to compile and analyse information was Excel 2003 for data organisation, SPSS for statistical analysis and ArcView 9.2 and Google Earth for GIS analysis. The numbers of questionnaires applied was 26 in Tacaaglé, out of 71 households, and 43 out of 446 households in La Primavera. The questionnaires were completed in the presence of the interviewer. Demographic data was collected distinguishing for age groups (0-5; 6-11; 12-17; 18:65; 65-) and gender (male / female). Existing official population data came from the National Census of Population and Housing in Argentina (INDEC, 2001). The census only offered figures at the municipal level, combining rural and urban population corresponding to the municipalities of Misión Tacaaglé (2,034 inhabitants in total, including rural communities 25 de Mayo and Carpintería) and Laguna Blanca (6,508 inhabitants, including also the indigenous community La Primavera).

Since the census did not give information at the community level, population is estimated. In the case of La Primavera, Iñigo (2008) who estimates 800 families and 3,800 people (based on interviews carried out in 2005 (Iñigo, 2008) is followed. Recent studies increase this number up to the range between 4600-5000 people. In the case of Tacaaglé, for the communities of Carpintería and 25 de Mayo, data from the Peasants Movement in Formosa (MOCAFOR) survey and the Social Agricultural Program considered between 255 and 284 people (interview data).

ANNEX1 shows the questionnaire applied to La Primavera Community. The questionaries were modified after corroborating the factibility to apply the information selected. Some questions were adapted and modified to apply in Tacaaglé and La Primavera.

1.4.4. Quantitative indicators developed within the MuSIASEM approach: Land and Time analysis (Chapter 4 and Chapter 5).

In the case of land use we started with a study of land use changes made by the Ministry of Forests (Naumann and Madariaga, 2003) with data from fieldwork activity (2008-2009). We use the categories of accounting for the fund elements LAND presented in Giampietro (2003):

$$TAL = LU_{NC} + LU_{SC} + LU_{COL}$$

NCL= National Park, RAMSAR sites (wetlands) and water bodies

COL = $LU_{agr} + LU_{liv} + LU_{infr}$ + others

LU_{SC} =LU semicolonized

where

TAL stands for Total Available Land (or availability) which includes both colonized and non-colonized , and it conforms the land budget for the system analyzed

NCL stands for non-colonized land

COL stands for colonized land, and comprises the various categories of land uses under direct control of humans – e.g. colonized land for agriculture (agr), livestock (liv), infrastructure (infr), and others. COL for Colonized land (splitting into LUi), □LUi = COL

LU_{SC}, stands for semi-colonized land. Examples are land for hunting or gathering.

LU_{agr} can also be split in two subcategories: subsistence agriculture and industrial agriculture that is focused on expansion of soybean or cotton cultivation. LU_{infr} is mainly land use for the dwelling and includes the constructed area as well as the surrounding area for keeping poultry and pigs.

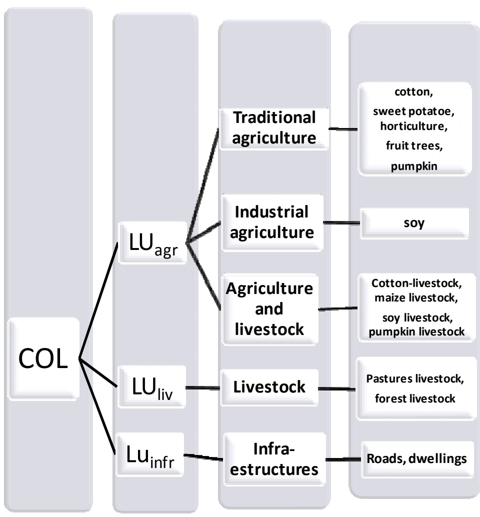


Figure 11 Taxonomy of categories of land uses within colonized land.

Regarding human time use we build on previous work to select the set of categories relevant for our study (Giampietro, 2003; Pastore et al. 1999). Total Human Activity (THA) is the total human time a society has available for conducting all the activities, and is measured in hours. It equals population times 8,760 hours. THA can be split in different sub-categories according to the specific activity:

• Time for physiological activities (Physiological Overhead) HA_{PO}, referring to the accumulated number of hours for sleeping, eating and personal care.

• Time spent on unpaid work (HA_{UW}), including the number of hours used in maintaining the household, such as cooking, cleaning, going to the store, childcare.

• Time allocated to paid work activities (HA_{PW}), i.e., the number of hours that are related to the market.

• Time for mobility and transportation (HA_{TR})

• Time for leisure and recreation activities (HA_{LE})

Therefore:

$THA = HA_{PO} + HA_{UW} + HA_{PW} + HA_{TR} + HA_{LE}$

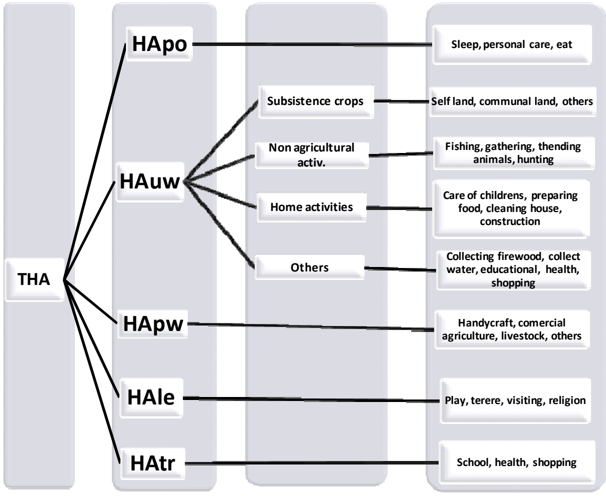


Figure 12. Taxonomy of categories of time uses

1.4.5. Quantitative indicators developed within the MuSIASEM approach: Choice of Typologies for the analysis (Chapter 4 and Chapter 5).

Typologies that consisted only of a limited set of relevant qualities and a finite set of possible structural/functional linkages were identified for the two communities analyzed in Chapters 4 and 5. This step of associating the observed system with a typology of the observed natural system can be related to the process of scientific perception (Giampietro and Mayumi, 2006). The concept of typology also indicates a definition of a finite set of observable qualities associated with the scientific representation of an observed system.

Household typologies are then considered in relation to the total sample of households across different villages, with no reference to the village to which they belong. That is, typologies of households reflect only the characteristics of the activities considered for the farming system and the profile of working time allocation within the household (Gomiero and Giampietro, 2001).

The use of typologies as a mechanism to assist in the targeting of policies, interventions and adoption of technologies is widespread, and well established (Kostrowicki 1977; Rajkomar *et al.* 1996; Cramb *et al.* 2004; Senthilkumar *et al.* 2009; Tittonell *et al.* 2010). The typology definition by Williams and Grünbühel (2010) has two functions: i) to clearly identify households with different resources, livelihood, and options for adaptation, and ii) mechanism or tool to scale up from farm and community level findings to support policy development at provincial or district levels (Williams and Grünbühel, 2010).

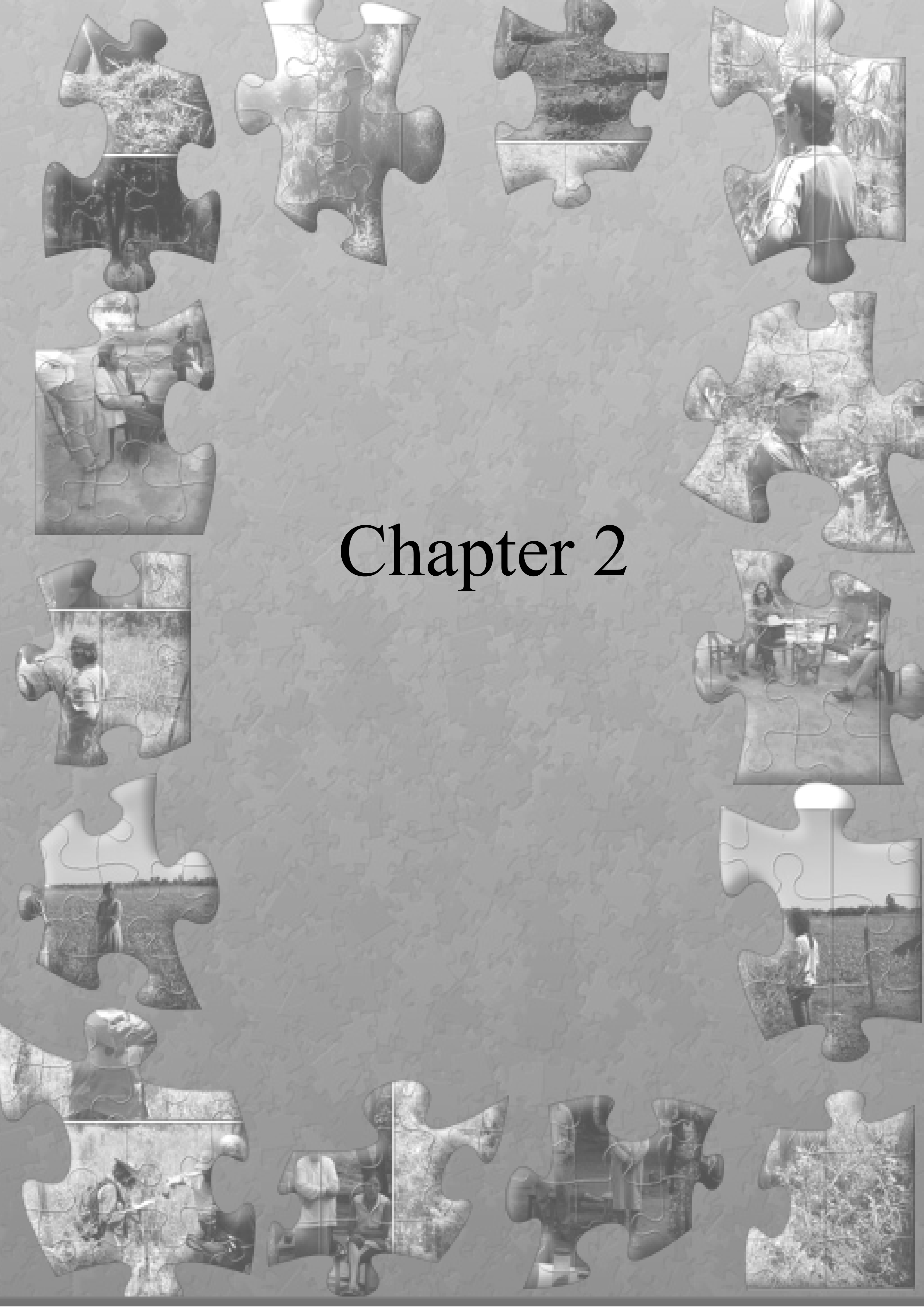
1.5. The balance between qualitative and quantitative methods

Studying agricultural systems with only a particular methodology always gives us a limited vision of the issue and a linear view of causality. In order to avoid these negative features, the thesis incorporates a holistic approach that allows us to study rural systems as complex systems. As can be seen throughout the study of different methodologies, each of them covers a specific aspect of the rural system. On the one hand, I seek to understand with the MuSIASEM approach the biophysical changes associated with the evolution of agriculture (analyzed at different levels), on the other hand with the adoption of concept of political ecology I seek to gain insight in the socio-cultural and political aspects behind it.

The methodologies applied in Chapter 4 and 5 focus more at the local scale, as it was observed that there are many studies from a global, national and even regional perspective. By developing and applying local methodologies I could observe that there are some limitations to the generalization of the protocols of analysis (and the results). Each space-time (or hierarchical level) is a different world. In this regard I also learned that it is necessary to adapt the chosen methodologies to local characteristics.

In conclusion, in relation to the development and use of methodologies, I sought making a bridge between exact and social sciences, as well as applying new types of methodologies developed with post normal science in mind. In this respect work with the actors involved has been of great relevance, especially farmers. My effort has been to understand their narratives and integrate them into the analytical framework. This is a very important component to make and design better local development programs, involving the socio-cultural aspects, very often absent in governmental institutions.

Finally I would like to emphasize that in order to change local ralities (the purpose of applied science or science for governance) the methods used must approach local reality. In relation to this point, academia and the scientific world can sometimes be very far from the local perception of what such a reality is.



Chapter 2

Chapter 2[7]: Food security and fossil energy dependence: an international comparison of the use of fossil energy in agriculture (1991-2003)

2.1. Introduction

In the five years up to mid-2008 the prices of basic food commodities doubled or tripled. For instance, the cereals FAO price index went up from 95 in year 2002 to 167 in year 2007 (FAO 2009). This generated a serious food crisis in 2007, which was experienced world-wide (both in developed and developing world) and primed food riots in many cities of developing countries (Krugman, 2008). This food crisis can be explained by a combination of the following factors: (i) increase in food demand due to world population growth; (ii) changes in dietary habits, with an increase in the consumption of animal products, which entails a double conversion of grains used to feed animals (Pingali, 2006); (iii) the occurrence of unfortunate events (such as a couple of poor years of production); (iv) the increasing demand of grains for agro-biofuels (IMF, 2007; The Guardian, 2008; World Bank, 2008; Giampietro and Mayumi, 2009). The food crisis was harder in developing countries, where food's share in household spending is higher (IMF, 2007). Are we in the presence of a systemic change in the existing balance between demand and supply? In the affirmative, this would imply that the issue of food security, interpreted as the ability of producing enough food

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[7] This chapter builds on a published paper with the same title: Nancy Arizpe, Mario Giampietro, Jesus Ramos-Martin 2010. **Food security and fossil energy dependence: an international comparison of the use of fossil energy in agriculture (1991-2003)**. *Critical Reviews in Plant Sciences, Vol.30: 45-63.*

supply over a limited amount of available land – which is shrinking with demographic growth - will get more and more relevant at the world level.

In relation to this point, Ramonet (2009) reported that in the last years more than 8 million hectares of agricultural land have already been purchased worldwide by countries with a limited endowment of arable land per capita such as South Korea, China, Saudi Arabia, and Japan. These figures change according to the source. GRAIN (2008) called this process "land grabbing" and stated that to date more than 40 million acres have changed hands or were under negotiation – 20 million of which were in Africa alone, with the side effect of reducing the number of small scale farmers and adding more pressure to water resources. Williams (2009), reporting on an UN event to try to prevent this trend in Africa, quoted David Hallam, deputy director of the trade and markets division at the UN's Food and Agriculture Organization (FAO) saying that "in the worst cases it's fair to say we are looking at neo-colonialism".

When dealing with the issue of food security and sustainability of agriculture, it is essential to focus on the constraint that the requirement of land, soil, water and other natural resources entails on the possibility of generating an adequate supply of food (Pimentel and Giampietro, 1994a). In fact, the severity of this constraint determines the amount of technical inputs that have to be used in agricultural production (or that should be used to get a certain output), which in turn affect the ecological impact of this production. Therefore, it is important to visualize the big picture of existing trends of technical progress in agriculture at the world level, in order to be able to contextualize the discussion of alternative techniques of agricultural production. When talking of the use of technical inputs in agriculture, it is well known that the revolution in the yields achieved in the last century can only be explained by the massive injections of fossil energy associated with modern techniques of agricultural production (Cottrell, 1955; Gever at al. 1991; Leach, 1976; Odum, 1971; Pimentel and Pimentel, 1979; Smil, 1988; 1991; 2001; Steinhart and Steinhart, 1974). The success of this solution has been extraordinary: "*In the past century, the world population has tripled from 2 billion at the beginning of the twentieth century to more than 6 billion at present. It is most impressive to say that the increase in the productivity of agriculture was* *able to meet the increase the demand for food by this increased population, at the same time that land per capita was proportionally shrinking. Moreover, agriculture did not only meet the growing food demand due to population growth, but it also succeeded to match the demand of food of more people consuming much more per capita. In fact, at present, the grain consumption per capita in developed countries is around 700 kg of grain per year with peaks up to 1,000 kg per year – when including the indirect consumption in the food system for animal production, beer production, and other industrial food products*" (Giampietro and Mayumi, 2009). But this extraordinary success implies a risk, an increasing dependence of food security on fossil energy: "*the survival of peasants in the rice fields of Hunan or Guadong -with their timeless clod-breaking hoes, docile buffaloes, and rice-cutting sickles - is now much more dependent on fossil fuels and modern chemical syntheses than the physical well-being of American city dwellers sustained by Iowa and Nebraska farmers cultivating sprawling grain fields with giant tractors. These farmers inject ammonia into soil to maximize operating profits and to grow enough feed for extraordinarily meaty diets; but half of all peasants in Southern China are alive because of the urea cast or ladled onto tiny fields - and very few of their children could be born and survive without spreading more of it in the years and decades ahead*." (Smil, 1991 p. 593).

For this reason analyzing the dependence of food production on fossil energy has become a very important topic (Stout, 1991; 1992; Pimentel and Giampietro, 1994b; Giampietro, 2002; Pimentel and Pimentel, 1996; Smil, 1988; 1991; 2001).

Ten years ago, in a special issue of Critical Reviews in Plant Sciences dedicated to the sustainability of agriculture (Paoletti *et al*. 1999), one of the papers was dedicated to an international comparison of the use of fossil energy in agriculture (Giampietro *et al*., 1999). The goal was to study the different mixes of technical inputs used in different typologies of countries - over a significant sample of world countries. In this chapter the same type of analysis is repeated 10 years after, with the goal of studying the evolution of the pattern of use of technical inputs in different typologies of countries. What happened in relation to this issue in the last ten years? Are we reducing the dependence of our food security on oil? These questions are extremely relevant since the era of cheap energy seems to be over and for good. The chosen sample includes countries at different levels of density of population (net exporters vs net importers of food) and at different levels of economic development (developed vs developing countries). The comparison over the chosen sample of countries refers to the years 1991 and 2003.

Looking at the future, peak oil could imply a possible reduction in the current heavy use of fossil energy inputs to agriculture. This reduction may very well be accompanied by an increase in labour inputs and a reduction of transport. This combination of changes could eventually lead to food production being devoted primarily to local consumption. This scenario seen by some authors as almost unavoidable - "Fossil fuel depletion almost ensures that this *will* happen" (Heinberg, 2007) - will represent a disaster for the growing mass of urban poor in many developing countries. To this regard it should be noted that in 2007 more than 50% of human population was urban (UNFPA, 2008). This explains why, a better understanding of the link between the use of the different technical inputs and food production is essential for discussing future scenarios of food security. In particular, in order to develop alternative methods of production, it is important to compare the use of fossil energy (how much fossil energy? for which inputs? in relation to which tasks?) in the agricultural sector of different countries.

2.2. Data source and conversion factors

The quantitative assessments given in this study are based on:

The data-set taken from FAO Agricultural Statistics.

Databases for world agricultural production are available at FAO web site (http://www.fao.org/corp/statistics). Data referring to 1991 and 2003 is selected. This database covers different aspects of agricultural production: (1) means of production – e.g. various technological inputs used in production (excluding data on pesticide use), (2) food balance sheets – accounting of production, imports, exports and end uses of various products, as well as composition of diet and energetic value of each item, per each social system considered; (3) data on agricultural production, and (4) data on population and land use. Data on pesticides have been estimated using data from literature. Assessments of pesticide consumption have been re-arranged starting from the estimates of Pimentel (1997) to fit FAO system of aggregation.

The data used in this study are reported in Table 1.

Table 1Relevant characteristics of selected countries

	Gross Food Consumption (PJ/Year)		Gross Food Production (PJ/Year)		Land in Production (10^6Ha)		Work in Production (10^6Hours)		Technical Inputs: Irrigation (1000sHa)		Harversters-Threshers (1000s)		Tractors (1000s)		Nitrogenous Fert. Consumption Tonnes		Phosphate Fertilizers Tonnes		Potash Fertilizers Tonnes		Pesticides Tonnes	
	91	2003	91	2003	91	2003	91	2003	91	2002	91	2003	91	2003	91	2002	91	2002	91	2002	92	2000
Argentina	175	211	407	660	27	29	2962	2916	1560	1561	48800	50000	274034	299620	95700	432628	54500	283300	17100	23598	---	---
Australia	125	210	318	615	46	48	924	878	4	4	56600	56500	316000	315000	462300	972300	680200	1077290	142100	230000	119654	---
Bangladesh	376	523	325	455	9	8	70414	78932	3027	4597	0	0	5250	5530	705600	1049900	216600	222300	82200	151400	2906	6340
Burundi	20	20	20	19	1	3	5616	6468	72	74	2	2	165	170	1000	852	1000	711	100	976	186	218
Canada	347	492	689	683	52	52	966	724	720	785	152114	115800	734149	732600	1253287	1629763	592300	637910	327497	346082	58936	---
China	5844	6481	5586	6218	131	155	993050	1021146	48384	54937	43996	362200	795713	995421	19970500	25430147	7284300	9924054	2404300	4250465	208	37
Costa Rica	16	23	16	22	1	1	618	652	78	108	1180	1190	6500	7000	62400	52068	16000	33743	38000	65751	---	40120
Egypt	360	501	224	320	3	3	15340	17070	2643	3400	2260	2325	59000	89700	775000	1068923	150000	142179	38400	57701	10954	---
France	487	542	890	836	19	20	2606	1562	2100	2600	122300	91000	1410000	1264000	2569000	2279000	1255000	729000	1741000	960000	85249	97490
Germany	581	706	639	688	12	12	3044	1762	482	485	141200	135000	1500000	944000	1720000	1787654	519000	327000	729658	479673	55415	57788
Ghana	75	122	69	112	4	6	8670	11762	9	11	130	19	4050	3600	7000	14170	200	8590	800	8270	---	164
India	3150	4013	3095	3790	169	170	466048	547030	47430	57198	3000	4200	1063012	2528122	8046272	10470810	3321213	4004779	1360600	1646993	141539	91487
Italy	182	425	171	302	12	11	4024	2316	2710	2750	47715	37500	1455811	1680000	906720	785314	661970	372026	418000	275302	170169	150450
Japan	736	697	263	239	5	5	8878	4618	2825	2607	1169000	1042000	1966000	2028000	576000	463000	696000	482000	480000	339000	---	---
Mexico	538	797	432	563	26	27	17106	16968	5800	6320	19000	22500	317313	324890	1155200	1176400	379900	349900	84300	185600	---	---
Netherlands	152	198	103	115	1	1	616	454	557	565	5560	5600	182000	149500	391759	284000	75000	52000	94000	66000	---	---
Spain	346	513	338	409	20	19	3656	2330	3388	3780	48821	50454	755743	943653	862156	802500	501655	601300	381382	488300	31839	35700
Uganda	83	123	81	115	7	7	15238	7312000	9	9	15	15	4600	4700	500	4330	300	2698	400	2278	144	
UK	369	428	355	350	7	6	1200	1002	165	170	48000	47000	500000	500000	1365000	1142000	365000	283000	441000	376000	59448	63093
US	3146	3838	3769	4764	188	176	7156	5696	20900	22500	663000	662000	4541725	4760000	10383900	10878330	3826400	3874960	4573700	4545159	408686	---
Zimbabwe	32	39	34	29	3	1	6546	7154	100	117	833	800	18000	240	89822	60000	43200	30000	31100	20000	5222	---

Source: Data from FAOSTAT and WRI

The set of energy conversion factors taken from an overview of the available data in the specialized literature

Energy conversion factors tend to apply generalized values, but at the same time to reflect peculiar characteristics of various socio-economic contexts in which agricultural production occurs (e.g. reflecting the system of aggregation provided by FAO statistics).

The conversion factors used to assess the amount of embodied fossil energy slightly different from those used in the original study of Giampietro *et al*., 1999, since some data have been updated. For this reason, the original data set used in the CRPS paper of Giampietro *et al*. (1999) has been recalculated using this set of conversion factors to obtain a better comparability of the two assessments presented in this paper referring to 1991 and 2003.

Machinery – to assess energy equivalent of machinery from FAO statistics basic conversion factors suggested by Stout (1991) are adopted, since they refer directly to FAO system of accounting. A standard weight of 15 Metric Tons (MT) per piece (both for Tractors and for Harvester and Thresher) for USA, Canada and Australia; a common value of 8 MT for pieces in Argentina and Europe; a common value of 6 MT for pieces in Africa and Asia. To the resulting machinery weight Stout suggests an energy equivalent of 143.2 GJ/Metric Ton of machinery. This value (which includes maintenance, spare parts and repairs) is quite high, but it has to be discounted for the life span of machinery. It is the selection of the useful life, which will define, in ultimate analysis, the energy equivalent of a metric ton of machinery. Looking at other assessments, made following a different logic, it is possible to find in literature values between 60 MJ/kg for H&T and 80 MJ/kg for tractors, but only for the making of the machinery. The range of 100 – 200 MJ/kg found in Leach analysis (Leach, 1976) includes also the depreciation and repair. Pimentel and Pimentel (1996) suggest an “overhead” of 25 – 30 % for maintenance and repairing to be added to the energy cost of making. In general a 10 year life-span is applied to these assessments. The original value of 143.2 GJ/Metric Ton of machinery suggested by Stout can be imagined for a longer life-span than 10 years (the higher the cost of maintenance and spare parts the larger should be the life span). Depending on different types of machinery the range can be 12 – 15 year. Therefore, in this assessment a flat discount of 14 years has been applied to the tons of machinery, providing an energy equivalent of 10 GJ/MT/year.

Oil consumption per piece of machinery – conversion factors from Stout (1991) – again these factors refer directly to data found in FAO statistics. The estimates of consumption of fuel per piece are the following: 5 MT/year for USA, Canada and Australia; 3.5 MT/year for Argentina and Europe; 3 MT/year for Africa and Asia. The energy equivalent suggested by Stout is quite low (42.2 GJ/MT of fuel – typical for gasoline, without considering the cost of making and handling it). A quite conservative value of 45 GJ/MT as average fossil energy cost of "fuel" has been adopted.

Fertilizers – conversion factors from Hesel (1992) – within the Encyclopedia edited by Stout (1992) – These assessments include also the packaging, transportation and handling of the fertilizers to the shop. Values are:

For Nitrogen, 78.06 MJ/kg – this is higher than the average value of 60 – 63 MJ/kg for production (Smil, 1987; Pimentel and Pimentel, 1996) and lower than the value estimated for production of Nitrogen in inefficient plants powered by coal (e.g. in China), that can reach the 85 MJ/kg reported by Smil (1987).

For Phosphorous, 17.39 MJ/kg – this is higher than the standard value of 12.5 MJ/kg reported for the process of production (Pimentel and Pimentel, 1996). But still in the range reported by various authors: 10 – 25 MJ/kg by Smil (1987), 12.5 – 26.0 MJ/kg by Pimentel and Pimentel (1996). The packaging and the handling can explain the movement toward the upper value in the range.

For Potassium, 13,69 MJ/kg – also in this case the value is quite higher than the standard value of 6.7 MJ/kg reported for production. Ranges are 4 – 9 MJ/kg given by Smil (1987) and 6.5 – 10.5 MJ/kg given by Pimentel and Pimentel (1996). Clearly, the energy related to the packaging and handling, in this case influences in a more evident way the increase in the overall cost per kg.

Irrigation – conversion factors suggested by Stout (1991) are 8.37 GJ/ha/year for Argentina, Europe, Canada, USA, and Asia; and 9.62 GJ/ha/year for Africa and Australia. These values refer to full fossil energy based irrigation. However, when looking at FAO statistics on irrigation one can assume that only a 50% of it is machine irrigated. So that this conversion factor has been applied only to 50% of the area indicated as irrigated (but in Australia).

Pesticides – a flat value of 420 MJ/kg has been used for both developed and developing countries. This includes packaging and handling (Hesel, 1992). Values in literature vary between 293 MJ/kg for low quality pesticides in developing countries to 400 MJ/kg in developed countries (without including packaging and handling).

Other energy inputs - at the agricultural level there are other technical inputs which are required for primary production. For example, infrastructures (commercial buildings, fences), electricity for on farm operations (e.g. drying crops), energy for heating, embodied energy in vehicles and fuels used for transportation. For this reason a flat 5% of the sum of previous energy inputs has been adopted in this analysis. This has been applied only to agricultural production in developed countries.

2.3. The results of the study

2.3.1. The effect of changes in Demographic Pressure and Bio-Economic Pressure

In relation to the 21 countries included in the sample in Table 2 is reported:

(i) the actual ***land productivity*** (density of the internal supply of food energy per hectare) and the threshold of the density of production per hectare that would be required to be self-sufficient according to the ***Demographic Pressure***;

(ii) the actual ***labor productivity*** (intensity of the internal supply of food energy per hour of labor) and the threshold of the density of production per hour of labor that would be required to be self-sufficient according to the ***Bio-Economic Pressure***.

Table 2 A comparison between levels of productivity per ha and per hour: (i) actually achieved, and (ii) needed for self-sufficiency

Country	Land Productivity (actual Supply) (GJ/Ha)		Demographic Pressure (needed for self-sufficiency) (GJ/Ha)		Labor Poductivity (actual Supply) (MJ/hr)		Bio-Economic Pressure (needed for self-sufficiency) (MJ/hr)	
	1991	2003	1991	2003	1991	2003	1991	2003
Argentina	14,8	22,8	6,4	7,3	137,3	226,3	59,1	72,5
Australia	6,9	12,8	2,7	4,4	344,2	700,1	135,3	238,8
Bangladesh	35,6	54,0	41,1	62,1	4,6	5,8	5,3	6,6
Burundi	15,1	14,1	15,4	14,8	3,5	2,9	3,5	3,1
Canada	13,3	13,1	6,7	9,4	712,8	943,2	359,4	679,3
China	42,5	40,2	44,5	41,9	5,6	6,1	5,9	6,3
Costa Rica	31,9	41,6	30,5	44,7	26,6	33,5	25,4	36,0
Egypt	84,8	93,3	136,1	146,3	14,6	18,7	23,5	29,4
France	46,3	42,7	25,3	27,7	341,4	535,3	186,7	346,9
Germany	54,1	57,1	49,2	58,6	209,9	390,5	190,9	400,6
Ghana	16,0	17,6	17,3	19,2	8,0	9,6	8,6	10,4
India	18,3	22,3	18,6	23,6	6,6	6,9	6,8	7,3
Italy	14,4	28,3	15,3	39,8	42,5	130,6	45,1	183,7
Japan	50,5	50,4	141,4	147,1	29,6	51,7	82,9	150,9
Mexico	16,6	20,6	20,7	29,2	25,3	33,2	31,5	47,0
Netherlands	112,5	121,9	166,5	210,3	166,4	253,4	246,2	437,2
Spain	16,8	21,9	17,2	27,4	92,4	175,7	94,6	220,0
Uganda	11,8	15,7	12,0	16,7	5,3	5,9	5,4	6,3
UK	53,6	61,3	55,7	75,0	296,1	349,3	307,8	427,4
US	20,1	27,1	16,8	21,9	526,7	836,4	439,6	673,8
Zimbabwe	11,2	8,7	10,6	11,5	5,2	4,1	4,9	5,4

The pattern of correlation of the two values of: (i) actual density of food energy supply per hectare of arable land in production; and (ii) needed density of food energy supply per hectare of arable land to be self-sufficient is illustrated in Figure 13. The graph shows that the original correlation found in 1991, remained throughout the time window - the movement of the values over time has been on a diagonal to arrive to the points recorded in 2003. This confirms the findings of previous studies (Giampietro, 1997b; Conforti and Giampietro, 1997). That is, the countries that have high demographic pressure (DP) tend to have a high production of food energy per hectare. The group of countries that have the highest demographic and land productivity are the Netherlands, Egypt and Japan. Another cluster includes the United Kingdom, Germany and Bangladesh. For a cluster analysis over this type of comparison see Conforti and Giampietro (1997).

In other words, current technological performance in agriculture in terms of yield per hectare is affected by existing demographic pressure.

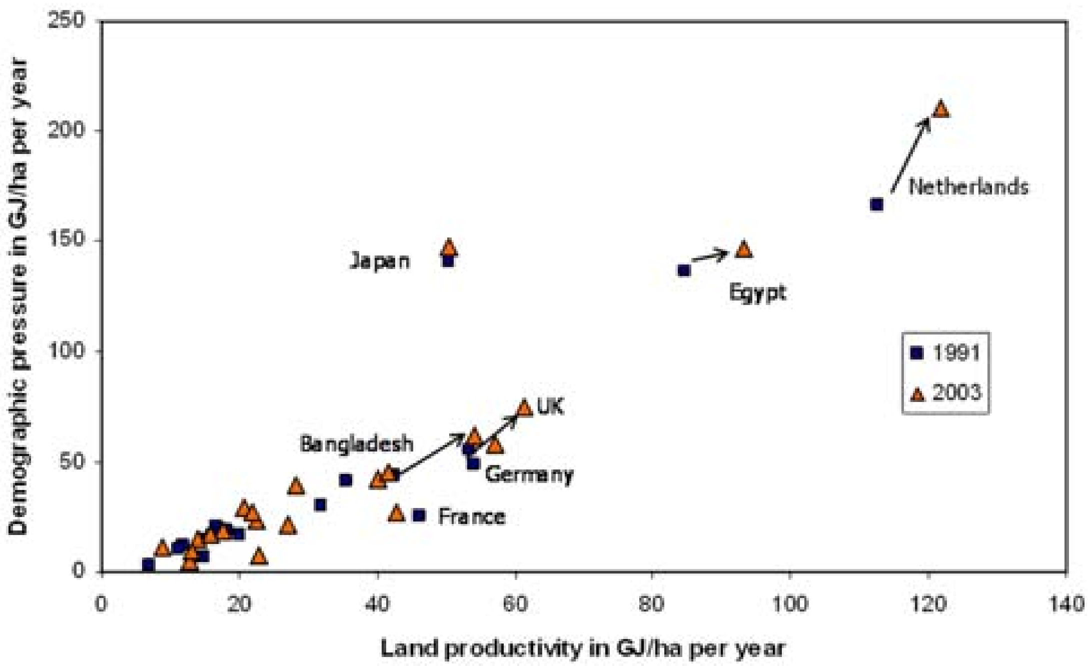


Figure 13 Land Productivity versus Demographic Pressure

The same analysis, referred to the intensity of food production (actual versus needed) per hour of labor is illustrated in Figure 14. The two values of: (i) actual intensity of food energy supply per hour of work in agriculture in production; and (ii) needed intensity of food energy supply per hour of work in agriculture to be self-sufficient - originally correlated over the sample in 1991 - keep the same pattern in 2003. Also in this case the movement of the values has been on a diagonal. That is, the countries that have a high Bio-Economic Pressure (BEP) tend to have also a high production of food energy per hour of labor in their agricultural sector.

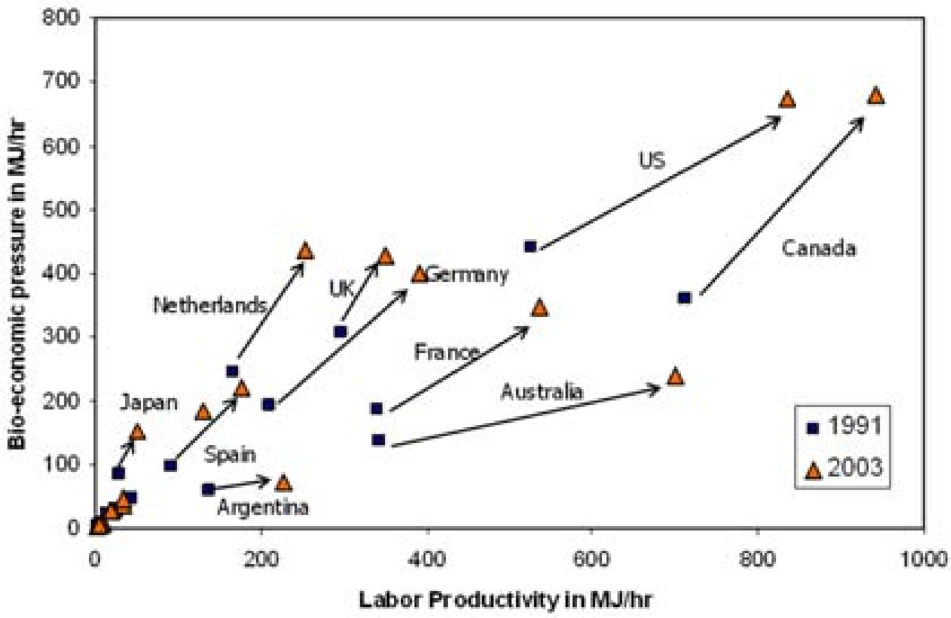


Figure 14 Labor Productivity versus Bio-economic Pressure

In this analysis three groups for developed countries can be observed, which all have increased their intensity of the flow of energy per hour over the given time window: (a) those that had the BEP already very high: USA by 53%, and Canada by 89%; (b) those that had medium high: Australia by 76%, France by 85%, Germany by 109%, UK by 53% and Netherlands by 77%; (c) those that had a BEP low – in relation to the standard of developed countries: Spain Japan and Italy. All the other developing countries remained more or less stable in relation to the intensity of production per hour (as it will be discussed later on). Argentina is a special case, being a country which is an important food exporter with abundant land per capita. Hence, this analysis confirms that technological performance in agriculture in terms of actual labor productivity is definitely affected by changes in Bio-Economic Pressure (which reflects increasing levels of consumption), but this effect is more evident in developed countries.

What are the implications of this fact? The idea that the various countries included in the sample strive for self-sufficiency in food production is, of course, a simplification of reality. We all know that in a globalized world international trade plays a significant role in stabilizing equilibrium between the requirement and supply of food (Giampietro, 1997b). As a matter of fact, the majority of the countries included in this sample are net food importers (see Table 1). Still, it is important to observe that even those countries that heavily rely on food imports – e.g. Japan – because of their high demographic pressure tend to use in a more intensive way their land in order to produce as much as possible food on their own land.

In general terms the effect of demographic growth has implied that the arable land per capita has been decreasing over all the 21 countries, when considering the difference between 1991 and 2003 can be said. However, as illustrated in Figure 15, the overall decrease in arable land per capita does not coincide with an analogous reduction in arable land per farmer. In fact, a dramatic reduction of the number of farmers in the economy of modern societies can offset the reduction of arable land per capita – due to an increase in DP - and imply an increase in arable land per farmers – due an increase in BEP.

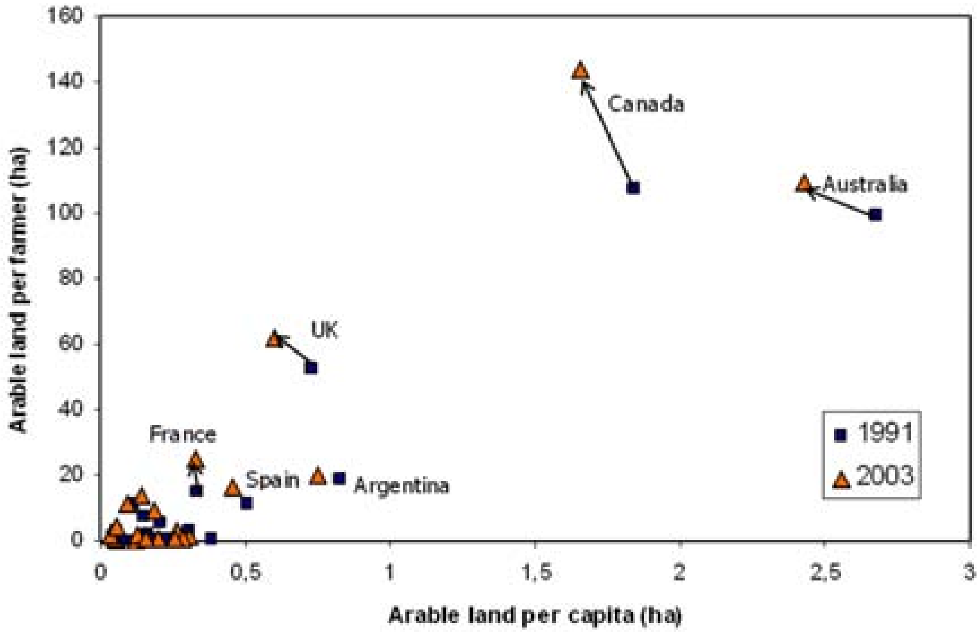


Figure 15 Arable land per capita versus Arable land per farmer

For instance, looking at our data set the arable land per capita – in 1991 – this value is about the same for the United States (0.72 ha) and Argentina (0.83 ha) whereas the arable land and permanent crops per agricultural worker is much larger in the United States (52 ha) than in Argentina (18 ha). The same type of difference – determined by the difference in the fraction of farmers in the work force of the two countries - remained in 2003. The arable land per capita was still similar in the US (0.59 ha) and for Argentina (0.75 ha) in 2003. Still, again, the amount of arable per farmer was much large in the US (61 ha) than in Argentina (19 ha) due to the much smaller percentage of farmers in the labor force in the United States.

Similarly, densely populated European countries, such as Germany France, Italy and the UK, have limited amount of arable land per capita – in the range of 0.12-0.20 ha per capita. These values are comparable with the values of arable land available per capita in India or Burundi. However, the percentage of farmers in the work force of European countries (around 2% in 1991 and around 1.5% in 2003) is much smaller than the values found in developing countries (e.g. 49% - in 1991 and 47% in 2003 for Burundi or 42% - in 1991 and 38% in 2003 for

China). This implies that, at the same level of DP, the amount of arable land per farmer is larger in countries having a higher level of BEP.

This last observation requires looking at another relation implied by the theoretical framework adopted in this study. The increase in Bio-Economic Pressure (the reduction of the fraction of farmers in the work force) is directly associated with the level of economic growth – the level of GDP – of a society. As illustrated in Figure 16 both the fraction of the work force in agriculture and the fraction of GDP from agriculture decrease dramatically for countries with high levels of GDP. No developed country has a percentage of work forces in agriculture larger than 5%. The pattern is pretty robust over the considered time window.

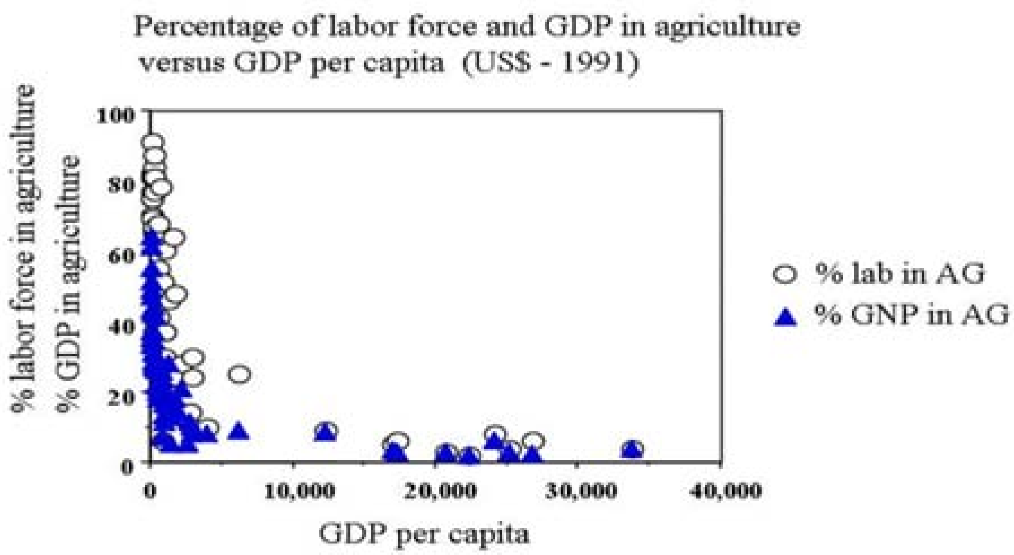


Figure 16 Percentage of labor force and GDP in agriculture.

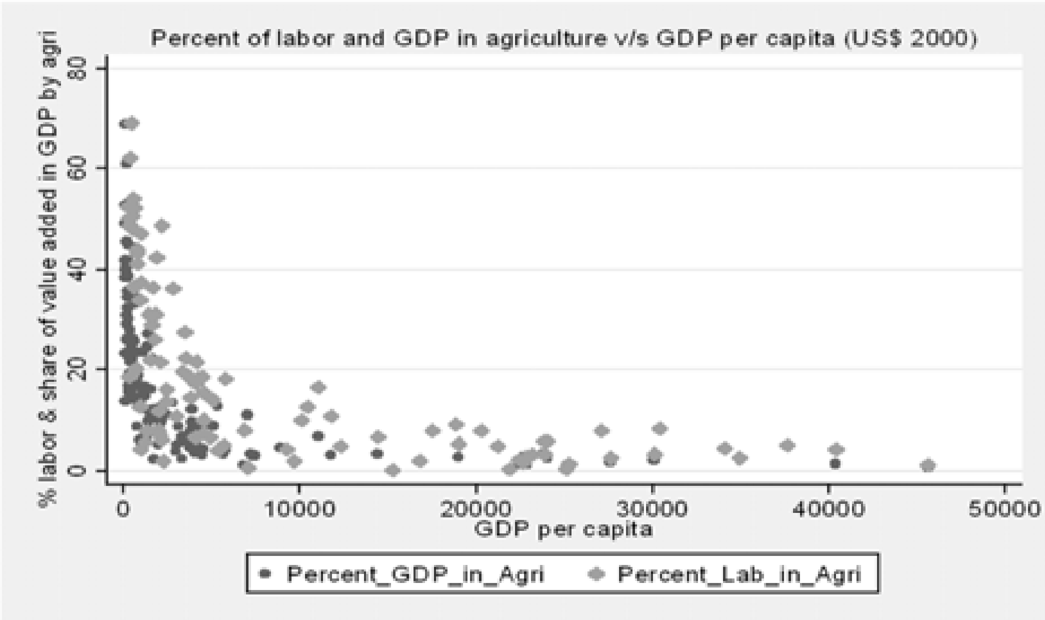


Figure 17Percent of labor and GDP in agriculture.

2.3.2. Technological inputs dealing with increases in demographic pressure (how to boost Land Productivity with Irrigation and Fertilizers)

Irrigation

Irrigation is a costly way to augment the yield per hectare. Apart from scarcity of water (Postel, 1997), irrigation requires expensive fixed investments and large energy inputs for operation. For example, a corn crop producing 9,000 kg/ha requires about 7 million liters of water (Pimentel, *et al*., 2004). Irrigated corn in Nebraska requires 3 times more fossil energy than a rainfed corn crop in eastern Nebraska producing the same yield (Pimentel, *et al*., 2004). The relationship between land availability and the use of irrigation for the sample of selected countries is shown in Figure 18. It shows that the more a country is faced with land constraints, the more its agriculture relies on irrigation. Exceptions are Burundi, Ghana, Uganda, and Zimbabwe, which are located in the humid tropics or subtropical areas of Africa and have sufficient rainfall (to national averages is being referred).

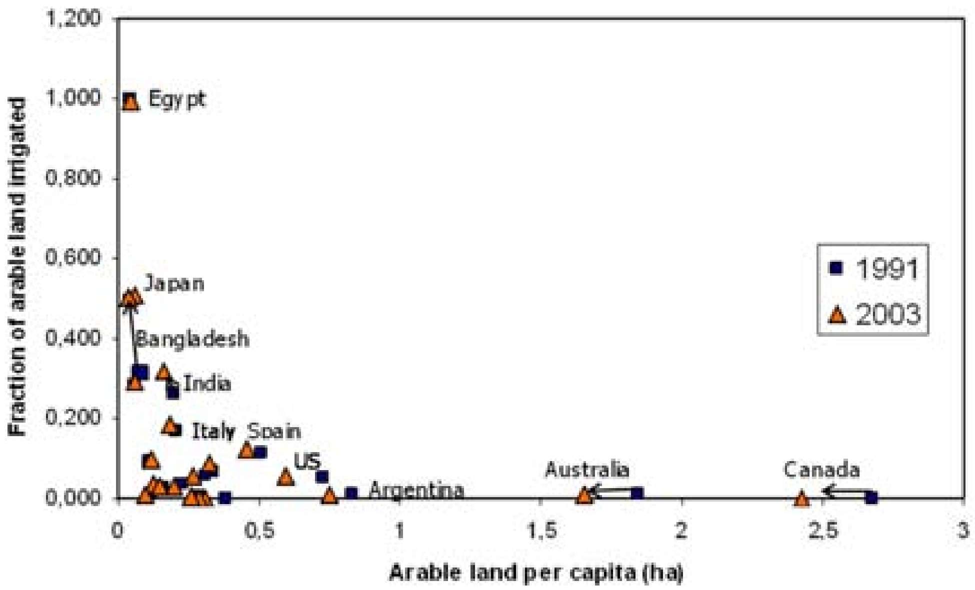


Figure 18 Land availability versus Use of Irrigation

When checking the relationship between changes in GDP per capita and changes in the use of irrigation over the period 1991 and 2003– as illustrated in Figure 19 – that increases in bio-economic pressure – associated with increases in GDP p.c. – do not necessarily translate in an increase of irrigation is found (Giampietro, 1997b; Giampietro *et al*. 1999). This analysis confirms the point that the input of irrigation is applied to augment the yields per hectare, and that therefore it is not directly related to the need of increasing the productivity of farm labor.

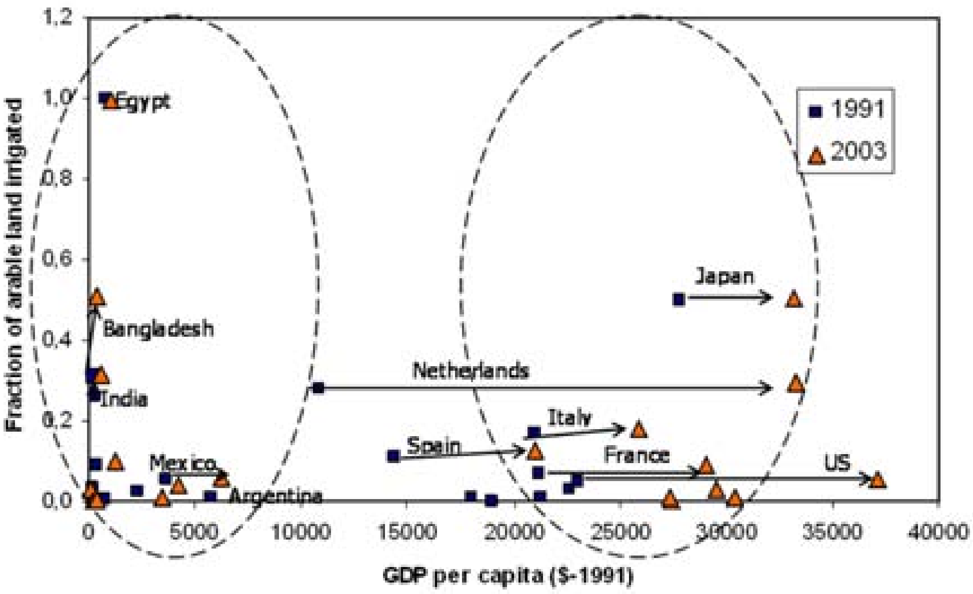


Figure 19 GDP versus arable land irrigated

Nitrogen fertilizer

The rise of N in fertilizer has increased worldwide of about 150% in many crops (Frink *et al*., 1999). In addition to its growing use, the N fertilizer is the most 'expensive' technical input in terms of fossil energy. This is the reason why on the use of the N fertilizer as the representative of the entire class of fertilizers is been focused.

The relationship between land availability and use of nitrogen fertilizer, shown in Figure 20, indicates that agriculture in countries with land shortage tends to use as much fertilizer as possible. Like for the input of irrigation– when considering the picture obtained at a large scale – the input fertilizer is applied to augment yield per hectare can be said. That is, the use of this input is not directly related to the need of increasing the productivity of farm labor.

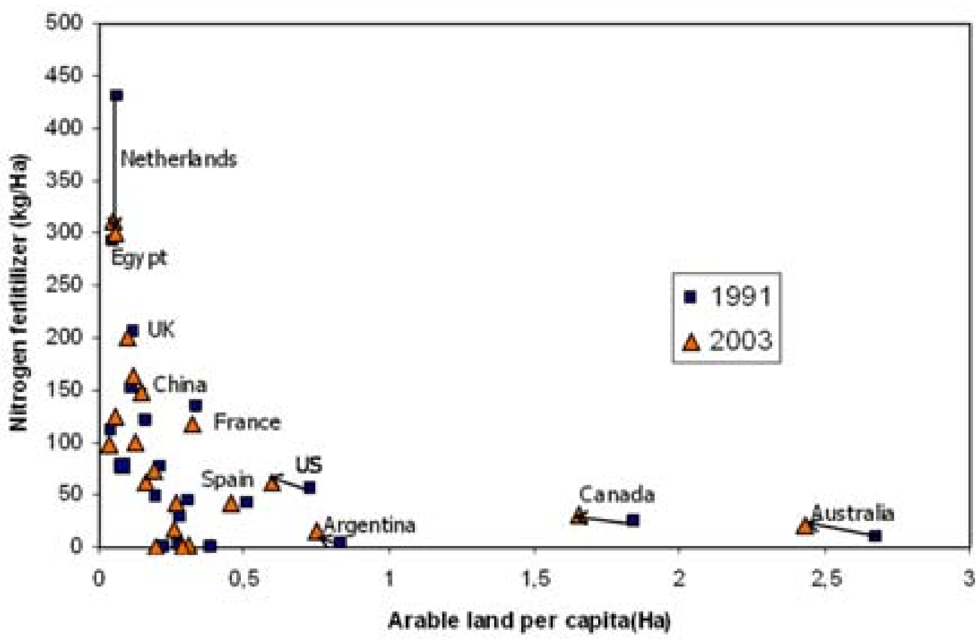


Figure 20 Arable land versus Nitrogen fertilizer

When nitrogen use is put in relation with GDP per capita (Figure 21), a clear division between developed and developing countries can be seen. Within each of these two groups, nitrogen use appears to be related to scarcity of arable land (according to the pattern observed in Figure 20). Changes related to changes in GDP (the differences between the year 1991 and 2003), shows that in some countries – notably The Netherlands reducing the consumption of 43% - the consumption of fertilizer has been adjusted, optimizing its use in relation to economic performance and environmental impact (reducing the leakage of P and N in the water table).

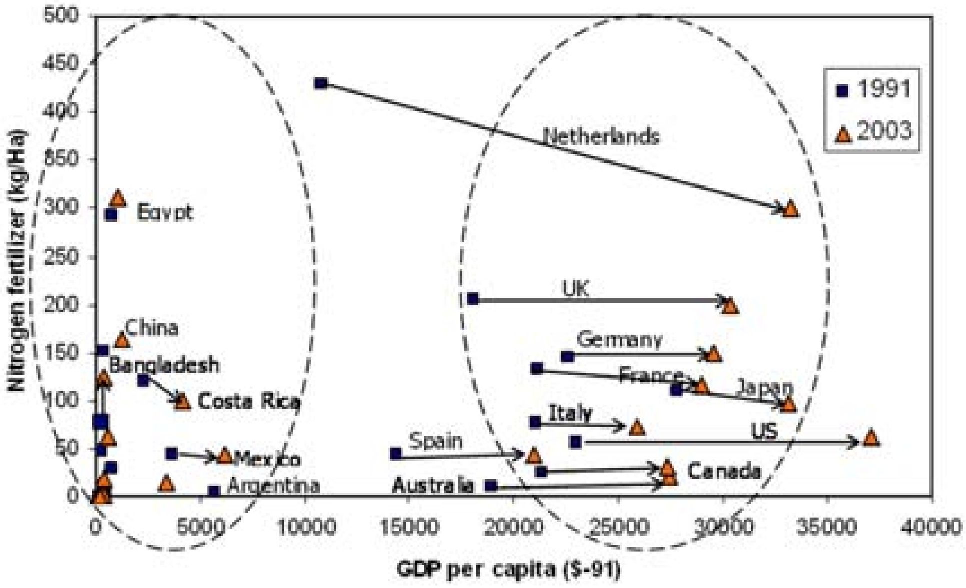


Figure 21 GDP versus Nitrogen fertilizer

2.3.3. Technological inputs dealing with increase in bio-economic pressure (how to boost Labor Productivity with Machinery)

Machinery

The relationship between machinery per farmer and GDP per capita for the 21 selected countries is shown in Figure 22. The use of tractors does indeed appear to be related to the level of GDP, which in turn translates into the need to achieve high labor productivity for farmers. Although densely populated countries, such as Japan and some of the European countries with limited amount of arable land, make this relation nonlinear.

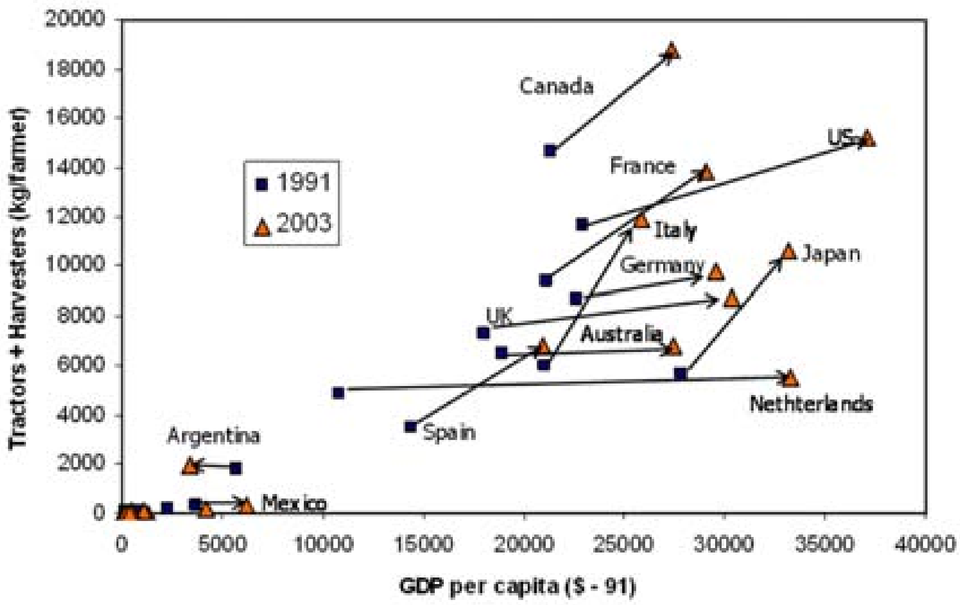


Figure 22 GDP versus Tractors-Harvesters

In this graph it is clear that tractors are used only by developed countries with the exception of special countries having the option of becoming grain exporters (Argentina in our sample).

A crucial factor determining the use of tractors is land availability, which depends on the available land per farmer – this is to say on demographic pressure, economic development and land tenure. This relation is illustrated in Figure 23, which puts tractor use per farmer in relation to land availability per farmer.

From this graph one can see that agricultural sectors facing shortage of arable land are less likely to increase their use of machinery per farmer, especially in developing countries. By looking at the changes taking place in developed countries, the use of Tractors and Harvesters reflects the effects of high levels of bio-economic pressure determining a tiny working force in agriculture can be noticed.

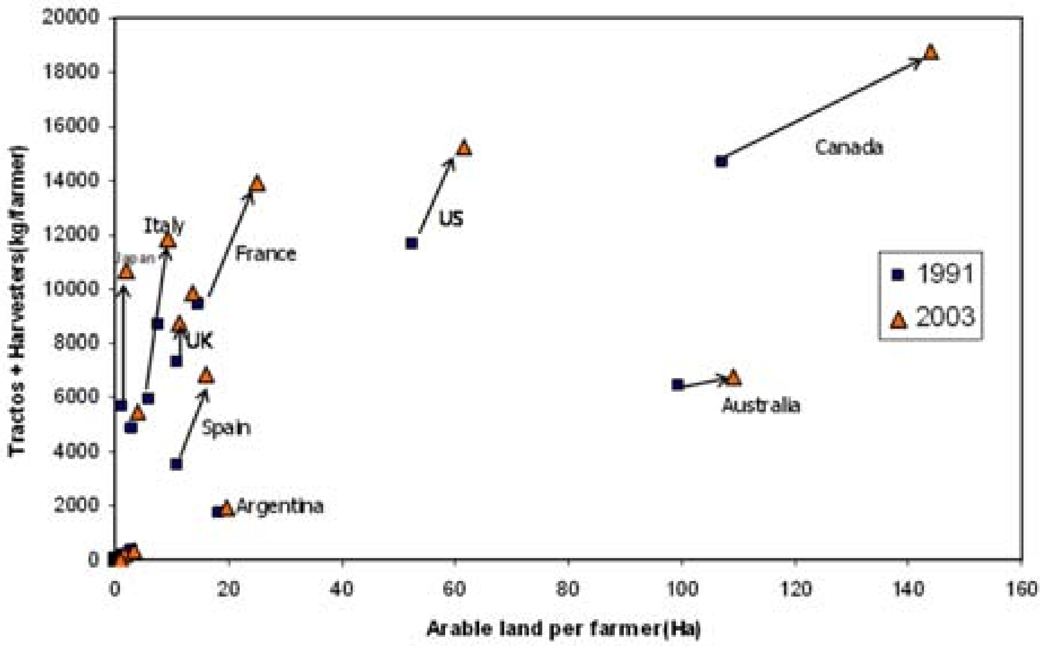


Figure 23 Arable land versus Tractors-Harvesters

2.3.4. Limited Substitutability of Natural Capital with Technological Inputs

Most of the countries of the world are now to some degree dependent on food imports. These imports come from cereal surpluses produced in only a few countries that have a relatively low population density and intensive agriculture. For instance, in the year 2003, the United States, Canada, Australia and Argentina provided about 45% of net cereal exports on the world market (FAO, 2005).

It is easy to guess that if the Demographic Pressure (DP) increases also in exporting countries, they will see their internal grain demand increase and their arable land available per capita decrease. Let us remind here that the value of DP is not only affected by population growth, but also by changes in the diet towards more meat consumption, as the ones reported by Pingali (2006) for Asia. This is so because in the calculation feedstuffs for animals is also included. Under these conditions the cereal grain surplus now exported on the international market may be seriously eroded. This will make even more important the challenge determined by the continuous increase in demographic pressure in those countries which are already importing food.

As discussed in the introduction many developing countries rely heavily on fossil energy, especially in form of fertilizers, to sustain their internal food supply. A future slow down of fossil energy consumption-because of either a decline of oil supplies, increase in oil prices, or growing restrictions on fossil fuel use to limit its environmental impacts may very well generate a direct competition between fossil energy use in developed countries, to sustain a high standard of living, and that in developing countries, to provide an adequate food supply for survival (Pimentel and Giampietro, 1994b). The recent food crisis generated by large scale agro-biofuel production can be interpreted as a first example of this problem (Giampietro and Mayumi, 2009).

On the other hand, it is obvious that the ability of boosting labor productivity of farmers by using more machinery makes only sense in presence of the availability of a large amount of arable land per farmer. The relation between arable land per farmer and labor productivity is shown in Figure 24. This figure shows that at a given point in time, there is a clear relation between availability of arable land and labor productivity. This relation, however, can be established only by the use of an increasing amount of tractors. This is to say that countries like Australia, Canada, and the United States have the highest labor productivity but also the largest use of machinery and the largest use of arable land per farmers – the three things go together. Actually, the major increase in productivity of labor in these countries can be associated to a major increase in the use of machinery – e.g. Australia had an increase of 100% in the crop output: from 700 MJ/worker/year in 1991 to 1400 MJ/worker/year in 2003. The possibility of intensifying the use of tractor per farmers, however, depends on the availability of a huge amount of arable land (e.g. more than 100 ha) per agricultural worker.

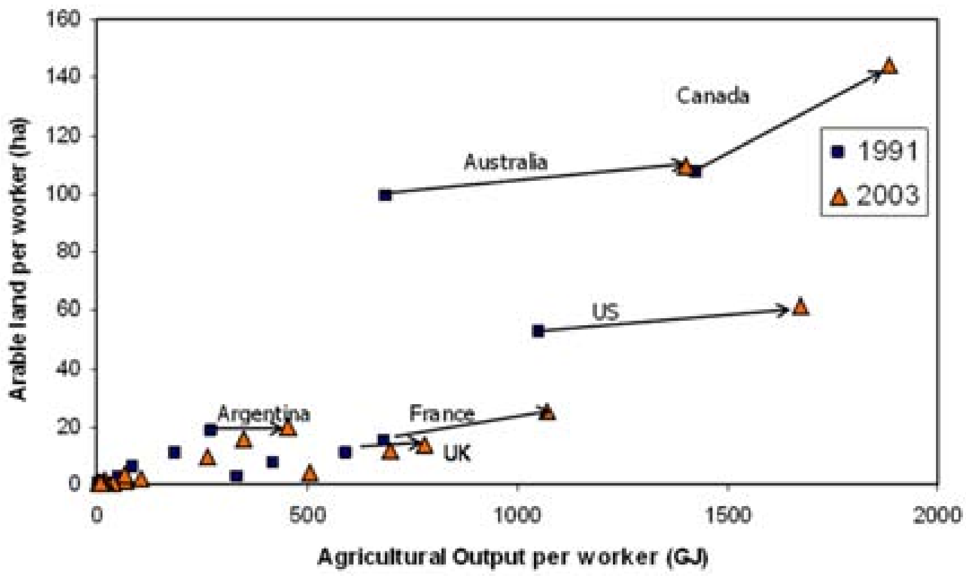


Figure 24 Agricultural Output versus arable land

Different is the situation of the other European countries where agriculture is evidently subject to severe biophysical constraints in terms of shortage of arable land per farmer (when compared with Australia or USA), a consequence of demographic pressure.

E. Technological Inputs and Demographic and Bio-Economic Pressure

The relationship between productivity of land and productivity of labor in agriculture is depicted in Figure 25 and reveals some interesting trends. For instance, US and Canada agriculture have a lower performance in terms of yield per hectare than agriculture in Bangladesh, China, Costa Rica, Ghana, Egypt, and the European Union.

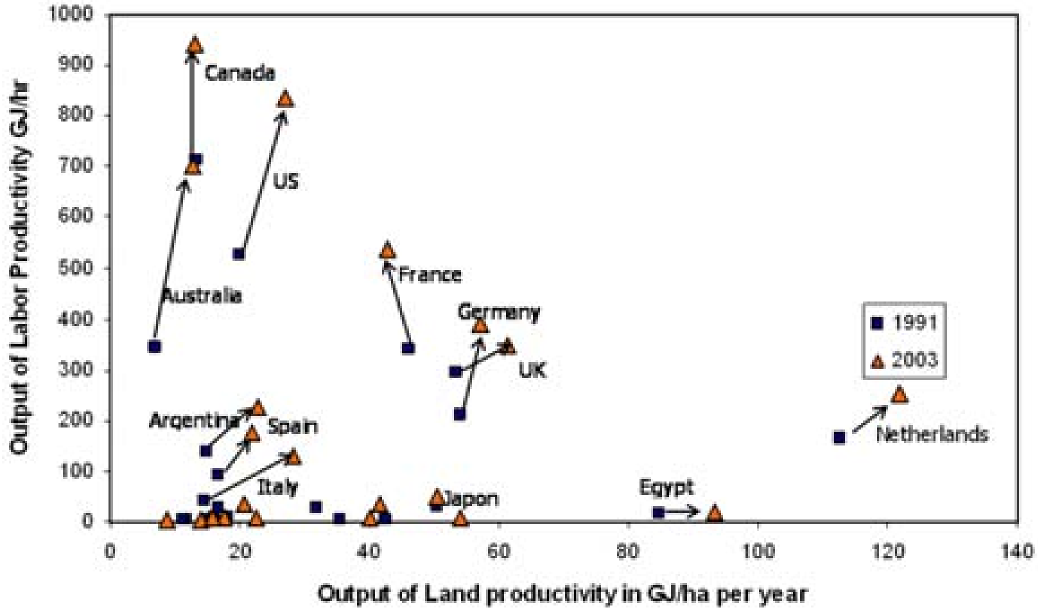


Figure 25 Output of Land Productivity versus Output of Labor productivity

On the other hand, US agriculture has the best performance in terms of labor productivity. China, with its huge population, suffers such a severe shortage of arable land that all technological and fossil energy inputs appear to go into raising land productivity with little regard for farm labor productivity.

The Netherlands and Egypt have a high land productivity increasing from 1991 to 2003 as well as the labor productivity. This pattern, however, is not present in other countries. These data indicate that for the 21 agricultural systems studied, the purpose of energy and technological inputs used in agriculture is not necessarily the same. Differences are related to different definitions of 'efficiency' for agriculture depending on the different levels of bio-economic and demographic pressure affecting societal choices.

2.3.5. The overall pattern of Energy Consumption in Agriculture

The consumption of fossil energy in agriculture can be divided in two categories: direct and indirect. Direct consumption of energy refers to the consumption of fuels for operating machineries, irrigation pumps, heating greenhouses and the moving loads, the consumption of electricity for drying crops, heating and illumination – that is energy spent in the agricultural sector. Indirect consumption of fossil energy refers to the energy spent in the industrial sector for the production of the technological inputs used in agriculture. This indirect consumption includes the production of fertilizers and pesticides (in the chemical sector), the fabrication of machinery (in the mechanical sector) and the fabrication of other infrastructures. For this reason, it is normal to find a discrepancy between the estimates of energy consumption of the agricultural sector found in national statistics and the estimates based on the accounting of direct and indirect fossil energy consumption, which include also the embodied energy in the technical inputs.

To clarify this issue, an overview of the contribution of the different form of energy is provided in Table 3. In relation to the calculation of this table, in other inputs a flat of 5% of the sum of other technical inputs are required for primary production was assumed; for example, infrastructure (commercial buildings, fences), electricity for on-farm operations (e.g. drying of crops), energy for heating and energy inherent in use of vehicles and fuels for transportation (Giampietro, 2002)

Table 3 Fossil energy input in agricultural production for selected countries

	Indirect Energy Inputs												Direct Energy Inputs											
	Nitrogenous (PJ)		Phosphate (PJ)		Potash (PJ)		Machinery (PJ)		Pesticides (PJ)		Total Indirect (PJ)		Irrigation (PJ)		Fuel (PJ)		Other inputs (PJ)		Total Direct (PJ)		Estimated Grand Total (PJ)		Reported in Statistics (PJ)	
	1991	2002	1991	2002	1991	2002	1991	2002	1991	2000	1991	2002	1991	2002	1991	2003	1991	2003	1991	2003	1991	2003	1991	2003
Argentina	13,1	13,1	0,9	4,9	0,2	0,3	25,8	28,0	0	0	40,1	46,3	13,1	13,1	50,8	55,1	5,2	5,7	69,1	73,9	109,2	120,1	69,0	113,4
Australia	0,4	0,4	11,8	18,7	1,9	3,1	29,8	29,7	50,3	0,0	94,2	51,9	0,4	0,4	58,7	58,5	7,7	5,5	66,7	64,4	160,9	116,3	46,2	77,7
Bangladesh	25,3	38,5	3,8	3,9	1,1	2,0	0,4	0,4	1,2	2,7	31,9	47,5	25,3	38,5	0,7	0,7	2,9	4,3	28,9	43,6	60,8	91,0	11,2	24,9
Burundi	0,7	0,7	0,02	0,01	0,01	0,01	0,01	0,01	0,1	0,1	0,8	0,8	0,7	0,7	0,02	0,02	0,1	0,1	0,8	0,8	1,6	1,7	---	---
Canada	6,0	6,6	10,3	11,1	4,5	4,7	70,9	67,9	0	0	91,7	90,2	6,0	6,6	199,4	190,9	14,9	14,4	220,3	211,8	312,0	302,0	84,6	94,2
China	405,0	459,8	126,5	172,3	32,9	57,3	67,2	108,6	0,1	0,02	631,6	798,1	405,0	459,8	113,4	183,3	57,5	72,1	575,8	715,2	1207,4	1513,2	463,4	718,9
Costa Rica	0,7	0,9	0,3	0,6	0,5	0,9	0,6	0,7	0	16,9	2,1	19,9	0,7	0,9	1,2	1,3	0,2	1,1	2,1	3,3	4,1	23,2	1,4	4,8
Egypt	25,4	32,7	2,6	2,5	0,5	0,8	4,9	7,4	4,6	0	38,1	43,3	25,4	32,7	8,3	12,4	3,6	4,4	37,3	49,6	75,3	92,9	---	1,9
France	17,6	21,8	21,8	12,7	23,8	13,0	122,6	108,4	35,8	40,9	221,6	196,7	17,6	21,8	241,3	213,4	24,0	21,6	282,9	256,8	504,5	453,5	118,3	94,7
Germany	4,0	4,1	9,0	5,7	10,0	6,5	131,3	86,3	23,3	24,3	177,6	126,8	4,0	4,1	258,5	169,9	22,0	15,0	284,5	189,0	462,1	315,8	103,5	70,0
Ghana	0,1	0,1	0,0	0,1	0,0	0,1	0,3	0,3	0,0	0,1	0,4	0,7	0,1	0,1	0,6	0,5	0,1	0,1	0,7	0,7	1,1	1,4	1,6	8,2
India	397,0	478,7	57,7	69,5	18,6	22,2	85,3	202,6	59,4	0,0	618,0	773,1	397,0	478,7	143,9	341,9	57,9	79,7	598,8	900,3	1216,8	1673,4	54,6	241,5
Italy	22,7	23,0	11,5	6,5	5,7	3,7	120,3	137,4	71,5	63,2	231,6	233,8	22,7	23,0	236,8	270,5	24,6	26,4	284,0	319,9	515,7	553,7	103,5	117,1
Japan	23,6	21,8	12,1	8,4	6,6	4,6	250,8	245,6	0	0	293,1	280,4	23,6	21,8	423,2	414,5	37,0	35,8	483,9	472,1	777,0	752,5	89,6	117,2
Mexico	48,5	52,9	6,6	6,1	1,2	2,5	26,9	27,8	0	0	83,2	89,3	48,5	52,9	53,0	54,7	9,2	9,8	110,8	117,5	194,0	206,7	73,1	89,8
Netherlands	4,7	4,7	1,3	0,9	1,3	0,9	15,0	12,4	0	0	22,3	18,9	4,7	4,7	29,5	24,4	2,8	2,4	37,0	31,6	59,3	50,5	11,8	20,7
Spain	28,4	31,6	8,7	10,4	5,2	6,6	64,4	79,5	13,4	15,0	120,0	143,2	28,4	31,6	126,7	156,6	13,8	16,6	168,8	204,8	288,9	348,0	62,0	85,8
Uganda	0,1	0,1	0,01	0,05	0,01	0,03	0,4	0,4	0,1	0,0	0,5	0,5	0,1	0,1	0,6	0,6	0,1	0,1	0,8	0,8	1,3	1,3	---	---
UK	1,4	1,4	6,3	4,9	6,0	5,1	43,8	43,8	25,0	26,5	82,6	81,7	1,4	1,4	86,3	86,2	8,5	8,5	96,2	96,0	178,8	177,7	33,4	12,8
US	174,9	188,3	66,4	67,3	0,0	0,0	416,4	433,8	171,6	0,0	829,4	689,4	174,9	188,3	1171,1	1220,0	108,8	104,9	1454,8	1513,2	2284,2	2202,5	609,4	641,3
Zimbabwe	1,0	1,1	0,7	0,5	0,4	0,3	1,5	0,1	2,2	0,0	5,8	2,0	1,0	1,1	2,5	0,1	0,5	0,2	4,0	1,4	9,8	3,4	2,9	37,5

Source: Giampietro (2002) and calculations on FAOSTAT.

Reported In Statistics: Data from IEA World Energy Statistics and Balances considering Agriculture/Forestry - Petroleum Products.

When interpreting this data set against the rationale adopted in this study, countries with high GDP per capita and high demographic pressure, such as Japan and the Netherlands, have a high consumption of fossil energy both per hectare and per worker can be observed. Countries with high GDP per capita but relatively low demographic pressure, such as the United States, Canada, and Australia, have high consumption of fossil energy per farmer (to achieve high labor productivity) but relatively low energy consumption per hectare of arable land. Between these countries in European countries like France, UK, Germany, Italy and Spain can be observed. The opposite is true for countries with high population density and low per capita income, such as China and Egypt, which basically invest important amount of fossil energy, but only to boost the productivity of food per hectare.

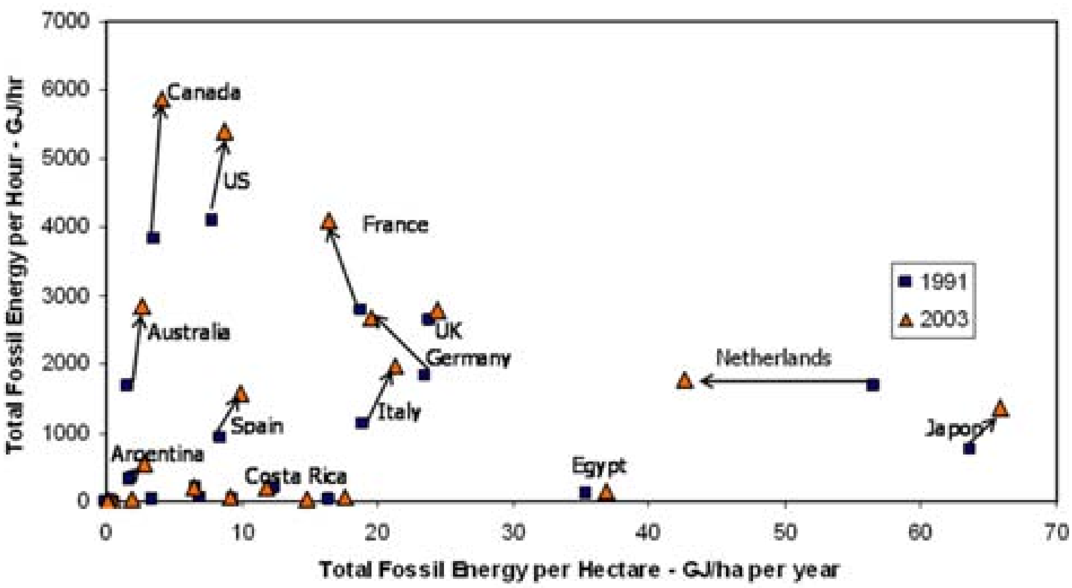


Figure 26 Total Fossil Energy per Hectare versus per Hour

This observation suggests that a mosaic of different solutions to the challenge of a sustainable food production, especially when considering that other biophysical constraints should be expected – e.g. availability of water, soil, climatic conditions – and ecological constraints – e.g. the level of destruction of natural habitats, which are needed for biodiversity preservation – are different in different areas of the world. This is to say, that it is not reasonable to expect that the future technical progress of agriculture, even when discussing of agro-ecological solutions should be obtained by implementing a common pattern all over the world. Rather than looking for technological packages to be applied all over the planet (extensive adaptation), without regards for the local specificity, we should be looking for specific solutions tailored on the specificity of different situations. When dealing with the sustainability of agriculture "one size does not fit all".

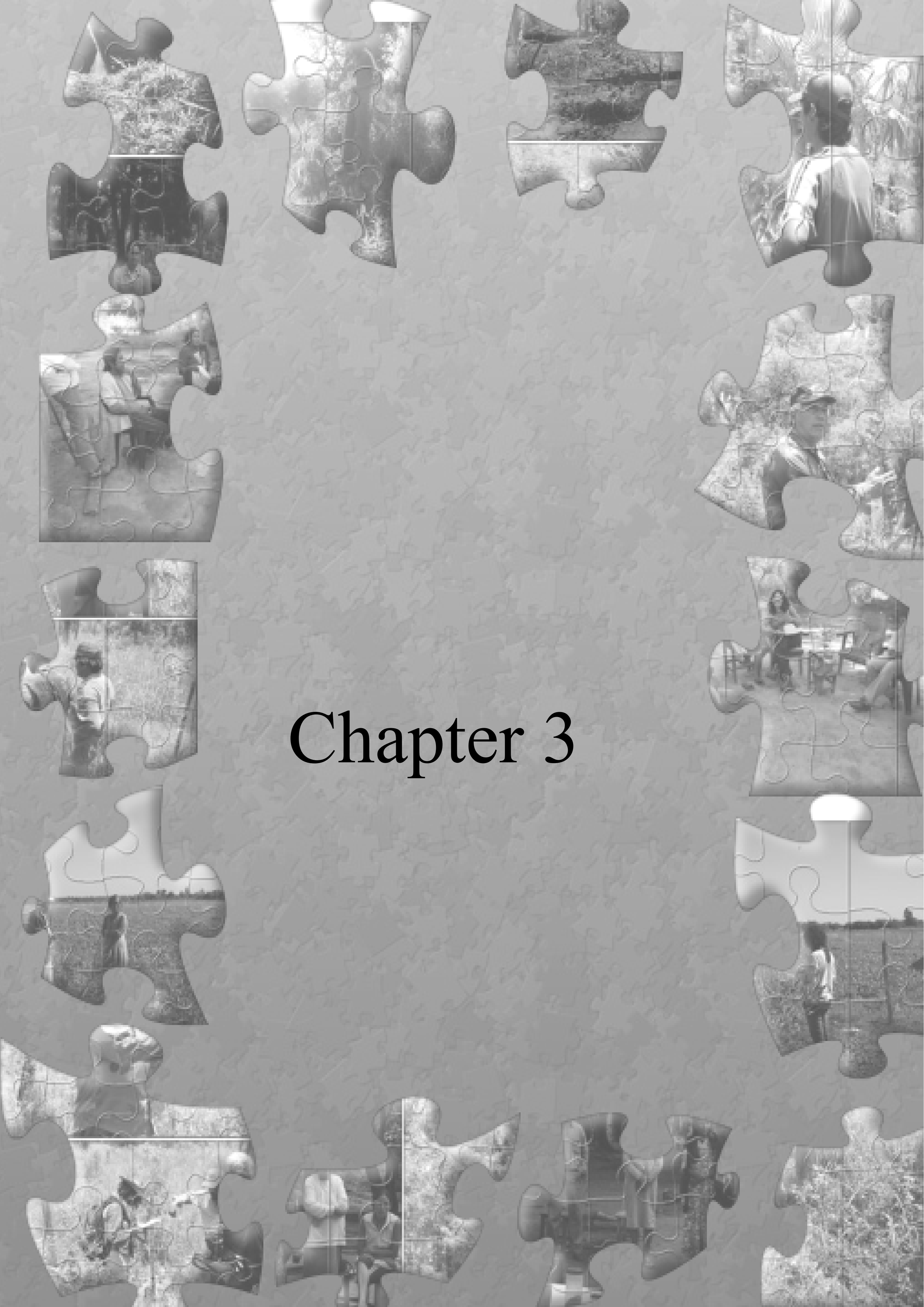
2.4. Conclusion

The analysis presented in this paper clearly shows the existence of huge differences in the situation experienced by farmers operating in different contexts (e.g. developed countries versus developing countries; very populated countries versus sparsely populated countries). These differences may be further boosted, in the future, by existing trends of demographic and economic growth. In fact, there are countries in Africa and in America and Asia where population is still growing faster than GDP and countries where the GDP is growing faster than population.

When considering socio-economic constraints, due to the required high level of investment per farmer (Giampietro, 2008; Giampietro and Mayumi, 2009), in many developing countries it would be impossible to follow the "Paradigm of Industrial Agriculture" which has been implemented in developed countries. In fact, replacing the work of farmers with expensive pieces of machinery and huge injections of technical inputs requires the availability of a lot of capital, the existence of consumers capable of buying expensive food, and the possibility of absorbing the vast majority of rural population into cities where they can work in the industrial or the service sector with productivity that (in economic terms, not in physical terms) is higher than in the villages they left behind. Many developing countries do not have enough money to invest in a capitalization of their agriculture, nor rich consumers which can buy expensive food, nor an economy which can offer well paid jobs in the cities. This point is in favor of alternative techniques of production based on a low dependence on external inputs. As a matter of fact, when looking at the changes in the use of technological inputs over the time window considered in this study, tractors, nitrogen and irrigation have increased at the world level, but at considerable different rates in Africa and Europe can be noticed.

When considering biophysical constraints, a continuous increase in demographic pressure results in the requirement of a continuous increase in food production. Since the best arable land is already in use, this translates into the need of bringing new land under production, expanding irrigated land area and applying Green Revolution technologies also on marginal land. In many countries in Africa, Asia and some countries in South America this translates into a continuous expansion of agricultural production into fragile and ecologically sensitive regions, where yields are lower than in fertile land. This requires a larger use of technical inputs with lower economic return and a much larger environmental impact in terms of loss of habitat for biodiversity preservation. To make things worse, economic development not only tends to reduce the number of farmers, but also to change the mix of food products in the diet of the growing urban population. As a consequence of this fact, in developing countries more people are eating more animal products (dairy and meat). This translates into an increasing quantity of grains consumed per capita, for the supply of animal products. That is, the combination of population and economic growth translates into a major boost in the requirement of food production, and therefore a major boost to the stress on terrestrial and aquatic ecosystems.

Nobody can predict the future of agriculture in 50 years from now. What we can say is that it is very unlikely that the future technical development of agriculture will continue by doing "more of the same" as done right now. For this reason it is important to study alternative system of agricultural production capable of generating a diversity of performances, which can be selected in different contexts in relation to different criteria and different typologies of constraints.



Chapter 3

Chapter 3[8]: Top down-bottom up participation

Participatory processes in the soy conflicts in Paraguay and Argentina

The process of mechanization of agriculture explained in Chapter 2 leads to local/regional conflicts that are going to be analyzed in Chapter 3, leaving for 4-5 their analysis in biophysical terms at community and household level.

3.1. Introduction.

The last decade has seen a drastic expansion in soy production in Latin America as part of the continued application of the industrial model of agriculture. This expansion is taking place mainly in Brazil, Argentina, Paraguay, Uruguay and Bolivia. In Argentina, soy production increased from 11 Mton in 1990-1991 to 48 Mton in 2007-2008, and its sowing surface increased from 16.6 MHa to 30.7 MHa (SAGPyA, 2008). In Paraguay, production increased from 3.5 Mton to 6.8 Mton, while the sowing surface increased from 1.3 MHa in 2000-2001 to 2 MHa in 2007-2008 (INBIO, 2008). The negative environmental and social impacts of this expansion are now widely documented (e.g. Altieri, 2009; Gudynas, 2008; Holland *et al*., 2008; Pengue, 2005; Steward, 2007). The environmental impacts, which have created a huge "ecological debt" (Pengue, 2005), include increased deforestation, water pollution, soil degradation, loss of agro-biodiversity, and health problems associated with increased use of pesticides and herbicides[9]. Social impacts include peasant displacements, loss of livelihoods, increased rural

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[8] This chapter builds on the published article Gustavo A. García-López and Nancy Arizpe 2010. **Participatory processes soy conflicts in Paraguay and Argentina.** *Ecological Economics Volume 70, Issue 2.Pages 196-206*

[9] The major culprit for these problems is the herbicide Roundup, to which genetically-modified soy is resistant, leading to higher herbicide use.

conflicts, and loss of food security and sovereignty (Mora, 2006). It is estimated that in the last decade, soy expansion led to the displacement of about 300,000 peasant and indigenous families in Argentina, while eliminating four out of five existing farming jobs, leaving only 1 job per 500 hectares (MOCASE/Vía Campesina, in enREDando, 2008). Since only those plantations with 500+ hectares become viable, some 60,000 farms went out of business while the area of GM-soy almost tripled, leading to significant land concentration (ibid). There is also a loss of food security and sovereignty, as the traditional subsistence-based crop diversity of family agriculture is substituted by soy monocrops controlled by large agri-business corporations such as Monsanto (Palau, 2004). Paraguay has about 10% of its agricultural land under soy cultivation (Gudynas, 2008). Between 1999 and 2008, the acreage under cotton production, the mainstay of small farmers, decreased by 67%, while the area under soy almost doubled (INBIO, 2008). In Argentina, soy now covers more than 50% of the agricultural surface, and in the last five years the expansion of the soy frontier displaced about 4,6 MHa of other crops and grazing land (Pengue, 2009).

These impacts have led to an increasing number of ecological distribution conflicts which pit multinational corporations and governments, who promote the expansion of the genetically-modified industrial model of agriculture, against peasant movements which seek to change the political-economic forces determining what is produced, when and for whom, while trying to protect natural resources and subsistence-based agro-ecological farming (Petras and Veltmeyer, 2005; Rosset, 2003). In this sense, they represent an "environmentalism of the poor" (Martínez-Alier, 2002).

Scholars have increasingly focused on the role of participatory methods for policy-making as a way to solve or manage these conflicts (e.g. Keeley and Scoones, 1999; Warner, 2006; Wittmer et al., 2006) and to promote sustainable resource management (e.g. Antunes *et al*., 2009; Jollands and Harmsworth, 2007). This potential relies on the ability of such processes to recognize multiple perspectives about reality and be an alternative to traditional decision-making by 'experts' and monetary valuation (ibid). Participatory processes are based on the idea of deliberation, through which actors can achieve mutual understanding, consensus, or compromise. These approaches contrast with previous "top-down" approaches, where the 'rational experts' make decisions, alienating local ('ignorant') peoples and their experiences (Agrawal and Gibson, 2001; Chambers, 1997; Fraser *et al*., 2006; Marshall, 2005). Yet within the last decade, research has highlighted the problematic and complex nature of the participatory paradigm (Cooke and Kothari, 2001; Hickey and Mohan, 2004; Holmes and Scoones, 2000; Smith, 2008). Most of the criticism has focused on the failure of participatory processes to generate real social change because of their inability to deal with issues of "power and politics" (Hickey and Mohan, 2005). These criticisms parallel those made by social justice activists (see Young, 2001). In addition, there are gaps in understanding how the participatory model fits into each particular context.

In this chapter, the 'soy conflicts' in Paraguay and Argentina are analyzed, focusing on two parallel yet contradictory participatory processes that have emerged to deal with these conflicts. On one hand is a top-down process, originated by large agri-business multinationals and international conservation NGOs; on the other is a bottom-up process, organized by peasant organizations and social movements. Both processes present opposing models of agriculture and sustainability. In the next section, a conceptual framework that contrasts both processes is developed. The third section briefly presents the methodology and study areas. The case study of the participatory processes related to the soy conflicts in Paraguay and Argentina is presented in section four, focusing on how specific characteristics of both processes relate to different outcomes in their policy proposals. Finally, section five develops several major points for discussion and the conclusions.

3.2. Top-down and bottom-up participatory processes: A conceptual framework.

3.2.1. Who organizes the process?

Despite their origins as a critique of top-down policy-making, many participatory processes still remain expert-driven and undemocratic (Cooke and Kothari, 2001). In many cases, the process is initiated by the government. In many others, such as our case, it is corporations (as part of their 'corporate responsibility' strategies) and Non-Governmental Organizations (NGOs) who lead the process. It is the initiating actors who select the form and function of the process, the stakeholders, and those who will represent them. The final decision often rest on the initiators, and the process is seen as advisory, not binding. This can be called a top-down model.

As Holmes and Scoones (2000) note, questions of *who convenes the process and who frames the questions* are crucial. Top-down processes facilitate the selective inclusion of stakeholders, the pre-definition of issues to fit the organizers' objectives and to exclude thorny issues, and overall the maintenance of the status quo. For corporations, these processes can be a legitimizing mechanism of their pre-defined plans or a form of "accommodation" – implementing cosmetic changes to prevent more significant ones (Hamann and Acutt, 2003), i.e. "greenwashing" (GRAIN, 2006). In fact, proponents of large-scale development projects often use participatory processes as a "promotional (selling) approach" to build support for their project, reinforced by the common reluctance from initiators to cede control of the process (Warner, 2006).

Recent work has pointed to the limitations of government-initiated participatory processes in natural resource management in developing countries (Agrawal and Chhatre, 2007; Gelcich *et al.*, 2006; Nayak and Berkes, 2008).They are less effective because decisions are skewed toward State interests; the processes are "more formal, hierarchical and formulaic"than self-organized community processes, reducing feedback between resources and resource users; and because of a long history of antagonism and covert resistance to government initiatives (Agrawal and Chhatre, 2007). In addition, participation is higher and more enduring when processes are initiated from the bottom-up (ibid; Jollands and Harmsworth, 2007).

Still, rather than discarding the participatory model altogether, develop an alternative one of processes self-organized by communities and peasant movements, and revolving around a combination of grassroots meetings and mobilization, with the goals of empowerment (changing power relations) and achieving structural change is sought. This “bottom-up” model draws on the work of Ostrom (1990) and others (e.g. Long’s (2001) “actor-oriented” approach) who have shown the possibilities and successes of self-organized, grassroots collective action; and on development scholars’ calls to relocate participation within the radical tradition of politics and development, placing emphasis on reducing existing inequalities and empowering disadvantaged/marginalized groups (Edmunds and Wollenberg, 2001; Hickey and Mohan, 2005). In the remainder of this section, we relate the issue of who originates the process of participation to considerations of who participates, what counts as participation, and how power is distributed. Figure 27 represents the stakeholders involved in both participatory processes at different scales (global, national, regional, local) in the context of agriculture expansion pressures by the international market.

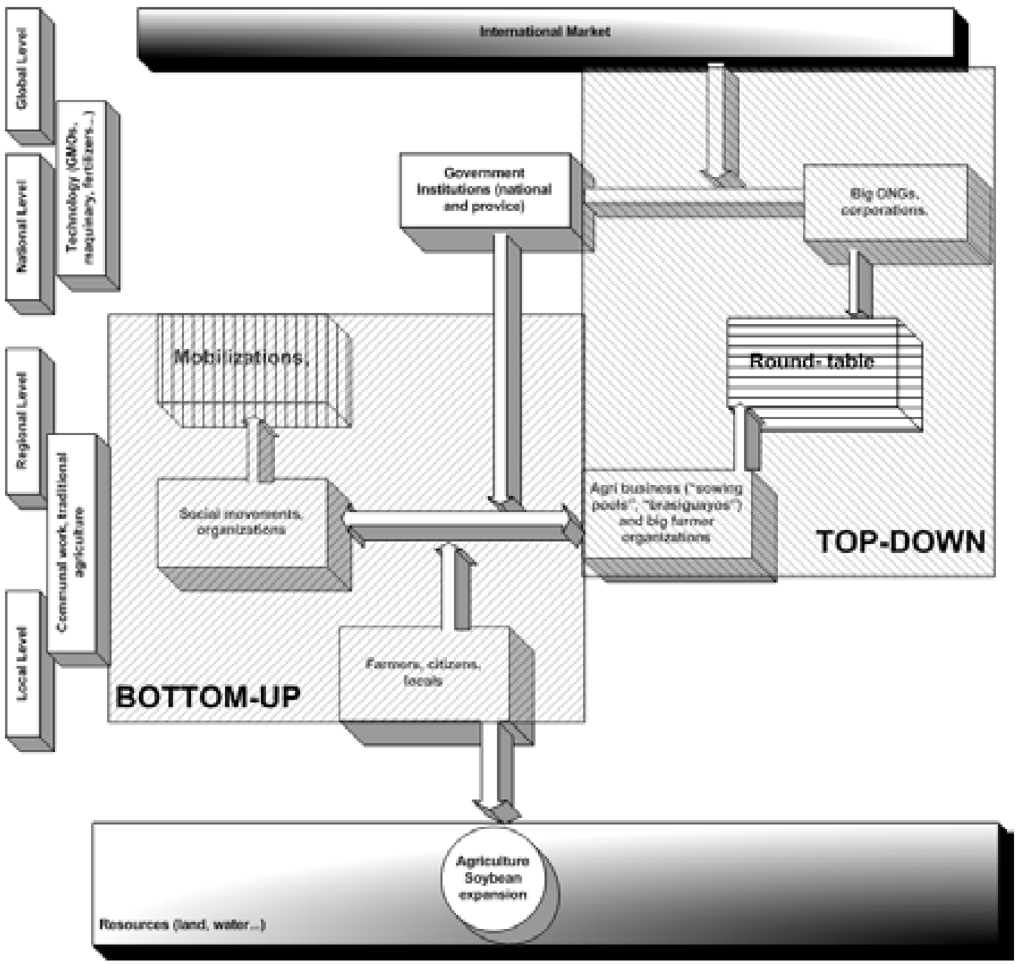

Figure 27 Model of bottom-up and top-down participatory processes.

3.2.2. Who participates? Citizens, NGOs, and social movements

Participatory processes have to be *inclusive and representative*–effectively involving multiple stakeholders, particularly those previously excluded– and they have to expand forms of participation and agendas (Holmes and Scoones, 2000). Yet while there are different approaches to 'representation' of diverse interests, and the selection of stakeholders is one of the most contentious parts of participatory processes, the question of *who is included and who is excluded* often remains unclear and less discussed . Since different actors bring particular interests to the table, who gets to participate has undeniable effects on the results of the process.

Top-down models of participation face difficulties with these questions, particularly in contexts of undemocratic rule, clientelism, corruption, and pro-agribusiness policies, as in much of Latin America[10]. First, they can easily become mechanisms of co-optation, recentralization of state power, and local elite capture, as government-initiated decentralization programs have shown (e.g. Agrawal and Chhatre, 2007; Larson and Ribot, 2007; Nayak and Berkes, 2008; Ribot *et al*., 2006). Second, there might be a "*tyranny of the group*", where the participating groups reinforce the interests of the most powerful (Cooke and Kothari, 2001). Third, there may be deliberate exclusion of certain actors which are not recognized as 'stakeholders', are difficult to identify, or simply not wanted in the process. Peasants are particularly prone to exclusion, given their geographical dispersion and dynamic and heterogeneous nature. Moreover, many of them, particularly indigenous peasants, often don't possess citizenship rights, so the state grants these rights strategically to maintain power relations (Johnson and Forsyth, 2002; Li, 2002). Grassroots social movements –which are crucial stakeholders in most ecological distribution conflicts– are also often excluded from top-down participatory processes, especially when they adopt a contestational stance against the government and when they advocate proposals that are 'too radical' for existing structures of power. Fourth, there is self-

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[10] These problems are not exclusive of top-down participatory processes, but we argue that they are exacerbated in comparison to bottom-up processes.

exclusion when groups see the process as controlled by certain groups and as a tool to legitimize certain decisions, or (for marginalized groups) because of high opportunity costs or lack of information (Warner, 2006).

NGO participation in theses processes has been frequent but controversial. In the 1990s development NGOs were praised as ‘democratizers of development’, vehicles for popular participation, and advocates for the poor (Bebbington, 2005). However, they have attracted growing criticism for being unrepresentative of and unaccountable to the poor people for whose well-being they claim to work, and for their inability to transform existing social structures (Hickey and Mohan, 2005; Mitlin *et al.*, 2007). NGOs have increasingly tended to represent rural development issues in ways that depoliticize them, paying more attention to market access than to inequality, redistribution, organization, and political participation (Bebbington, 2005; Mitlin *et al.*, 2007). Meanwhile, major international conservationist organizations (e.g. World Wildlife Fund (WWF)) have been increasingly subject to criticism for their alliances with and financial dependence on highly-polluting multinational corporations (e.g. Exxon, Monsanto) and their failures to meaningfully include local communities in decision-making (Chapin, 2004; Wilshusen, 2002). In fact, these organizations often view peasant practices as the problem, portraying them as inefficient and resource-degrading.

In contrast, bottom-up participatory processes are, by definition, organized by peasants, the actors directly using the land, and their organizations and movements. These processes are often based on horizontality –usually as an explicit response to the perceived hierarchical and undemocratic nature of government policy-making–and on the expressed inclusion, self-organization, and empowerment of traditionally marginalized actors, what Hickey and Mohan (2005) call “transformative participation”. This makes it ‘easier’ to organize and mobilize those previously-invisible stakeholders into a participatory process. Moreover, peasant organizations can serve as spaces to identify common needs/interests that can be presented as a collective position when engaging other stakeholders (Campos, 2000). Finally, by having their own participatory process, social movements are less prone to the problem of cooptation (Forbes and

Jermier, 2002). All of these qualities are not automatically present in all bottom-up participatory processes, but the literature cited shows that they are more likely to have them.

3.2.3. What counts as participation? Participation and mobilization

Long (2001) argues that participation consists of any strategies used by social actors to alter their situation; in other words, it is political action and takes place within and outside of institutionalized settings. From this perspective, mobilization, considered as a political act, is a form of grassroots participation. Mobilization is crucial because it gives marginalized actors a voice that is often omitted from top-down processes; it serves as a space of information-sharing, networking, and capacity-building – crucial for successful participation. In addition, in the context of highly unequal power relations, it can alter these relations and open new spaces of participation through the pressures put on governments or other powerful actors (e.g. Wampler and Avritzer, 2004; Warner, 2006), as will be evident from our case study.

Another issue is whether mobilization is a form of deliberative participation. Most deliberative democracy scholars argue that it is not, and that it is actually counterproductive to deliberation. Yet there is increasing theoretical and empirical suggestions that grassroots mobilization can include deliberation, often 'at the margins of mainstream processes', including multi-stakeholder platforms, face-to-face conversations, and/or deliberative forums and assemblies (Young, 2001; Warner, 2006; West and Gastill, 2004). Our case study tends to confirm these views.

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3.2.4. Power dynamics in participation: Equal playing field but unequal actors

Participatory processes are inevitably intertwined with, but often mask, power relations which substantially hinder their success and often lead to the disempowerment of certain groups, particularly the poorest, as the process is co-opted by the more powerful stakeholders (Cooke and Kothari, 2001; Edmunds and Wollenberg, 2001; Hickey and Mohan, 2005; Holmes and Scoones, 2000). Much of the literature has dealt with achieving consensus, but not on how to deal with dissent and conflict, where power plays a crucial role. Yet power relations affect all aspects of participation (Gaventa, 1980; Lukes, 2005). First, both the ability to participate and to influence the outcome, can be hindered by unequal power relations. Second, agendas can be manipulated to exclude key issues –particularly structural ones[11]. As exemplified in the case study, one key reason why social movements often reject offers by the government, multinationals or mainstream NGOs to participate in 'Forums' for 'negotiation' is precisely because the issues these movements want to bring to the table are not recognized as important or rejected as too radical. Third, the preferences of marginalized actors can be manipulated through information control, socialization, and psychological adaptations, bringing a sense of powerlessness to them. The process will appear deliberational or consensual, but it is 'manufactured consent' (Gaventa, 1980) – what Cooke and Kothari (2001) called the *tyranny of decision-making and control*.

Bottom-up participatory processes have a greater potential of shifting power imbalances and empowering marginalized actors. Given that marginalized actors initially control the process, they reduce some of the problems related to powerful actors' excessive influence on participants, agendas, preferences, and decisions. In addition, as recent work in decentralization has emphasized, grassroots mobilization is often crucial to restructure power dynamics, diminish the power of local and national elites, and ignite or enhance the process of democratic decentralization and participation (Agrawal and Ostrom, 2001; Cronkleton *et al*., 2008; Fox, 1996; Larson, 2005). Top-down processes, in contrast, have much more limited capacity in this respect because, by definition, they are organized by actors in positions of power, and because, as discussed above, they often have as their main motivation –and their main effect- the <u>increase</u> in state and/or corporate power. However, the potential for cooptation of

[11] This parallels the idea of the "procedural power" to determine what "language of valuation" is used in a given environmental conflict (Martínez-Alier, 2002).

bottom-up processes is always there, and the empowerment of marginalized actors largely depends on whether grassroots movements can maintain their autonomy.

3.3. Case study

In Latin America, several factors are relevant. The first is the national importance of agriculture as an economic and subsistence activity. Eighty (80%) percent of farmers in the region are concentrated in rural areas and play a crucial role in guaranteeing food security; the vast majority are peasant smallholders inhabiting degraded lands (MAG, 2002). Secondly, there is a highly unequal distribution of land ownership and income, and very insecure land tenure in rural areas. Paraguay is the country with the greatest concentration of land ownership in Latin American: 77% of arable land is owned by 1% of the population. Small farmers, who represent 40% of the population, own just 5% of all farmland. In Argentina, 70% of soy production is controlled by 3% of the producers (Buzzi, 2005). Thirdly, there is a historical tradition of undemocratic governments which have suppressed peasant movements through violence or clientelism (Petras and Veltmeyer, 2005), recently coupled with the capture of the state by agri-business corporations. The fourth is the current position of Latin American countries in the global economy as exporters of cheap natural resources and agricultural products for the developed countries (Muradian and Martinez-Alier, 2001), which translates into the promotion of capital-intensive, large-scale, industrialized agriculture for export (Pengue, 2009).

In order to better understand bottom-up participation linked to the conflict of soy expansion, with archival research focused on the expansion's impacts was begun, the ensuing conflict, and the different participatory processes that have emerged to deal with the problem. Fieldwork was then carried out between October 2008 and March 2009 in two regions, Northern Argentina and Eastern Paraguay (using participant observation and interviews.

In Northern Argentina, the departments of Pilcomayo, Pilaga and Pirane were visited, focusing on the conflicts in the villages of Tacaaglé, La Primavera and Lomas Senes. In-depth interviews were carried out with farmers, peasant leaders and representatives of governmental and non-governmental institutions.

The former included the National Institute of Farming Technology, (INTA for its Spanish acronym) in Laguna Blanca, the Farming Validation Center (CEDEVA), the Institute for Family Agriculture (IPAF), the Social Farming Program (ex-PSA), the Economy Ministry, the General Directorate of Cadastres, the Institute of Lands and Colonization (ICAA), and the Institute of Aboriginal Communities (ICA). Non-governmental institutions included NGOs (Amanecer, CARITAS), peasant movements of Formosa (MOCAFOR), indigenous communities (Tobas), and sowing pools. In Eastern Paraguay, participant observation was performed on the activities of the NGO La Soja Mata (Soy Kills), and of social mobilizations in Tecojoja, Alto Paraná and Asunción, with a particular focus on the leadership of peasant organizations. Interviews were carried out with the National Peasant Federation (FNC), Agrarian and Popular Movement (MAP), the National Peasant Organization (ONAC), the Peasant Association for Integrated Development (ACADEI), the Organization for Land Struggle (OLT), Vía Campesina (the Peasants' Way), the National Indigenous Peasant Central (CENOCIP), the Association of Farmers of Alto Paraná (ASAGRAPA), and members of the Paraguayan Human Rights Comission (CODEHUPY).

3.4. Current participatory processes for addressing the soy conflicts

3.4.1. Top-down processes: Forums for Sustainable/Responsible Soy

In 2004, a group of "concerned" producers, NGO's and companies initiated a series of multi-stakeholder forums, initially labeled the "Roundtable on Sustainable Soy"[12]. In March 2005, the Roundtable held its first meeting in Foz do Iguaçu, Brazil. Yet within a few months, giving in to popular pressure, the process's name was changed to the "Roundtable on Responsible Soy" (RTRS),

[12] This approach has parallels in the palm oil, cocoa, and sugar industries. WWF and Unilever have been major players in promoting sustainable palm oil plantations, another highly controversial project (GRAIN, 2006)

suggesting the idea of corporate social responsibility. A second conference was held in 2006 in Paraguay. Three more followed; the fifth will be held this year.

The Roundtable defines itself as "the global platform composed of the main soy value chain stakeholders with the common objective of promoting responsible soy production through collaboration and dialogue among the involved sectors in order to foster a economical, social and environmental sustainability."[13] Its membership includes three sets of stakeholders from Brazil, Argentina, Paraguay, and India: (1) *the producers*, dominated by large agri-business companies such as Brazil's Andrés Maggi Group, Paraguay's DAP Group, and Argentina's Los Grobo Group; (2) *industry, finance and trade organizations*,including agri-business giants ADM, Cargill, and Bunge (which control the majority of international soy trade), along with Nestlé, Unilever, the Swiss supermarket COOP, Carrefour, and Shell; and (3) NGOs, led by conservationist organizations such as WWF, the Moises Bretoni Foundation, and Guyra Paraguay, and a Dutch development NGO, Solidaridad. In total, there are 69 members from the corporate sector and only 19 members of the NGO sector (CEO, 2009). Neither small farmers nor indigenous groups have representation, and there is no explanation of why the membership in the process is closed and who selects members. Other interested stakeholders such as government and research organizations can participate as observers without voting rights. Table 4 presents an expanded list of actors and their objectives[14]. Three stakeholders have left the process because they considered it non-representative and illegitimate: the Federation of Workers in Family Farming of Southern Brazil (FETRAF-SUL), the Association of Soy Producers of Mato Grosso (APROSOJA) and the Foundation for Development with Justice and Peace (FUNDAPAZ). The first two continue to support soy expansion but outside the process.

Table 4 Stakeholder in the top-down participatory process

[13] See http://www.responsiblesoy.org/index.php?lang=en.

[14] The full list of members can be found at http://www.responsiblesoy.org/

Stakeholders		Country	Issue	Observation
Civil Society/ NGOs	WWF	United Kingdom/ International	El	Conservationists
	Conservation International	United States/ International		
	The Nature Conservancy	UK/ International		
	Guyra Paraguay	Paraguay		
	Moises Bretoni Foundation	Paraguay		
	Fundación Vida Silvestre	Argentina		
	BIOESTE Institute	Brazil		
	Aliansa da Terra	Brazil	El/En	Focused on improving land stewardship in agricultural frontiers in the Amazon
	ETHOS Institute	Brazil	En/Sc	Does analysis and implementation of corporate social responsibility strategies
	Solidaridad	Netherlands	En/Sc	Promotes sustainable value chains in agriculture, developed first Fair Trade label
Corporations	ADM	US/ International	En	Multinational agri-business corporations
	Bunge	Netherlands/ International		
	Cargill	US/ International		
	Unilever	Netherlands/ International	En	Multinational edible products corporations
	Nestlé	France/ International	En	
	COOP	Switzerland	En	Swiss supermarket chain
	Carrefour	France/ International	En	International hypermarket chain
	BP	UK/ International	En	Multinational energy corporation engaged primarily in oil and gas.
	Shell	UK/ International	En	Global group of energy and petrochemicals companies
	EXXON	US/	En	Multi-national energy corporation

		International		
	Monsanto	US/ International	En	Multinational biotechnology corporation
Producer Organizations	Andrés Maggi Group	Brazil	En	Large agro-industrialconglomerates involved in the soybean industry.
	DAP Group	Paraguay		
	Lucci Group	Argentina		
	Los Grobo Group	Argentina		
	Aapresid	Argentina & Paraguay	En	Promotes direct-planting techniques for soy. Members include Dupont, Syngenta, and Monsanto, and multinational banks.
	APDC	Brazil	En/Sc	Promotes direct-planting
	COAMO	Brazil	En/Sc	Agro-industrial cooperative

Sc=Social El= Ecological Ec= Economical

An Executive Board makes the main decisions, with the mandate of the General Assembly and the representation of the different sectors. The current Board has representation from Solidaridad and WWF-Brazil (Presidency and Vice-Presidency, respectively); two agro-corporations, (DAP and Brazil's SLC Agricola (Vice-Presidency and Executive Committee), and a multinational bank, Santander (Treasury). The decisions of the Roundtable are not binding for the government, but different agencies have used them as guides for their regulations, particularly in Argentina. The main objective of the process has been to establish a certification scheme for 'responsible'/'sustainable' soy based on a series of "principles and criteria", modeled after those in certification of sustainable forestry. There are five principles: "environmental responsibility", "good agricultural practice", "responsible community relations, "responsible labor conditions", and "legal compliance and good business practice" (see RTRS, 2009). Criteria include employees' rights, land rights, respect for small-scale and traditional land use, well-being of local population, protection of biodiversity and environmental impact mitigation, maintenance of water quality and quantity, maintenance and improvement of soil quality, and the elimination of certain banned agro-chemicals. Although voluntary, the corporations in the Roundtable have pledged to purchase only certified soy. At the 4th RTRS Conference in Brazil in 2009, the stakeholders defended these “principles and criteria”, arguing that they were the best strategy to change the negative impacts of soy expansion, while the DAP Group began a field test in San Pedro, Paraguay under this scheme (CEO, 2009). The Conference also introduced the idea of giving “carbon credits” to those applying responsible soy practices (WWF, 2009).

The Roundtable is related to other initiatives with similar objectives. One is a ‘responsible sourcing’ demonstration project in the Santarem region led by Cargill and Nature Conservancy, broadly rejected by the Brazilian Forum of NGOs and social movements during the March 2006 COP8 meeting of the Convention on Biological Diversity in Curitiba, Brazil (GRAIN, 2006). The other is the “Articulação Soja-Brasil” (Soybean Web-Brazil), where the debate on a certification scheme was more grassroots and had representation from most of the communities affected by soy expansion (Steward, 2007); Finally, while government institutions are not directly involved in the RTRS, that at the regional level government institutions such as the Provincial Government in Formosa, Argentina, are organizing supposedly ‘participatory’ processes in which government agents promote soy expansion for small farmers was found. Research institutions have also been playing an important role in convincing small farmers to rent their land or to directly plant soy (offering GMO seeds, machinery and/or financial subsidies). The representatives of the *sowing pools*[15] had a privileged role, making agreements with agencies at the Provincial level (e.g. ICAA) to obtain private cadastral information about farmland and purchase ‘public’ lands which have no legal owner but which have been historically inhabited by peasant or indigenous communities was also found. Religious institutions are also important stakeholders at this level,through their own NGOs (e.g. CARITAS) or movements with community-level representation. Some support soy corporations

[15] Sowing pools are investment companies which bring together landowners, contractor and technicians for soybean production, and which favor capital concentration in the hands of large contractors that lease the land from small and medium landholders (Binimelis et al., 2009). Much of the production in Argentina occurs under the auspices of these organizations (Buzzi, 2005).

and farmers' market integration, while others support grassroots social justice and human rights.

3.4.2. Bottom-up participatory processes: The peasants' counter-gatherings

Top-down initiatives have been met with widespread criticism from civil-society and peasant organizations –including most Paraguayan NGOs and urban and rural social movements– which have either been excluded from the process or have refused to participate. As a response, they have organized a series of counter-meetings to develop alternative proposals regarding soy expansion. The first was held in 2005under the slogan "No Sustainable Soy". For the Roundtable's 2006 conference in Paraguay, Vía Campesina-Paraguay organized a protest (Vía Campesina, 2008). Table 3.2 presents an expanded list of actors and their objectives.

Table 3.2 Stakeholder in the bottom-up participatory process

Stakeholders		Country	Issue	Observation
Peasants Movements/ Organizations	ACADEI	Paraguay	Sc/El/En	Peasant organization
	MOCASE	Argentina	Sc/El	Struggles for land tenure and to improve agricultural policies
	MST	Brazil	Sc/El/En	Peasant social movement focused on agrarian reform
	CENOCIP	Paraguay	Sc/El	Peasant and indigenous organization
	MOCAFOR	Argentina	Sc/El/En	Peasant movement in Northeast Formosa
	ONAC	Paraguay	Sc/En	National organization
	OLT	Paraguay	Sc/El/En	Carries out land occupations
	CPI, CAPI	Paraguay	Sc/En	Indigenous organizations
	MAP	Paraguay	Sc/El	Rural organization
	MCNOC	Paraguay	Sc/El	Coalition of peasant organizations
	CONAMURI	Paraguay	Sc/El/En	Develops and promotes policies and strategies for sustainable development for the most vulnerable social sectors in rural areas

	Vía Campesina	Belgium/ International	Sc/El/En	International peasant movement promoting food sovereignty
NGOs	Soy Kills	Paraguay	Sc/El	Provides information about the human and environmental impacts of large-scale soy monocultures
	GRR	Argentina	Sc/El	Affinity group and space for dialogue on the impacts of global capitalism on rural areas
	CEO	Belgium	Sc	Research/watch dog group on corporations and their lobby groups in EU policy-making
	GRAIN	Spain/ International	Sc/El	Supports peasant movements in struggles for community-controlled, biodiversity-based food systems
Locals	Communal assemblies	Argentina & Paraguay	En/Sc/El	Concerned with displacements and health impacts of soy expansion/fumigation

Sc=social El= Ecological Ec= Economical

The movement claims to be the "genuine representatives of the small producer peasant sector in Argentina." (FNC, in enREDando, 2008), and position themselves in direct contraposition to the top-down participatory processes. The Rural Reflection Group (GRR), for instance, argues that rather than negotiating with agri-business companies about certification and natural resource management, NGOs should defend peasant and indigenous struggles for their lands. Fieldwork observations highlight that community assemblies form the basis of this grassroots deliberative process. There, peasants deliberate on the soy conflicts, decide on the next actions to take, and appoint representatives to discussions with other organizations and to the counter-gatherings.

These groups have set out to challenge the supposed sustainability/responsibility of soy production. From their perspective, the Roundtable is an attempt to "greenwash" industrial agribusiness and legitimize the existing environmentally and socially destructive practices of soy expansion (CEO, 2009; Holland *et al.*, 2008). Also, they argue that soy is not part of the region's culture or nutrition, but rather a commodity to be exported to developed countries and to produce benefits to large landowners and related agri-businesses. It is, in their view, a violation of their economic, social, cultural and environmental rights (Holland *et al.*, 2008; Interviews). A statement from the NGOs at the first counter-event denounced "the false concept of sustainable soy monocrops, officially promoted... in the interests of the North and of agribusiness, with the scandalous support of some large, supposedly environmentalist, national and international NGOs. Sustainability and monoculture are fundamentally irreconcilable, as are the interests of peasant societies and agribusiness." (GRAIN, 2006) Participants also denounced agribusiness for the commodification of life and land and governments for their failure to pursue agrarian reform. They pledged to "defend the cultures, territories and traditional economies of indigenous peoples and peasants, while building unity with the struggles of urban social movements."

Another central concern of this process has been the broader agrarian context. Rather than discussing how to produce soy sustainably, it proposes debating the issue of food sovereignty, which raises questions aboutwhat is to be planted in the first place, who owns the land, for whom is food produced, and who benefits from this process. These questions relate to the problems of highly unequal land ownership in Latin America (and thus to the issue of land reform) and of the export-based, industrial/agribusiness model of agriculture (Holland *et al*., 2008; Interviews; Steward, 2007). Participating organizations have also have called for government policies that protect natural, social, and cultural resources, strengthen regional economies (particularly through diversified small-scale and subsistence farming), establish seed banks, and develop local commercialization channels. These are obviously structural questions which the Roundtable has excluded from its agenda. Stakeholders in the process have also been explicit about their aim to change power relations through a "transformative struggle": "We are all together the indigenous peasants. Await, be truly afraid…They [agri-businesses] said they would go after the government, we come after them. After both of them, if necessary." (Strapazzón, in enREDando, 2008)

This process has achieved important victories in Paraguay. It was associated with the end of the Colorado Party's 61-year rule and the election of a leftist, pro-peasant President. In November 2008, a large mobilization of all the major organizations was held in Asuncion to demand that the President move forward with the promises of agrarian reform, limits on agro-toxic use, and increased support for small and medium farmers. Despite repression, the mobilization concluded with an opening of negotiations. In 2009, the government appointed peasant leaders to the agrarian reform agency, and recognized the importance of food sovereignty. In addition, it made important modifications to the Agro-Toxics Law to limit soy fumigations. However, pressure from the oppositional sectors (Congress, the military, agri-business corporations) have stalled or pushed back progress on some issues.For instance, in September 2009 a new law that favors the indiscriminate use of agrochemicals and reduces the 'protection border' for communities exposed to agro-toxics from 100mts to 50mts was approved by the Paraguayan Congress, and the President could not veto it.

Despite gains, grassroots participatory processes have faced limitations of their own. One issue relates to forms of organization. In Paraguay, the participatory processes and associated mobilizations have had strong representation of the majority of peasants and their organizations, as smallholders are very aware of the negative effects of soy expansion on them. Interviewees noted that this is largely due to the control of soy expansion by large *latifundios* (owned by so-called "*Brasiguayos*"), affecting most small farmers. Women, traditionally marginalized from these processes, have also had a strong presence, particularly in organizations such as the MAP. In addition, discussions involve all members and are not controlled by the leadership. In contrast, in Northern Argentina the national integration of small farmers is a recent phenomenon, and strong regional divisions remain. Farmers and peasant leaders pointed out that the dominant organizations (predominantly in the Pampa region) are based on mostly middle-class, small business entrepreneurs, which favor soy expansion. In fact, recently one of the main national farmer organizations, the Agrarian Federation, opposed the government's proposal to tax soy production to limit its expansion. Fieldwork observations also suggested that there are fewer peasant organizations and movements than in Paraguay –for instance the Northeast only has one organization (MOCAFOR)– and those that exist (mostly in the Chaco region) have taken an approach that somewhat excludes those not sharing its ideological stances. In addition, there are more profit opportunities for small farmers in Argentina because production is mostly done by sowing pools, which contrary to latifundios do not expel small farmers, but rather rent the land from them. Thus, small farmers are not very aware of the negative effects of soy expansion, or about the RTRS and the counter-gatherings. They are more interested in the economic convenience of switching to soy and the commercialization of their products.

Most organizations in both countries face the problem of insufficient resources, and in some there are internal conflicts regarding leadership strategies. Finally, indigenous peoples, who are crucial stakeholders, have not been well integrated into rural organizations or into the participatory processes, particularly in Argentina, where provincial government agencies (e.g. ICA) or NGOs (e.g. FUNDAPAZ) control their representation. The government refused to recognize the communities' legal aboriginal representatives and instead appointed local bosses as their spokespersons (Interviews). At the national level, the government's CPI (Council of Indigenous Participation) has not included these communities in their organization and thus they are not able to express their views.

3.5. Discussion

From the case study, several major issues surrounding the two alternative participatory processes can be identified. First, top-down models of participation have significant limitations that are context-dependent, which coincide with previous research and with criticism from social justice activists. In agrarian conflicts over highly incompatible goals in Latin America, the questions of who organizes, who participates, what counts as participation, and who has power are extremely important. Who organizes the process was in our study a crucial determinant of which actors were invited to participate, helping delineate the interests that would be represented and how issues would be defined. The literature on decentralization and community-based resource management offers evidence that suggests that this is not an isolated event. Often, when governments or other actors from the top (in this case, the agri-business sector and large conservation organizations) organize a process, many of its aspects are affected in ways that can reinforce patterns of marginalization, maintain the status quo, and increase the organizers' power. In our case, the top-down process showed a clear over-representation of industrial-scale producers, large multinational corporations, and conservationist (mostly international) NGOs, while excluding peasant and indigenous groups. The agri-business sector sought to safeguard its profits (i.e. soy expansion) while legitimizing their actions in the face of widespread criticism through a green certification; and conservation organizations showed their tendency to downplay social and cultural issues –and even some ecological ones (like the environmental impact of GMOs)– while negotiating or maintaining close ties with said sector. Argentina's Wildlife Foundation, for instance, has a long history of good relations with the landowning oligarchy and 'agri-business' (Glenza, 2005), while the Moisés Bretoni Foundation is heavily financed by the DAP Group. In contrast, the bottom-up counter-meetings included the participation of rural development organizations (e.g. GRR, Soy Kills) and peasant organizations, and focused on serving as spaces for critical discussion on soy expansion and catalyzing/empowering networks of these groups to counterbalance the power of big agri-business. This supports previous findings that had suggested social movements' crucial role in transformative participatory processes (e.g. Hickey and Mohan, 2005; Long, 2001).

Second, the highly unequal power relations_that characterize the soy conflicts not only helped exclude peasant actors but also smaller soy producer organizations (FETRAF-SUL and APROSOJA), who left the RTRS in view of the control exerted over it by the more powerful producers. More importantly, it power inequalities led to the exclusion of the most crucial, underlying issues in the soy conflict –namely, the concentration of land ownership and the sustainability of the capital-intensive, export driven agro-industrial model of soy production. Defining the issue as one of sustainable/responsible soy has been crucial for the agri-business industry and the conservation NGOs, because it assumes that large-scale soy monocrops can be_sustainable, despite strong evidence to the contrary from an ecological economics perspective (e.g. Pengue, 2005). The struggle to redefine the problem centers precisely on the argument that soy monocrops are inherently unsustainable/irresponsible, not only because of the environmental consequences, but also because of the social and economic ones. This confirms other scholars' claims that sustainability is a heavily contested concept (e.g. McManus, 1996). To paraphrase Martínez-Alier (2002), there is a conflict over the "language of valuation", which reflects underlying material conflicts, in this case over land and livelihoods, where the peasants represent an "environmentalism of the poor". In this context, it is needed to ask if it is possible or desirable to achieve consensus on this conflict, or whether, as Martinez-Alier suggests, the conflict take its course and side with those marginalized should be let. It is also needed to question whether including agribusiness corporations in a participatory process is beneficial for resolving these conflicts and promoting sustainability, in view of the fact that the objective of these corporations are incompatible with those of sustainability. The excessive involvement of NGOs is equally problematic because of the history of conflict between these organizations and peasant movements, and their often-cozy relationship with corporate donors. But, could we imagine a different participatory process where corporations agree with peasant organizations in not planting soy and promoting agrarian reform instead? Can peasants gain much from certified soy production, if profits are mostly at large scales, and if production and commercialization are already controlled by large corporations? Both seem unlikely, and hence the potential for achieving consensus appears dim.

A third and related point is that bottom-up participatory processes can address these power inequalities while pushing for structural changes that are left off the table in top-down processes. In the soy conflict, the bottom-up process has served as a space to challenge the hegemonic discourses and practices of 'sustainable soy' and agro-industrial agriculture in general, while creating an alternative model of agriculture based on food sovereignty and sustainability – including land redistribution, smallholder production for national consumption rather than export, and agro-ecological practices. This model takes as a starting point the peasants and the protection of their land and culture. It contests the dominant patterns of unequal resource use and the institutions and discourses that maintain those patterns, while defending livelihoods and a population's ability to control what it views as <u>its</u> resources (Bebbington *et al*., 2008). Because it is a model developed from 'outside' top-down processes and because it entails substantial mobilization/protest as part of the participatory process, it has the potential to ignite these changes. It suggests, as Hickey and Mohan (2005) have, that participatory processes are more likely to succeed when they form part of a wider radical political project that seeks structural changes, are focused on creating spaces of participation for marginalized actors, and understand development as a process of social change rather than a technocratic project. Still, one cannot assume that top-down processes will automatically be less empowering, and so we should rather look at the characteristics of each process and its outcomes.

Fourth, it is clear that bottom-up processes can include a wide range of participatory strategies with mobilizations often at the center, but also with direct actions such as burning or occupying soy fields, communal assemblies, and counter-gatherings parallel to top-down processes. These multiple tactics are intricately intertwined, are often outside of formal, mainstream participatory processes, and do not fit the usual dichotomies ('civil society vs. social movements', 'participation vs. mobilization'). An open question remains as to whether mobilization is a form of deliberative participation. For a tentative yes – and recent research supports our claim– while pointing out that more ethnographic research is needed to fully understand this relationship would be argued. However, as Smith (2004) argues, mobilization is a crucial part of deliberative democracy, because it serves to highlight the deficiencies of deliberative processes, and, it would be added, to activate collective action and open new channels of participation.

An open question is whether, both participatory processes to occur conjunctively are neede. The complexity and interdependence of resource management implies that neither process may be sufficient on its own (Kooiman, 2000). Moreover, both types of processes may be engineered to achieve changes at different times and scales. Bottom-up processes can promote structural yet long-term changes which not only improve outcomes but participatory processes themselves. It is clear that grassroots action/mobilization by peasant movements is what has achieved the most significant changes in Latin America, such as agrarian reform (Campos, 2000; Petras and Veltmeyer, 2005). Meanwhile, top-down processes may be more 'functional' and achieve relatively immediate yet marginal changes in outcomes, because by definition, they are usually better integrated into the official government decision-making process, and because oftentimes the initiators are more powerful actors. In our case, the Roundtable has already influenced policy-making in different agencies, and the certification process could bring about quick reductions in deforestation, soil erosion and water pollution. However, questions still remain about the supposed advantages of top-down processes. On one hand, as previous experience has shown, oftentimes even top-down participatory processes do not lead to any policy changes (Warner, 2006). On the other, it is needed to ask whether the impacts of soy expansion would be even worse if the big environmental NGOs had rejected participation in the Roundtable and instead sided with the peasant movements, or whether their participation helped consolidate soy expansion. Previous work found that rather than promoting more sustainable production methods, the Roundtable has led to further soy expansion and increased pesticide use, community conflicts, and deforestation (CEO, 2009). The Roundtable has thus legitimized soy expansion while failing to bring to the front more pressing issues of unequal land distribution and the democratic representation of peasants' interests in decision-making, the excessive power of agri-business, the imposition of the agro-industrial, export-based model of agriculture, and the genetic engineering of crops. This confirms research on businesses' adoption of environmental practices which concludes that what predominates is not real policy change but a "green ceremonial façade" (Forbes and Jermier, 2002). In addition, it is uncertain how many producers would actually join the certification scheme. If the experience of certified forestry is any indication, certification levels will be very low (only 8% of the world's forest area is certified). Lastly, given that almost 95% of soy in Argentina is genetically modified, certification would have to apply to GM soy (CEO, 2009).

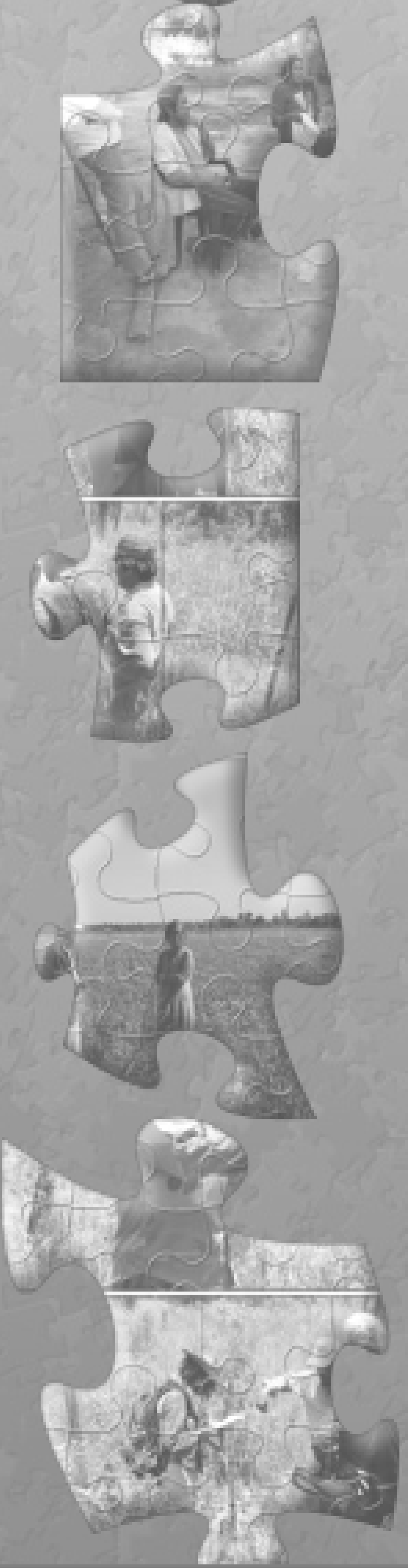
Regardless, it is important to highlight the relationship between both processes: top-down process can activate and solidify peasant networks and their bottom-up process. This was certainly the case here, where peasant organizations and movements came together precisely as a response to the RTRS. In this way, though the top-down process cannot bring a solution to the soy conflict on its own, it can help detonate one. In turn, the pressures exerted from below can improve top-down processes by, for instance, leading to the broadening of issues and actors and to the achievement of more just agreements. In our case, the bottom-up process pressured some organizations within the Roundtable – particularly Greenpeace– to change their stance and reject the concept of "sustainable soy", and to establish (along with WWF and TNC and major soy organizations ABIOVE and ANEC) a moratorium on soy sourcing from deforested Amazon sites. The remaining participants in the Roundtable responded with a new discursive strategy ("responsible soy") rather than a substantial change in direction, but the departure of FUNDAPAZ possibly also has to do with these pressures.

Fifth, contextual factors such as the histories of organization and participation, the political-economic context, and organizational strategies affect participatory processes. In our case, differences between Argentina and Paraguay have created different dynamics and possibilities of participation. The lack of national integration of Argentinean peasant organizations, combined with greater opportunities for profit in soy production for small farmers there, translates into less awareness of the problems of soy expansion and less peasant representation in the grassroots process.

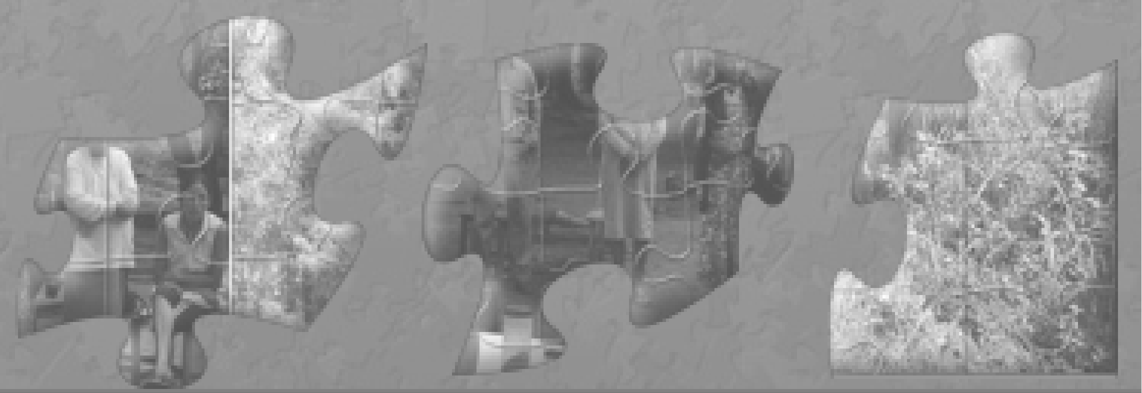
Finally, to emphasize that we cannot idealize the bottom-up participatory processes is needed. Citizen movements in Latin America have many limitations. These include scarce experience with participation (Smith, 2008); insufficient resources and insufficient inter-community coordination (e.g. Jollands and Harmsworth, 2008); inequalities within communities (e.g. Agrawal and Gibson, 2001; Li, 2002), and within and between social movements and peasant organizations; and market and globalization processes that intervene directly in the structures of rural organizations, leading to strategic readjustments that can weaken them (Mora, 2007; Taylor, 2001). Leaders of these organizations can also be co-opted by external agents or can be local elites or strongmen. Though it is not our case, research in other contexts also finds that peasant organizations against GM-based agro-industrial production may really be composed of relatively small coalitions of unrepresentative peasants allied with international activists and local intellectuals (e.g. Herring, 2006)[16]. Many of the other problems were observed in our case study. Insufficient resources was a constant among peasant organizations, though it was partly compensated by leaders' commitment. Inexperience with formal participatory processes is also a problem, reinforced in this context by authoritarian and clientelist rule and the lack of transparency and access to information by governments and corporations. And in both Argentina and Paraguay, the bottom-up process was marked by disagreements among different organizations and the exclusion of some key actors, particularly women and indigenous peoples. These exclusions, as Agarwal (2001) has emphasized, marginalize not only groups but also the issues they care about.

In conclusion, top-down participatory processes, which remain the most common, face severe limitations in contexts of ecological distribution conflicts with substantial power inequalities. Rather than solving such conflicts, these processes seem to 'hide' them while continuing and enhancing the status quo – in this case, soy expansion without agrarian reform. Thus, it is essential that bottom-up participatory processes be appreciated as empowering and as contributing to sustainability, at the same time that their own problematic elements and potential limitations are recognized. For the bottom-up approaches to mature as a theory and a practice, practitioners and academics alike must appreciate these general limitations and their contextual characteristics. More empirical studies are needed on how the participatory model performs when transposed into different geographical spaces, types of conflicts, and political projects.

[16] We thank Forrest Fleischman for pointing this reference out to us.



Chapter 4



Chapter 4[17]: Community scale. An analysis of the metabolic patterns of two rural communities affected by soy expansion in the North of Argentina

4.1. Introduction

Agriculture is a very important sector for Argentina, accounting for around 10% of GDP and approximately 60% of exports (CIA, 2009; FAO, 2010). In terms of employment, the agricultural sector only employs 1% of the working population directly, and around 37% indirectly (AAPRESID, 2008), showing a high level of capitalization compared to other countries in the region (Arizpe *et al.*, 2011). The sector has been undergoing major changes over the last decades related to the expansion of soy.

The model of the soy expansion currently present in Argentina and Brazil implies boosting consumption of different inputs such as machinery, oil, fertilizers and transgenic seeds (Pengue, 2005). Associated changes in land use imply impacts in socio-cultural lifestyles and biodiversity, and pose a threat to food and energy sovereignty (Altieri, 2009).

The area under soy cultivation in Argentina has increased from 6.9 million hectares (Mha) in the 1990s to 16.6 Mha in 2008 (Tomei and Upham, 2009). The land allocated to soy reached 18 million ha in 2009 (Goldsmith *et al*. 2004;

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[17] The chapter builds on the draft paper of the same title *Nancy Arizpe, Jesús Ramos-Martin and Mario Giampietro 2011* Characterization of the metabolic profile of two rural communities threatened by soy expansion in the North of Argentina (submitted to the International Journal Agriculture Ecosystem and Environment).

IADB-Garten Rothkopf 2007; Mathews and Goldsztein, 2009). This expansion of arable land has meant that since the introduction of genetically modified soy in 1996, the country has tripled soy production, with an average of 40 million tons of grain in 2008. This was also achieved by increasing yields, from 2,105 kg per hectare in 1996 to 2,826 kg in 2008 (Negri, 2008). Expansion of agricultural area for soy is increasing deforestation and habitat loss during the last century (MSyA and UNEP, 2004; Zak *et al*., 2008). Argentina and Brazil produce approximately 90 percent of world soy supplies (Mathews and Goldsztein, 2009).

The production of soybeans became completely transgenic in Argentina in 2008. This fast expansion in GM soy resulted in several (positive and negative) impacts such as increasing yields, reduction of farm jobs, increasing monetary flows associated with crop production, increasing pressure on traditional 'marginal' and non-colonized areas, forest clearings, biodiversity losses, carbon releases from both soil and biomass stocks, loss of traditional, mixed agricultural systems and a decline in agricultural diversity, among others (Qaim and Traxler, 2005; Morello and *et al*., 2006; Monti, 2008a; Monti 2008b; Zak *et al*., 2008; Tomei and Upham, 2009; Pengue, 2009b).

Recent agricultural expansion is largely driven by modern agribusiness companies oriented to the global market of grains (e.g. soybean). Agribusiness companies profit from economies of scale, administrate very large properties, and aim to put into production all profitable land in order to maximize revenue (Grau and Aide, 2008). The main producers are large-scale companies with multinational, corporate connections (e.g. Cargill, Bunge and Louis Dreyfus) joined by organizations with large financial and technological capabilities (sowing pools[18]). The expansion of this crop is supported by government inaction that assumes that large-scale soy mono-crops can be sustainable (Garcia and Arizpe, 2010). At the moment, however, there is no large-scale national policy or plan for

[18] Businessmen, farmers or agronomists, who set up a financial pool to capture resources for leasing fields, purchasing inputs and hiring third-party services to reduce costs, increasing production scale and reducing environmental and climatic risks in agricultural production (Pengue, 2009a)). They are investment companies which bring together landowners, contractors and technicians for soybean production and favor capital concentration in the hands of large contractors that lease the land from small and medium landholders (Binimelis et al., 2009).

guaranteeing the long term sustainability of agriculture within which the expansion of soy may be regulated. In this situation the markets is determining the direction of agricultural development pushing for intensification and export, which has increased the sector's vulnerability to fluctuations in external markets (Tomei and Upham, 2009).

At the regional scale, the main areas under transformation in the country are the Pampas and the Chaco region in the North of Argentina (Pengue, 2009a). Recent processes of rapid deforestation have been described in the Chaco forest in Bolivia, Paraguay and Argentina (Zak *et al*., 2004; Grau *et al*., 2005; Boletta *et al*., 2006; Gasparri and Grau, 2009). Waterway Paraná Paraguay promotes agricultural expansion due to irrigation potential and facilitates the expansion of the soy model to the north of the country (Pengue, 2009a). At the present time an agricultural pressure exists in the Chaco Region where our case studies are located. There is a high demand for new land for soy production that implies a major change in production systems. This change is characterized by technology to intensify production and the adoption of new economic, productive, financial and cultural models that are not characteristic of this region (Pengue, 2005). This expansion has led to a rise in the number of conflicts in the North of Argentina, mainly in poor communities, and due to limited access to land (EPRASOL, 2008). It has also contributed to deforestation, displacement of peasants and farmers, increased demands on water, soil degradation and pollution.

The aim of this article is to characterize and analyze the metabolic pattern – an integrated characterization of flows (monetary and biophysical flows) in term of intensity (per hour of human activity) and in terms of density (per hectare of land use) - of two rural communities, described at the local scale within the context of soy expansion to new areas in North Argentina. The quantitative information is obtained by applying the Multi Scale Integrated Analysis of Societal and Ecosystem Metabolism (MuSIASEM) framework. The resulting integrated characterization is used to individuate relevant changes experienced by the two communities because of the soy expansion, and to study the differences between the two communities due to their distinct responses.

The structure of the rest of the paper is as follows. Section 2 presents the data, methods and area of study. Then main results are shown in Section 3, which are discussed in Section 4. Section 5 offers some concluding remarks.

4.2. Study cases

The socio-economic, cultural, territorial and agricultural data come from the databases of the Ministry of Finance, Ministry of Agriculture, National Institute of Statistics, and the Province of Formosa. Existing maps were complemented with participatory mapping for the area under study. Due to the lack of information at the local level, questionnaires and in-depth interviews were used to complement the available data when needed. The software used to compile and analyse information was Excel 2003 for data organisation, SPSS for statistical analysis and ArcView 9.2 and Google Earth for GIS analysis. The numbers of questionnaires applied are 26 out of 71 households in Tacaaglé, and 43 out of 446 households in la Primavera. The questionnaires were completed in the presence of the interviewer. The in-depth interviews were the same number as questionnaires and lasted about 3 hour. Demographic data were collected distinguishing five age groups (<5; 6-11; 12-17; 18-65; >65) and gender (male / female).

The fieldwork had two principal goals: (i) Identification of the case studies, better definition of the sample, as well as identification of both the main conflicts and needs of the communities. (ii) Data gathering in relation to the different dimensions of analysis (economic activity, land use, time use, etc).

To fulfill these two goals an integrated set of research activities were carried out in the 6 months, in which the first author lived in the two communities. These activities can be described using different labels: a) action research (Bryman, 1989), b) participant observation (Rusell, 2000; Bryman, 1989), c) participatory mapping to identify the different land uses associated with the perceptions and narratives of the locals (NOAA, 2009; FIDA,2009), d) time use analysis, following families in their daily activities keeping records in diaries, e) in-depth interviews, semi-structured interviews (Bryan, 2008), and structured interviews (Bryan, 2008).

4.2.1. The multi-scale view of the metabolic pattern

By implementing the flow-fund model, within the MuSIASEM approach it becomes possible to develop a quantitative accounting of flows across different hierarchical levels and scales (Giampietro et al. 2000; Pastore et al. 2000; Gomiero and Giampietro, 2001; Giampietro, 2003; Giampietro et al. 2011). In particular, when dealing with the analysis of farming systems we can define "metabolic units" [autopoietic systems capable of reproducing themselves when operating in favourable boundary conditions – Giampietro et al. 2011] at different hierarchical levels: households, communities, municipalities. Figure 28 shows the multi-scale nature of the accounting associated with this analysis of metabolic pattern. In this paper we have chosen as focal level the community level – which is level n in the figure applied to our case study. The characteristics of the community are affected by upper level constraints (the characteristics of the municipality to which the community belongs – level n+1), and its behaviour is the result of the initiating conditions determined at the lower level. In particular, the characteristics of a community are determined by the household typologies (defined at the level n-2) and the profile of distribution of instances of these typologies within the community.

Because of this choice of focal hierarchical level, this paper focuses on the main differences in the pattern of land uses and the pattern of human activity, expressed at the community level, between the two communities analysed, La Primavera (*Potae Napocna Navogoh*) and Tacaagle. In a forthcoming paper we provide the same type of analysis carried out at the level of lower level components (i.e. households) of those communities.

Multi-scale and our focal level at the community level

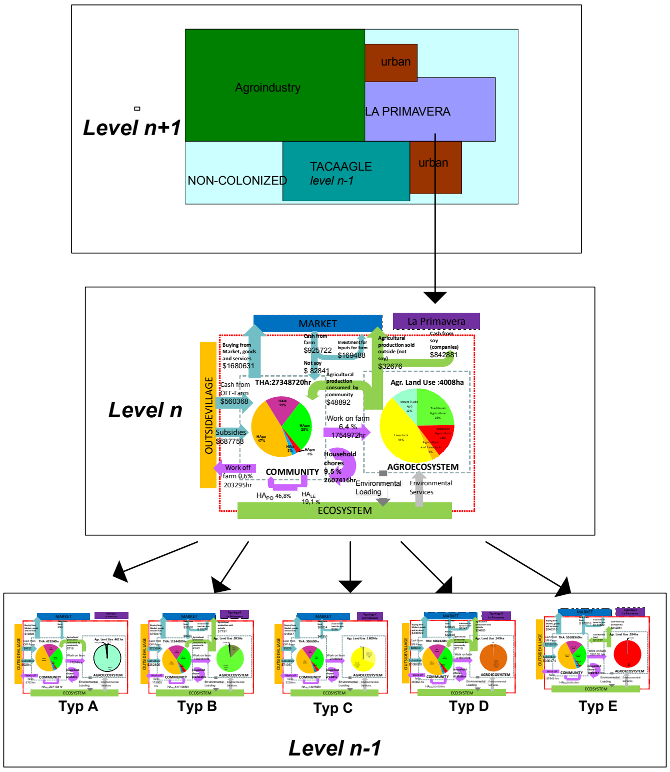


Figure 28 Multi-scale and our focal level at the community level

Source: own elaboration.

4.3. Results

In this section first the profile of allocation of the fund element land (budget of colonized land across different compartments) and the profile of allocation of the fund element human activity (budget of human activity across different compartments) of the two communities is presented. Then a comparison of the two communities based on an integrated analysis of flow/fund ratios is provided. The different land-time budgets found in the two communities are used to analyze the density (flows per hectare) and the intensity (flows per hour) of monetary and biophysical flows.

Population and land data based on the findings of our surveys are presented in Table 5. The difference in population density is very large, for example in Tacaaglé, where most of the inhabitants live in an urbanized setting, whereas in La Primavera the indigenous still consider land and resource management as a part of their life reflecting a deep cultural link with natural ecosystems.

Table 5 Characterization of the communities in terms of people and land.

Communities	No. Inhabitants	No. Household	Total Land (Ha)	Density (pop/100 Ha)
La Primavera	3,122	446	5,186	60
Tacaagle	284	71	5,576	5

Source: own elaboration. Household Survey, 2009

4.3.1. The pattern of land use at the community level

The characterization of the fund element "land use" in the two communities is carried out using three main categories: (i) colonized land – land under human control in which the density and intensity of biomass flows is determined by human agency (high external input agriculture); (ii) non-colonized land – land covers outside human control in which the density of biomass flows is determined by ecological processes; and (iii) semi-colonized land – land in which human activity does not alter the value of natural processes of production of biomass, based on natural recycling of nutrients (low external input agriculture). Still human agency prevents, in these categories of land use, the expression of the typology of land cover that would be expected in the area without human interference - e.g. use of natural pasture for seasonal feeding livestock. This category of land is characterized for having more biodiversity than colonized land. Non-colonized land also includes areas of rivers and lakes and the forest, even if used for hunting or gathering.

Table 6 Distribution of land use types

Type of LU	Tacaagle (Ha)	%	La primavera (Ha)	%
Colonized	3,961	71	1,722	33
Semi-colonized	1,599	29	1,715	33
Non-Colonized	16	0	1,749	34
Total LU	5,576	100	5,186	100

Source: own elaboration.

4.3.1.1. Characterizing Land use in Tacaaglé's community across hierarchical levels

The profile of distribution of land uses in Tacaaglé's community is shown in Fig. 5. This characterization is based on the selection of categories defined in Table 22. In this view a small amount of non-colonized land corresponding to the river *"Riacho porteño"* and the riparian vegetation can be individuates.

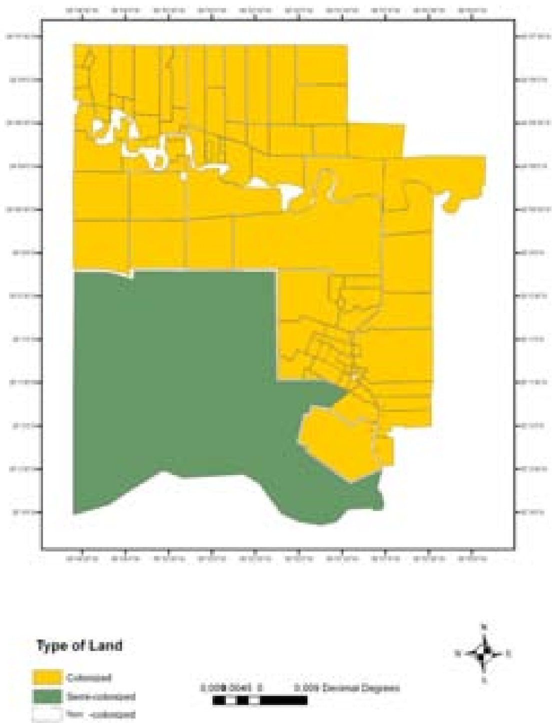


Figure 29 Distribution of land use in Tacaaglé's community

Source: own elaboration.

A more articulated analysis can be obtained by adding additional categories of land uses defined within the category of colonized land. Using the definition of colonized land given above, these categories according to the main activity performed there, either related to agriculture or livestock can be defined. The list of categories used for this more detailed analysis of the profile of land uses within colonized land is given in Figure 29.

A detailed information about the main crops and plots of land characterized using this taxonomy was obtained through ethno-cartography and cross-referencing with GPS. This information was merged with Google Earth images in order to define the extent of plots (locally called chacras[19]) with more precision.

Table 7 presents the dendrogram of land uses according to the different categories determined by the activities performed. It is started with the total available land (TAL), which is split into colonized land (COL) - the vast majority - and non-colonized land (NCL) – mainly riparian. Colonized land is then split into the main activities, agriculture (37 %), livestock (62%) and infrastructure (1%). The main category is clearly livestock, followed by the combined use for agriculture and livestock. It is already seen that soy is the main cultivar, higher than cotton (another cash crop) and horticulture and fruits (subsistence). The non-colonized land refers to the river (Riacho Porteño).

Table 7 Dendrogram of land use in Tacaaglé

[19] It is a rural area where agriculture and / or livestock is practiced, whether it is minor or major.

		Land Use Tacaagle	Ha		Type	Ha	Categories	Ha
		COL	5,560		Traditional Agriculture	673	cotton	285
							sweet potato	55
							horticulture, fruit trees	262
							maize	9
							maize, cotton	41
				LU_{agr}			maize, sweet potato	18
							pumpkin	3
					Industrial Agriculture	496	soy	496
					Agriculture and Livestock	874	cotton-livesock	209
TAL	5,576						maize-livestock	554
							soy-livestock	99
							pumpkin-livestock	12
				LU_{liv}	Livestock	3,508	pasture-livestock	1,599
							forest-livestock	1,909
				LU_{inf}	Infraestructures	8	roads	7
							dwellings	1
		NCL	16		Water bodies	16	rivers	16

Source: own elaboration.

The spatial distribution of actual land uses over the taxonomy of categories introduced in Table 3 is shown in Fig. 23. The map shows small-size producers[20] have a greater diversity of crops, and they also share plots[21] between households. The medium-size producers generally cultivated a particular crop depending on regional market demand. And finally the large-size producers are distributed in areas closer to the semi-colonized land. It is important to observe that both small and large-size producers use the semi-colonized land for extensive livestock. In general, this is private land where the owner leases access for grazing to livestock owners.

[20] The small producers have less than 10 hectares.

[21] Every defined area has in general one property that could be one extended family (meaning two or more households).

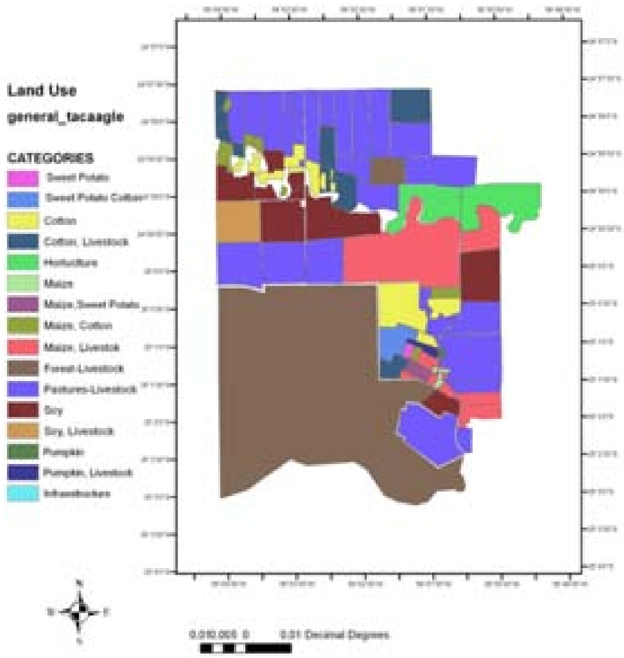


Figure 30 Map of the land uses in Tacaaglé's community

Source: own elaboration.

4.3.2.2. Characterizing Land use in La Primavera community across hierarchical levels

The profile of distribution of land uses in La Primavera community is shown in Fig. 24. This characterization is based on the selection of categories defined in Table 7. In this case, non-colonized land consists of a lake and forest land that is currently the focus of a dispute between the community and the Rio Pilcomayo National Park. The community land of Qom population was included in the National Park in 1951 and since the year 2000 they lost use rights to the lake for their livelihood.

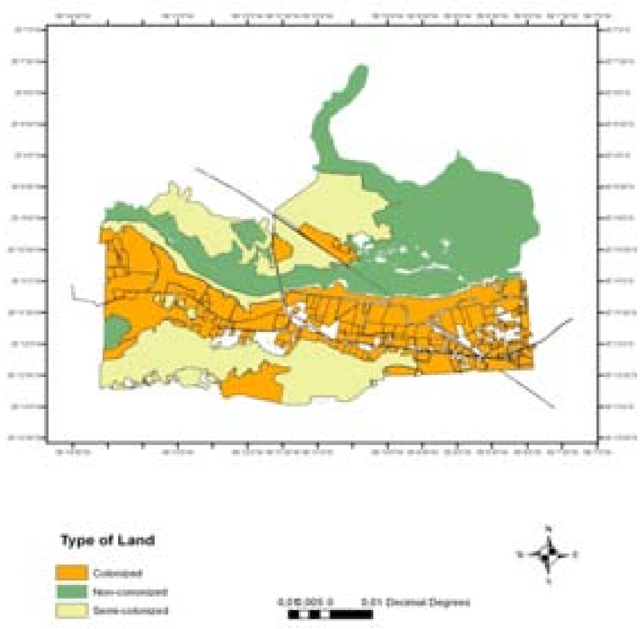


Figure 31 Distribution of land use in La Primavera“Potae Napocna” community

Source: own elaboration.

Although having 10% more population than Tacaaglé, La Primavera community has a higher proportion of non-colonized land (33.2%) due to the overlap with the national park. The community also has smaller plots of land related to their density.

The list of categories used for this more detailed analysis of the profile of categories of land use within the category colonized land is given in Figure 31.

The dendrogram of land uses according to the different activities performed within colonized land is shown in Table 8. The total non-colonized land (30%) consists of the lake, and other water bodies, as well as wetlands. Colonized land is then split into the main activities, agriculture (30%), livestock (31%) forest (8%) and infrastructure (3%). The main category is agricultural land and livestock, followed by forest. Soy is the main cultivar, higher than cotton and horticulture and fruits for subsistence is aready seen. Most of the cotton production has been displaced by soy.

The indigenous population does not use the land for industrial agriculture. They generally rent it to non-indigenous producers. However, they take care of crops and livestock.

Table 8 Dendrogram of land use in La Primavera“Potae Napocna”

		Land Use La primavera	Ha		Type	Ha	Categories	Ha
		COL	3,437		Agriculture	995	fruits	51
				LU_{agr}			cotton, maize	350
					Industrial Agriculture	594	soy	594
					Agriculture/livestock	149	cotton, maize, livestock	149
TAL	5,186			LU_{liv}	Livestock	1,809	pasture-livstock	556
							mountain-livestock	1,254
				LU_{infr}	Infraestructures	22	roads	19
							dwellings	4
				LU_{mount}	Forest	461	forest	461
		NLC	1,749		Water bodies	701	lakes	701
					Marsh	1,048	marsh	1,048

Source: own elaboration.

The spatial distribution of actual land uses (2008-2009) over the taxonomy of categories introduced in Table 8 is shown in Fig. 25. From this figure the spatial distribution of the land use is quite different from that found in Tacaaglé can be seen: there is less crop diversity (agriculture) and a major share of non-colonized land or semi colonized land – i.e. wetlands, lakes and forests. The forest land is important to obtain resources such as food (gathering and hunting), fuels (wood) and water. A large area (rapidly expanding) allocated to soy (10%) can be identified in the middle of the community.

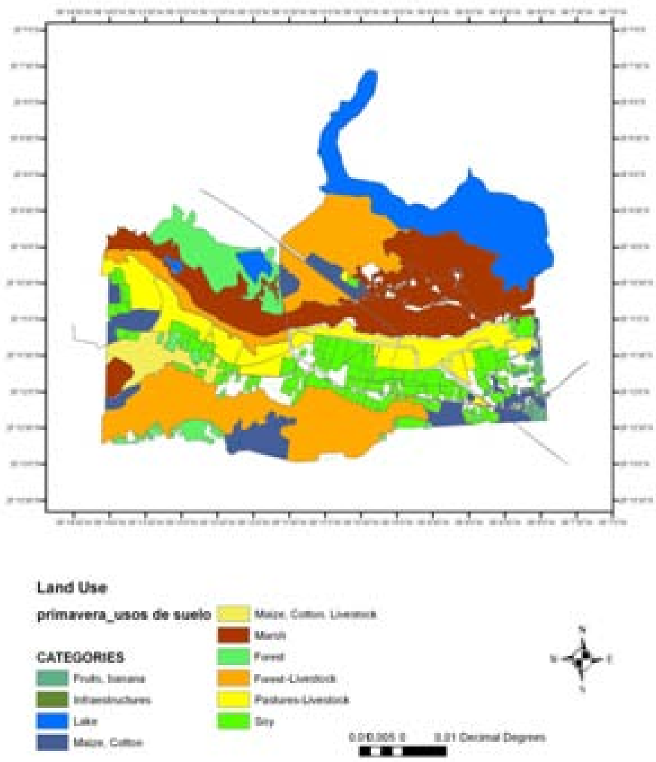


Figure 32 Map of the land uses in La Primavera "Potae Napocna" community.

Source: own elaboration.

4.3.3. The pattern of time use at the community level

The characterization of the fund element "human activity" in the two communities is carried out using the taxonomy of categories defined in section 2.3.3. In addition to this classification, the information obtained via interviews, at the household level, made it possible to distinguishing the different profile of human time allocation of men and women.

The data are illustrated in Fig. 26 for both communities. As expected, the largest fraction of human time is spent in Physiological Overhead (47%) – sleeping, eating, personal care of each individual during the day - followed by unpaid work time (30%). Within this category women not only have household maintenance activities, but also contribute to gathering forest products and other farm activities. With regard to leisure time, the assessment includes resting time (e.g. naps after lunch) and cultural activities (e.g. terere or mate)[22]. As shown in figure 33, the two communities generally spend little time in paid work (8%) mostly because they get food from their own chacras or government support. Very little time is spent for transport (3%) although it is important for rural societies such as these where people do not live in nuclear villages[23].

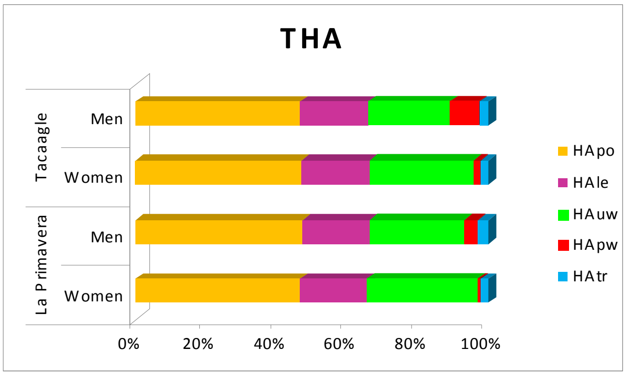
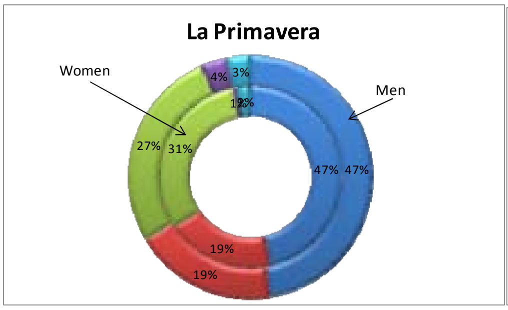
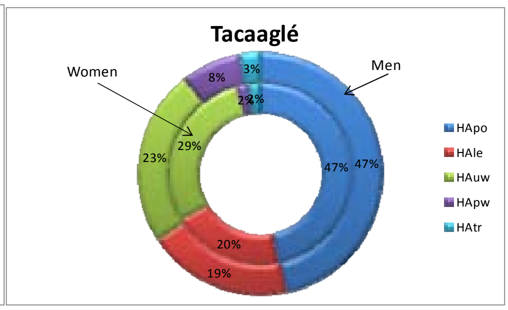


Figure 33 . Distribution of the THA by classification and gender.





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In Table 9 the different categories of human activities used to study time allocation (measured in hours/years) and their share (%) can be identified. From this comparison we can see that the amount of human time allocated to

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[22] It is a cultural drink.

[23] The distribution considers an urban area in the centre and the chacras around this area.

physiological overhead is almost the same, with a small difference in sleeping and eating between the two communities.

Table 9. A comparison of the profile of Time Use in the two communities

				La primavera		Tacaagle	
			Activities	Hr/year	%	Hr/year	%
THA	HA_{po}		Sleep	9,865,871	36.1	856,071	34.4
			Personal care	1,446,098	5.3	147,197	5.9
			Eat	1,488,607	5.4	159,932	6.4
				12,800,576	46.8	1,163,200	46.8
	HA_{uw}	Subsistence crops	Self-land (Chacra)	814,975	3.0	79,512	3.2
			Communal Land	481,151	1.8	10,238	0.4
			Others	14,417	0.1	0	0.0
				1,310,543	4.8	89,750	3.6
		Non-agriculture activities	Fishing	64,616	0.2	2,851	0.1
			Food gathering	74,038	0.3	2,851	0.1
			Small farm/tending animals	196,499	0.7	16,797	0.7
			livestock/tending animals	36,466	0.1	28,302	1.1
			Hunting	214,154	0.8	3,628	0.1
				585,772	2.1	54,429	2.2
		Home activities	care of children	2,213,812	8.1	207,550	8.3
			Preparing food	226,922	0.8	33,171	1.3
			Cleaning the house	102,091	0.4	15,852	0.6
			Construction	64,590	0.2	3,672	0.1
				2,607,416	9.5	260,245	10.5
		Others	Collecting firewood	399,698	1.5	12,279	0.5
			Collecting water	435,742	1.6	5,701	0.2
			Educational	1,582,708	5.8	179,120	7.2
			Health	304,058	1.1	22,298	0.9
			Communal gatherings	309,768	1.1	10,753	0.4
			buying/shopping	260,093	1.0	22,637	0.9
				3,292,066	12.0	252,788	10.2
				7,795,797	28.5	657,212	26.4
	HA_{pw}		handicraft	138,756	0.5	0	0.0
			Comercial agriculture	391,694	1.4	71,854	2.9
			livestock	52,735	0.2	41,395	1.7
			others	203,295	0.7	15,611	0.6
				786,480	2.9	128,860	5.2
	HA_{le}		Play	2,622,388	9.6	246,430	9.9
			Terere	784,321	2.9	72,562	2.9
			friend/familiar visiting	826,747	3.0	78,263	3.1
			Religious activities	985,693	3.6	81,709	3.3
				5,219,150	19.1	478,964	19.3
	HA_{tr}		buying/shopping	231,113	0.8	20,214	0.8
			Health	327,289	1.2	21,509	0.9
			School	76,918	0.3	8,552	0.3
			others	111,398	0.4	9,329	0.4
				746,718	2.7	59,605	2.4

Source: own elaboration.

Human activity in unpaid work includes hours dedicated to the following tasks: subsistence crops (4%); non agricultural activities (2%); household activities (10%)[24]; and other activities (11%). In terms of unpaid work, some activities such as hunting and gathering, and collection of firewood and water are more important in La Primavera community.

Human activity in the paid work category reveals interesting differences. La Primavera shows a lower proportion of time devoted to paid work, however commercial agriculture and handicrafts are the main sources of paid work there. In contrast, Tacaaglé doubles the amount of time allocated to commercial agriculture, more than doubles that in livestock and practices no handicrafts at all.

4.3.4. The land - time budget analysis (LTB): the integrated analysis of the two fund elements "land uses" and "human activities"

The LTB analysis integrates the previous analyses of time and land aggregating the information at a given hierarchical levels: either the land-time budget of a household (at the level n-1) or the land-time budget of the community (at the level n). The analysis of land-time budget can be integrated with an analysis of flows – e.g. monetary and food flows – providing useful information for sustainability analysis.

The two fund elements "land use" and "human activity" are essential for the reproduction and operation of rural systems. With the MuSIASEM approach it is possible to study the allocation of these two elements in autopoietic units (households, communities, municipalities, countrie) across different hierarchical levels and scales. This result can be obtained by combining the two dendrograms of split of the fund elements land use, illustrated in Tab. 7 and Tab. 8 with the information about the dendrograms of split of Total Human Activity over the categories shown in Tab.9. In this way it becomes possible to couple the two dendrograms of the distribution of fund elements across levels distributed over the same taxonomy of categories - Giampietro (2003) and Grünbunhel and Schandl (2005) – as illustrated in Fig. 27.

[24] Activities mainly related to women's roles such as caring of children, preparing food, cleaning the house

The dendrogram of allocations of hours of human activity starts with Total Human Activity (THA) in the box on the upper left side of Fig. 8. This initial amount of human activity is then divided into “Physiological Overhead” (POHA) and “Human Activity Disposable Fraction” (HADF).

Out of the total amount of hours of “Human Activity Disposable Fraction” (HADF), the society allocates a certain fraction to its own reproduction. This fraction includes leisure, education, social life and events. This fraction of human activity belongs to the category Leisure and Education (L&E), which should be considered as a sort of “societal overhead” on labor time as this amount of hours of human activity are not directly used to perform economically productive activities. The remaining of HADF is included in the category “work time” (HAWork) which is allocated to a number of economic and household activities: off-farm wok (agricultural companies or industries outside the community), cash cropping (harvesting for profits), subsistence farming (agriculture, livestock, hunting and gathering), household chores (all household activities not related to food production).

By using these categories it becomes possible to generate more effective comparison among the communities. For example, La Primavera community shows a higher share of work time even though not necessarily agricultural work. In fact, hunting and gathering are time intensive activities. In general, more work for subsistence is found in La Primavera because of cultural reasons. Giampietro (2003) further divides the category of Work Time into additional categories: (i) work in the household’s own land (W-land); and (ii) off-farm work (W-off farm). In relation to this categorization, Tacaaglé community has a larger fraction of human activity dedicated to working the land, which is the main source of income. In terms of land use, this translates into a structure of small and medium-size plots.

The dendrogram of allocations of hectares of colonized land starts with Total Available Land (TAL) in the box on the upper right side. In our accounting system the TAL of the community is defined by the administrative boundaries of the system.

Of the total amount of land that can be used by the community (the total budget), there is a first fraction that is not used productively by the society. This non-colonized land (NCL) can also be considered as the Ecological Overhead of Available Land. This label suggests that a portion of available land should be preserved from human exploitation, because of some sort of social agreement, justified either by the need of conservation, religion taboos, cultural traditions. The remaining land is included in the category of 'Colonized Land' (COL), which refers to all land used productively by the society. This category is further subdivided into land not in agricultural production (LNAP) and agricultural land (LIP). Forests provide firewood, construction material, food, and marketable products. Agricultural land (LIP = Land in Production) comprises fields, pasture, fallow land, and gardens. Within agricultural land it is possible to distinguish between land for commercial production (LIP$) and subsistence land (LIPsub). The proportion of the land in the category LIP$ can be further allocated to different categories of land use (and concurrent categories of human activities): for cash crops, productive land used to cover taxes, productive land used to cover technical inputs (self-produced inputs, such as seeds, or purchased inputs, such as fertilizer, tools and machinery). This category makes it possible to individuate a final division in Figure 34 between land that produces net disposable cash (L-NDC) and land that is producing monetary flows needed to pay taxes and inputs (L-pay inputs).

At this point this quantitative information makes it possible to calculate for selected categories both: (i) density of flows per hectare of specific categories of land uses (e.g. food per hectare, added value per hectare); and (ii) intensity of flows per hour in specific categories of human activity (e.g. food per hour of labor, or added value per hour of labor). These values can be used for comparison and to generate benchmarks making possible to assess the performance of rural communities, in relation to different criteria. For example the average net production of added value per hour in the category "work in cash crops" and within this category compare the performance of different crops as a source of income can be calculated. In the same way, the assessment to the whole household, aggregating all the monetary flows entering in the household economy divided by the amount of hours invested in the various categories of human activity associated with generation of cash can be moved. The same analysis of individual activities or aggregate performance in relation to relevant flows (monetary or food) can be carried out in relation to the categories of land uses.

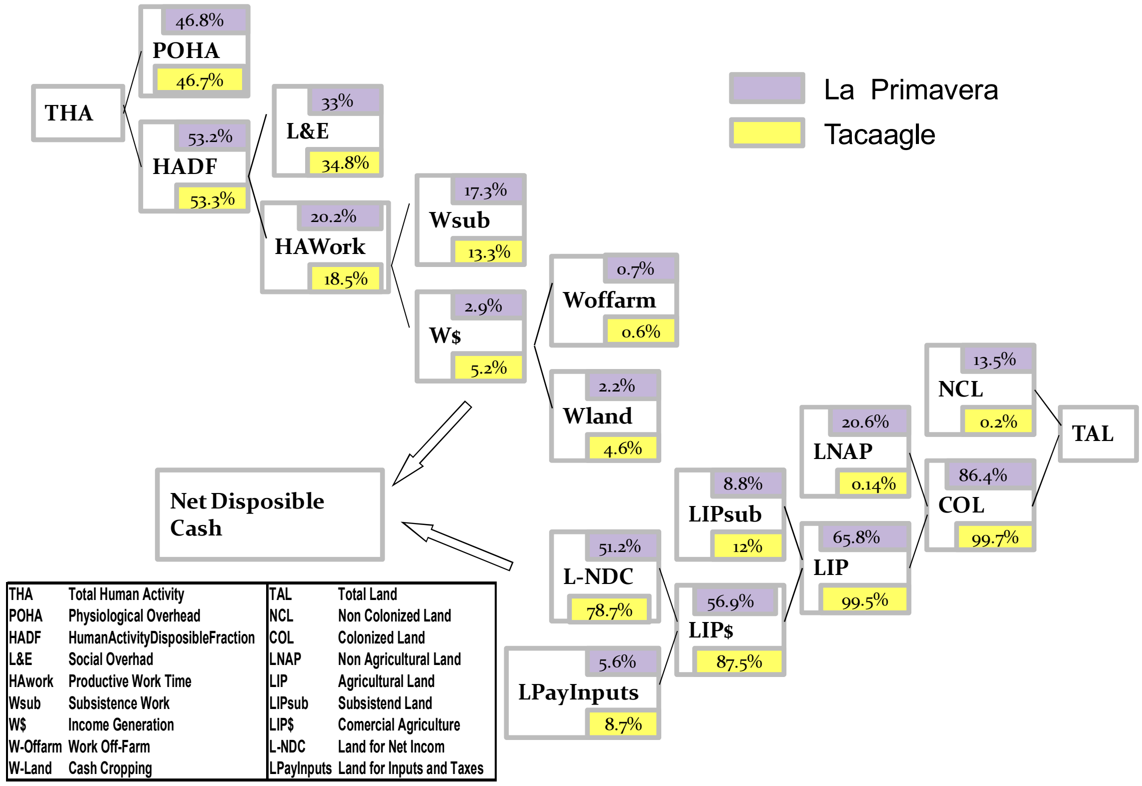

Figure 34. Land Time budget analysis.

Source: own elaboration.

4.3.5. The analysis of flow elements: monetary and food flows

4.3.5.1. Monetary flows

The accounting of monetary flows has been done using the same taxonomy of categories used for the land-time budget. This choice is required to make it possible to generate two sets of ratios flow/fund elements characterizing the specific metabolic pattern of the two communities.

The monetary flows (US dollars/year) measured in US dollars 2008 are illustrated in Table 10. The data are organized in 4 main categories: (i) total production at the community level: (ii) the fraction of farm production self-consumed by the community; (iii) the fraction of the production sold outside; (iv) flows of subsidies. It should be noted that in this way two categories of monetary flows: (i) cash flow; (ii) the economic value of the goods consumed in subsistence (assessed by the quantity consumed time its market price) are being assessed.

By looking at these data, Tacaaglé community has a greater share of traditional agriculture, barnyard and livestock, as well as higher farm consumption can be seen. La primavera, on the contrary, focuses on industrial agriculture (soy), and an important share of their in income comes from renting land to companies.

Table 10 Monetary Flows in Tacaaglé and La Primavera "Potae Napocna"communities.

		Tacaagle total	La primavera total
Trad. Agriculture production	$/Ha	62.5	27.5
Soy production	$/Ha	463.2	1644.7
Livestock production	$/Ha	23.8	20.6
Barnyard animals production	$/Ha	0.2	0.2
Total Farm production	$/Ha	86.6	48.2
Trad. Agriculture consumed by the community	$/Ha	32.3	8.1
Livestock consumed by the community	$/Ha	11.2	5.9
Barnyard animals consumed by the community	$/Ha	0.3	0.3
Farm prodution consumed by the community	$/Ha	43.8	14.2
Cash out inputs of agriculture	$/Ha	10.6	9.9
Cash out inputs of soy	$/Ha	117.5	226.4
Cash out inputs of livestock	$/Ha	0.2	0.2
Cash out inputs of barnyard animals	$/Ha	0.2	0.1
Total cash out input	$/Ha	21.5	49.3
Agricultural production sold outside	$/Ha	19.6	9.5
Soy production sold outside	$/Ha	345.7	1418.4
Livestock production sold outside	$/Ha	12.3	14.5
Barnyard animals production sold outside	$/Ha	0.2	0.1
Total production sold outside	$/Ha	32.1	269.4
Land Rent to companies	$/Ha	157.9	52.6
Cash out to buy goods and services	$/Ha	104.9	489.0
Buying for the market	$/Ha	32.3	244.6
Work off farm	$/Ha	28.5	163.1
Subsides	$/Ha	1.0	200.1

Source: own elaboration.

4.3.5.2. Food flows

The total crop production in the two communities, estimated for the year 2008, is shown in Table 11. Such estimation has been obtained by combining information gathered via questionnaires to producers, fieldwork records and land use analysis. Crop production into energy units using conversion factors from FAO statistics has been converted. This allows us to assess the degree of self-sufficiency by comparing production with consumption.

Table 11 Energy Production in the Tacaaglé and La Primavera“Potae Napocna” communities.

Products	La Primavera Production T/year	Production 10^3kcal	Community consumption %	Tacaagle Production T/year	Production 10^3kcal	Community consumption %
Maize	710	504,508	80	660	1,963,263	100
Sweet Potatoes	-	-	-	1,272	1,091,999	70
Vegetable(pumpkins)	8	2,223	30	127	33,658	70
Bananas	109	61,679	20	2,620	1,000,829	30
Cottonseed	250	-	-	716	-	-
Soybeans	1,489	-	-	1,201	-	-
Bovine Meat	105	241,386	10	187	451,710	50
Poultry Meat	2	3,128	100	3	4,164,911	80
Pig Meat	-	-	-	2	6,402,529	50

Data calculation base energy conversion from FAO 2007

Source: own elaboration.

Regarding endosomatic energy consumption (i.e. food intakes), this analysis in the information collected in the questionnaires and through participatory observation is based. Energy equivalences are calculated again with FAO conversion factors (FAO 2007).

The community of Tacaaglé has an average consumption of approximately 1,781 kcal/capita/day from crops. The total protein supply is 25g/capita/day and the fat supply amounts 37g/capita/day. These values come from the consumption of cassava, maize, beans, pepper, pimento, potatoes, pulses, rice, soy oil, spices, sunflower seed oil, sweet potatoes, tomatoes, other vegetables, wheat, starchy roots, peanut, alcoholic beverages, sugar, apples, pineapples, banana, grapefruit, lemons, limes, oranges, mandarins, melon and sugar cane. The non-crop based food supply is approximately 1,004 kcal/cap/day, with 64 g/capita/day of proteins and 71g/capita/day of fat. The main sources being honey, bovine meat, cheese, cream, eggs, freshwater fish, meat other, milk, pork-meat, poultry meat, animal fats.

The indigenous communities of west of Formosa province consumeabout 57,800 kcal to secure enough food for 13 family members for 3 days, at 1,500 kcal per person per day[25] (Torres *et al*., 1998). The introduction of wheat flour has been significant, and a portion of tortilla (200g) is eaten twice a day. La Primavera has a different diet including industrial products (flour, salt, sugar, corn, *yerba mate*, rice, candies, oil; wild vegetables (bush pepper, carob, sweet bush, sweet bush, mistol and chaguar[26]); wild animals (peccary, charata, chua, iguana, lizard, fish, brush turkey, alligator and,). In addition, domesticated vegetable crops consumed are sweet potato, lime, peanuts, corn, beans, watermelon, pumpkin and domestic animals include cow, duck and pork.

[25] The Qom's do not eat every day because their consumption historically is based in gathering-hunting. But the modifications of their consumption are also in dependence of the available food.

[26] This plant is used for handicraft.

4.3.5.3. Other relevant flows

There are other flows required for the stabilization of the metabolic pattern of these communities such biomass used for energetic purposes, fossil energy used in agriculture, electricity, drinking water and irrigation water, material for construction.

The analysis of these flows also indicates important differences between the two communities.

Consumption of biomass for energetic purposes

The estimated consumption of wood or coal for residential use was made on the basis of INDEC Census 2001, which reports the number of households using wood or charcoal for cooking. Tacaaglé consumed 213 ton/year[27] and La Primavera 1,338 ton/year. Formosa biomass extraction across native forest corresponds to 12,796 tons / year and 2,172 the cotton industry. (WISDOM/FAO, 2009)

Consumption of fossil energy in agricultural production

The community of Tacaaglé has a higher degree of mechanization. 9% of traction is done by animals while mechanical traction represents 91%. La Primavera, on the other hand, is more diverse and less mechanized, with human traction representing 68%, animal traction 27% and mechanical traction just 5%.

Data on fossil energy consumption in the form of agricultural inputs are given in Table 12. Here the coefficients calculated for another Argentinean region (Tucuman) for the year 2009 (Dilascio *et al*, 2009) applied to the technological coefficients calculated for our case study were used.

Table 12 Fossil energy input in agricultural consumption

[27] We consider three Tons per year in rural areas (Wisdom/FAO, 2009) and biomass similar to charcoal.

		MJ/Ha	La Primavera MJ/Ha	Tacaagle MJ/Ha
	fallow and soil preparatio	1,254	619,476	496,584
	sowing and fertilization	1,553	767,182	614,988
Inputs and agrochemicals	crop management	1,975	975,650	782,100
	total inputs and agrochemicals	4,783	2,362,802	1,894,068
	fallow and soil preparatio	100	49,202	39,442
	sowing and fertilization	368	181,792	145,728
Tillage and operation	crop management	398	196,612	157,608
	harvest	563	278,122	222,948
	tillage and operation	1,429	705,926	565,884

Data calculated with coeficients of Dilascia *et al*, 2009

Drinking water

Drinking water is supplied through tanks, or natural water bodies (lake, river). In La Primavera 83% of the population gathers water from the lake, the wetlands or community settings and 17% of the population uses tanks. In Tacaaglé the opposite occurs, with 93% of households using water tanks and only 7% natural water bodies.

Material for construction

Regarding to the use of materials for construction, there are two types of house construction. Those made from wood or palm fronds (traditional houses), and those made from concrete. La Primavera has 97% of traditional houses and only 3% concrete/brick houses, wheras in Tacaaglé the concrete houses are 63% versus 37% of traditional houses.

Commuting of people

Another important flow to be considered is the flow of people to move around the fund elements of human activity. In fact this movement of people does affect the profile of allocation of human time. In regard with transportation, 77% of people from the community of Tacaaglé use motorcycles and some trucks, basically to go to the grocery store and the farm, and some of them to commute to their job outside the community. Of those traveling to chacras or bringing children to the school: 8% use the bicycle and 15% go by foot. In the community of La Primavera 30% use the bicycle mainly to go to the grocery store that is located approximately 15km away. When they go hunting they mainly use the bicycle or the motorcycle. Children often go to school on foot and by bicycle.

However, it is not included these assessments in the comparative analysis of the metabolic pattern, carried out at the level of the whole communities, presented in the next section. These factors are more relevant when studying the characteristics of household typologies, at a lower level (they will be considered in study carried out at the household level, Arizpe *et al*. forthcoming)

4.3.6. Comparing the different metabolic patterns of the two communities

4.3.6.1. The characterization provided by the analysis of the metabolic pattern

In this section is used a standard representation of the metabolic pattern of a rural community, proposed by Serrano and Giampietro, (2009), that is based on the simultaneous characterization of: (i) the two fund elements "land use" and "human activity" and (ii) the two flows "monetary flows" and "food flows". These flows are associated - using the chosen taxonomy of categories - to a multi-level matrix of fund elements "land uses" and "human activities". This integrated representation of the metabolic pattern is presented in Fig. 9 and Fig. 10. In this section the general features of this integrated representation, in the next sections we comment the specific characteristics of the two communities are presented.

Characterization of the fund elements

(i) the two fund elements (Human Activity and Land Use) are represented by two pies in the middle of the figure, whereas the flows are represented by arrows indicating the interaction of the system with its context;

(ii) the pie on the left characterizes the fund element of "human activity" – its size and profile of allocation over lower level categories reflects the amount of human activity available (population) and the relative importance of societal activities in terms of requirement of human time;

(iii) the pie on the right characterizes the fund elements of "land use" – its size and profile of allocation over lower level categories reflects the amount of colonized (and semi-colonized) land available and the relevant importance of societal activities in terms of requirement of land uses;

Characterization of the flow elements

When looking for information about the effects of the interactions that the community has with the surrounding context we have to consider the arrows entering and exiting the metabolic pattern of the rural community. In this representation these interactions are with the:

(i) Biophysical context – e.g. the semi-colonized land affected and affecting the rural system;

(ii) Economic context – e.g. the effect of socio-economic interactions outside the borders, for example the government subsidies; and

(iii) Market context – through the analysis of sales of surplus products and purchases of consumed products that are moved across the boundary to stabilize the existing metabolic pattern.

Generation of indicators of performance

To this visual representation of the metabolic pattern a set of indicators of performance obtained by calculating various flow/fund ratios can be associated – e.g. relevant values of the density of flows (flow per hectare) and intensity of flows (flow per hour) over the two multi/level matrices of fund elements (Giampietro, 2003). That is, by using the MuSIASEM approach we can define for the farming system under analysis: (i) "what is done" – the taxonomy of categories used to describe the functions (human activities) and structures (land uses) expressed by the farming system; and (ii) "how it is done" – the characteristics of the processes (technical coefficients describing the various activities) carried out in the various activities (productivity of land, productivity of labor, economic costs, economic revenues). This information makes it possible to analyze and compare similar farming systems.

The coupling of the socio-economic dimension to the ecological dimension

The coupling of two types of fund elements provide an important link over two dimensions of analysis: (i) when characterizing the metabolic flows against the multi-level matrix of fund elements of Human Activity information useful to study socio-economic processes (e.g. monetary cost of labor, productivity of labor, dependency ratio, opportunity cost of commuting time) can be generated; (ii) when characterizing the metabolic flows against the multi-level matrix of fund elements of Colonized Land information useful to study how the pattern of societal metabolism is interfering with the metabolism of the ecosystem embedding the society and the existence of biophysical constraints to the expansion or intensification of human activity on colonized land (Giampietro *et al*. 2011) ca be generated. Put in another way, by adopting the MuSIASEM analysis, a bridge between the socio-economic and the ecological dimension, making it possible an integrated analysis of different metabolic patterns across levels and scales can be established.

Analysis of the trade-offs between market and subsistence economy

Agricultural production (traditional, industrial, subsistence) can go either to the market to be exchanged for money (soy from other crops-livestock are differentiated) or can be consumed directly within the village, as subsistence agricultural production. In this last case a virtual cash flow can be written, equal to the monetary value, which would have been paid in the market in exchange for the subsistence good produced. From the earnings obtained selling agricultural production, one fraction can be considered net income for the people in the community, whereas another fraction must be reinvested in agricultural production, buying material inputs (e.g. fertilizers, seeds, pesticides, machinery) or energy to run the machinery (e.g. oil for tractors, electricity).

4.3.6.2. The analysis of the metabolic pattern of Tacaaglé Community

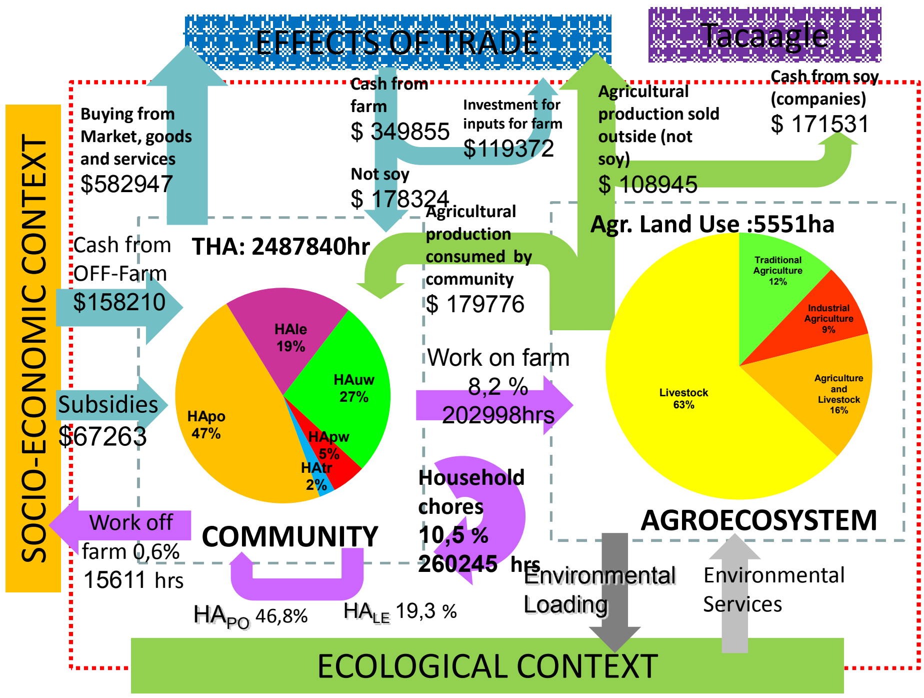

Figure 35. Metabolic Pattern of the Tacaaglé community

Source: own elaboration.

The metabolic pattern of the Tacaaglé Community is shown in Fig. 28. The break-down of the Total Human Activity of the community into different compartments (associated with functional tasks) is indicated in the left pie. Beside the human activity going into work in agriculture (cash-crops; subsistence and off-farm work) most of the human activity goes in Physiological Overhead and household chores, plus the residual of human activity going into Leisure. The break-down of the Total Colonized Land (including the semi-colonized) of the community is given in the pie on the right. Plots in Tacaaglé are small, ranging from 2 to 10 hectares while in the 25 de Mayo community producers are mostly medium-sized who specialize in some type of cash crop to be sold in the regional market.

The monetary flow accounts for all earnings obtained in the community from working activities performed outside the agricultural sector or by renting out land. The combined input of monetary flows makes it possible for the community to buy goods and services from the market.

4.3.6.3. The analysis of the metabolic pattern of La Primavera Community

The metabolic pattern of La Primavera a Community is shown in Figure 36. Most of the land for agriculture and livestock is generally rented. Indigenous population tends to rent the land to companies and work for them. 90% of livestock does not belong to the indigenous. They simply take care of it, on behalf of the owners, and they get wages in exchange, plus some cattle as food. This represents a large amount of cash flow, as compared to that of Tacaaglé, to which significant amounts of subsidies from the government have to be added. These large amounts, however, are quite low with the profits of soy companies it it is compared. The community receives less than 10% of those profits.

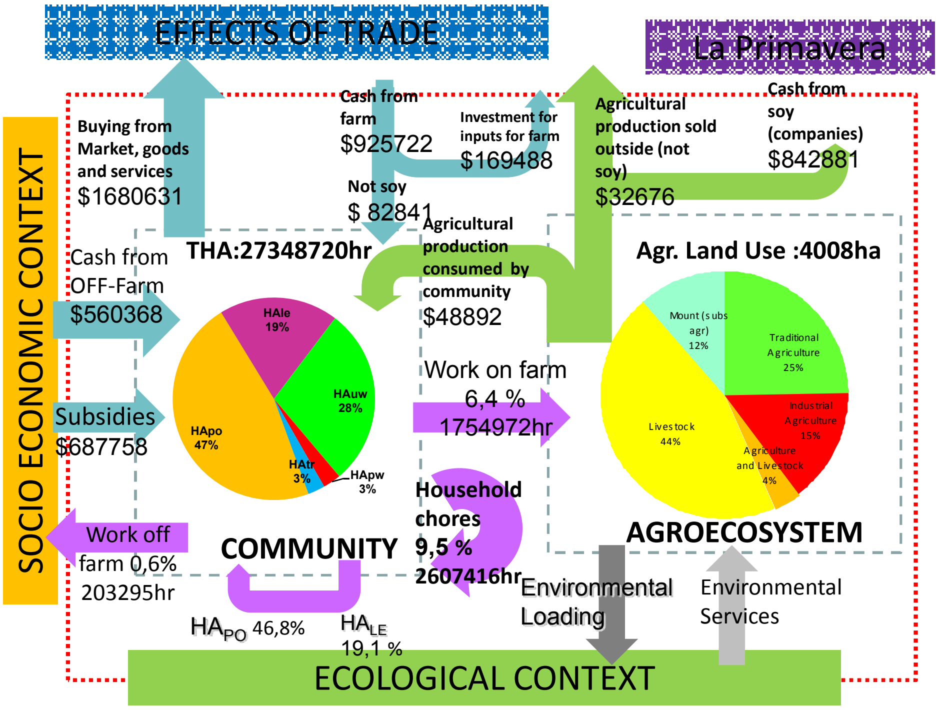

Figure 36 Metabolic Pattern of La Primavera “Potae Napocna”community

Source: own elaboration.

Profits from the sale of agricultural production are not kept within the community La Primavera, since they only rent the land. Coming to a comparison of the allocation of Human Activity with Tacaaglé, they spend less time in working on farm, which in any case is a new activity for this historically hunter-gatherer community. An important fraction of the total earnings goes to buying goods and services from the market can be also seen. The time allocated to transportation is significant because there is no access to public transport, while the communities are dispersed and 5-20 kilometres is a normal travel distance to the next market, hospital or school. The growing income, however, is increasing now the use of motorcycles or bicycles.

4.4. Discussion

The expansion of soy monocultures mainly in Argentina is affecting the livelihood of small producers who live in northern Argentina. It is important to note that in the past the province of Formosa has been developed on cultivation of cotton, which was very important in the 1970s, but has since been replaced, by other crops and livestock. Another historically important activity is livestock, which takes advantage of the natural pastures of the region. Logging has also been an important industry, which has expanded with the increase in the number of roads and associated infrastructure. Finally, the province also operates oil and gas wells in the west. From a demographic perspective, the province has been inhabited by different indigenous groups that found refuge in this "bleak" land after the *desert war (that took place in 1880)*. It was not until 1920 that Paraguay and Argentina began to systematically colonize this area. Indigenous and *criollos*[28] do not mix neither in social or financial terms.

These two different cultural backgrounds are reflected also in the demographic evolution of the two communities. Whereas La Primavera, home to a *Qom* indigenous group, who used to be nomadic just 100 years ago, shows no fast population growth and consequent crowding, reflecting an adaptation to the limited declared aboriginal reserve area, Tacaaglé, settled by Paraguayan-Argentinean migrants who were mostly engaged in agriculture and livestock, shows rapid demographic growth.

The introduction and expansion of soybean production has altered the pattern of human time use in both communities. Tacaaglé has seen a disassociation with the production process – landowners preferring to hire equipment or lease land. This contrasts with the attitude they used to have with respect to cotton production, where landowners were more involved and were responsible for all activities associated with production. In La Primavera this disassociation with the production process is even more pronounced as they used

[28] The indigenous called criollos to the inhabitants that colonized their land.

to be nomadic hunter-gatherers who have been confined in a protected area. As a result they just rent their land, although at a much lower price, and perform no further activity on that land. This means that their dependence on the market for sustaining their metabolism is larger, and this gets reflected in their land use.

In conclusion, the abandonment of agriculture-livestock rotation, coupled with the expansion of RR[29] soy monoculture has generated important and long-lasting changes in these two communities. When adoption an agro-ecological perspective, one could say that the soybean monoculture is a critical path away from environmental sustainability. The large scale development of corporate farming is based on the availability of external resources to invest in inputs and technology, and this development has altered the traditional relation of owners/producers with land, highlighting the figure of the tenant in the region, although with varied contractual arrangements (Albanesi *et al*., 2003).

Changes in relative prices, in particular, the recent increase in the price of soy, plus unfavorable economic policies have led to the disappearance of small and medium-size farmers and to the concentration of land and economic power in the region (Azcuy y León, 2005). When assessing the economic result of this change at the large scale, this change as a positive economic growth for the region, meaning a larger flow of added value (monetary flow) per capita can be perceived. However, when characterizing these changes in a multi-scale integrated analysis that this larger monetary flow does not reach households or rural communities, as it remains concentrated in the hands of tenants producing soy can be easily detected. Therefore, the monoculture expansion generates more monetary flows for urban elites, but supports fewer rural households. This cannot be considered a desirable development path for the rural communities analyzed here.

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[29] Roundup Ready Soybeans. The Roundup Ready® seeds contain in-plant tolerance to Roundup® agricultural herbicides, allowing growers to spray Roundup agricultural herbicides to kill the weeds without harming the crop.

4.5. Conclusions

In this paper the usefulness of the MuSIASEM as an integrated analysis tool to understand the effect of changes induced by the expansion of soy monuculture over two rural communities operating in the North of Argentina was tested.

Our preliminary results show that MuSIASEM can be used to establish a bridge between different dimensions of analysis (interfacing socio-economic variables with ecological and biophysical variables) and different scales of analysis (the local-scale characterization of households and communities can be related to variables and benchmarks referring to Regional or National analysis).

This multi-level analysis is also crucial since it makes it possible to effectively use the information generated using participatory methodologies for better understanding of the dynamics and complexity in the communities. The information generated in this way can be used to make it possible an informed deliberation, within local communities, over the pros and cons of soy expansion. In fact, information and communication technologies can be used to enhance the effectiveness of participatory processes for community capacity building. When local communities can generate (and be in control of) their own information – that is, when they can record such an information in the form of data referring to relevant categories, maps, pictures and videos, they can enrich the discussion over possible sustainable paths because their cultural diversity can be translated in a more effective perception of relevant issues to be considered. In this case study, for example, two communities operating within the same region, but totally different in cultural aspects and still expressing similar land uses were found.

Another important aspect of multi-level analysis is that it makes it possible to individuate the relations that flows have with fund elements at different scales and level of analysis. For example, soy monocultures certainly boost the monetary flows associated with an hectare of colonized land. However, when looking at the metabolic pattern of the community we can clearly see that the larger cash flow does not remain with (= it is not spent by) the rural communities.

In conclusion multi-scale integrated analysis of the metabolic pattern of rural communities provides a useful representation of the sustainability predicament by providing a holistic vision of the various aspects (dimensions of analysis) and perceptions of the various social actors (socio-economic units reproducing at different hierarchical levels). In our view this richer representation can help a better informed discussion over policies more suited to the needs of communities.

Chapter 5

Chapter 5[30]: Scaling-up the analysis of societal metabolism: from household to community metabolism

5.1. Introduction

The excessive specialization of agricultural production on a single species entails a decrease in biodiversity and changes in social structure and economic activities. In the last decade, different studies show that the monoculture of soy crop production produced different ecological impacts, for example, soil erosion and deforestation in more fragile areas (SAyDS, 2008). In 2003, the continuous production of soy led to losses of one million tons of nitrogen and 227,000 tons of phosphorous (Monti, 2008a).

There are several studies available illustrating the negative impact of the expansion of the monoculture of soy on the environment. Genetically Modified (GM) soy production implies the use of the herbicide glyphosate (agrochemical), which accounts for more than 70% of agrochemicals used in Argentina (Tuesca *et al*., 2007). The widespread use of glyphosate has led to the emergence of herbicide resistance in some weeds (Duke and Powles, 2008; Powles, 2008), and in 2005, a glyphosate-resistant strain of the weed Johnson grass (Sorghum halepense) was confirmed in Argentina (Tuesca *et al*., 2007). In addition to polluted water bodies and groundwater, the widespread application of agrochemicals can lead to changes in soil properties (SAyDS, 2008).

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[30] The chapter builds on the draft paper of the same title *Nancy Arizpe, Jesús Ramos-Martin and Mario Giampietro 2011* **Scaling-up the analysis of societal metabolism: from household to community metabolism.** To be submitted to the journal of Land Use Policy**.**

The main ecological problems of soy expansion are degradation and erosion, biodiversity loss, pollution problems in aquifers, access to water sources and use, overexploitation of forest resources and fisheries and agro-chemical pollution in towns and cities (Morello and Rodriguez, 2009). Deforestation alone reached a rate of more than 250,000 hectares per year for the period 1998/2006 distributed in the dry and humid Chaco, the Yungas and remnants of these forests including the Pampa region (Morello and Rodriguez, 2009).

Soy intensification has also led to negative health impacts in rural communities. But the effects that the dramatic change in the pattern of agricultural production induces in the daily life of the people living in rural areas are still not investigated systematically.

In relation to the health of rural people, crops are routinely sprayed with pesticides, from both the air and ground, within a short distance of local communities. Fumigants are applied to the grains as post-harvest routine in storehouses and transport containers (FAO, 1999). These agrochemicals are allergens and can produce respiratory and other ailments in vulnerable people (Dosman and Cockroft, 1989). Rural communities that live close to fields have documented high incidences of cancer, respiratory illnesses, and fetal abnormalities. However, there is a lack of official and empirical data on the impacts of pesticides on human health. In relation to this point the Argentinean health system records only acute poisoning. Therefore, most of the documentation regarding the long-term impacts of exposure to agrochemicals comes from health practitioners, the media, and affected communities and is largely anecdotal (Semino, 2008; Arizpe and Locatelli, 2009). The environmental laws regarding the storage and disposal of agrochemicals are poorly enforced, and the potential for leakage represents a further hazard to human and ecosystem health (Semino *et al*., 2007).

In relation to the local repercussions of the soy expansion on the change of the pattern of organization of the daily life of rural communities there is almost not systemic investigation. To address this knowledge gap I decided to use the concept of rural metabolism. This concept makes it possible to characterize the socio-economic structural and functional pattern of rural communities based on the individuation of household typologies. (Giampietro and Pastore, 1999; Pastore *et al*., 1999; Gomiero and Giampietro, 2001; Grünbühel *et al*., 2003; Grünbühel *et al*., 2005). This approach requires the individuation of relevant household typologies, which are defined using a set of relevant qualities and a finite set of possible structural/functional linkages determining their metabolic pattern. With metabolic pattern I mean an expected relation between fund elements (the profile of human activities and land uses) and flow elements (the characteristic benchmarks of the values of flow/fund ratios – e.g. money per hour of work, money per hectare of land use, crop produced per hour of work, crop produced per hectare of land use. This step of associating the observed system with a typology of the natural system can be related to the process of scientific perception (Giampietro and Mayumi, 2006). The concept of "typology" of metabolic element is important to generate a definition of a finite set of observable qualities associated with the scientific representation of an observed system, which can be described in this way across different levels of organization. The flow-fund model of Georgescu-Roegen implemented in the MuSIASEM approach makes it possible to scale-up the characteristics of various metabolic elements defined at a given level – i.e. the typologies of households – to define the characteristics of a different class of metabolic element defined at a higher level – i.e. the community to which the household belong.

This study deals with the scaling-up of the metabolic characteristics of relevant typologies of households (defined in a given community). This operation of scaling makes it possible to establish a bridge between the characteristic of the metabolic pattern of the community (as a whole) and the characteristics of its individual households. The possibility of establishing this relation is important for several reasons: (i) it makes it possible to analyze and compare different household typologies to identify the social, ecological and socio-economic impacts in the context of the soy expansion. That is, we can characterize, by getting into the shoes of farmers living within the chosen typologies of household, the living conditions of those people belonging to the specific household typology; (ii) it makes it possible to study how the changes at large scale –

affecting the characteristics of the whole community – will be reflected into a different profile of distribution of actual instance of people over the set of household types; (iii) it makes it possible to generate scenarios studying the compatibility between boundary conditions - how large scale external factors force feasible arrangements inside the community – and the perceived desirability of living conditions – how internal factors associated with the daily life within the household generate a different criteria of acceptability of changes.

Generating this multi-scale information about feasibility and desirability helps us to better understand and identify socio-ecological impacts and to develop more robust sustainability scenarios, which are discussed in Chaptern 4. Moreover, the information generated in this way is of great transparency and robustness. In fact the definition of the relevant typologies of households and the evaluation of their desirability can be carried out with participatory processes, by recording the local perceptions of the local social actors. In this way, it becomes more likely to generate useful information about the performance of local / regional development plans to build according to the local needs. Therefore, the information generated in this way is more likely to result useful for local governments to support rural development, mitigation of biodiversity loss, empowering the different actors of the relation between indigenous/locals and improving livelihoods. The findings remain a community-owned reference to learn about different aspects such as poverty alleviation, rural development and biodiversity conservation.

5.2. Case study

The communities studied are described in chaptern 4. Figure 37 shows the multi-scale nature of these metabolic systems. Upper levels (level n and level n-1, village and district) set the constraints by which our focal level (level n-2, household level) must operate. Each typology of household is characterized by a particular metabolic profile. It is the combination of these metabolic profiles and the distribution of household types in a particular community that ultimately defines the metabolic pattern of that community. In our case, the metabolic profiles of La Primavera and Tacaaglé communities in the North of Argentina have been explored in chaptern 4 where we analyzed the village level. In this thesis the analysis is given in Chapter 4 – Fig. 28. In this paper we begin with analysis at the level of the household, and then upscale results to the village level.

This study addresses the main differences in human time allocation and land use across different household typologies, in order to explain the specific pattern of societal metabolism of a given community through differences in: (i) metabolic characteristics of the set of household typesl; and (ii) the profile of distribution of the population of households over the set of household types.

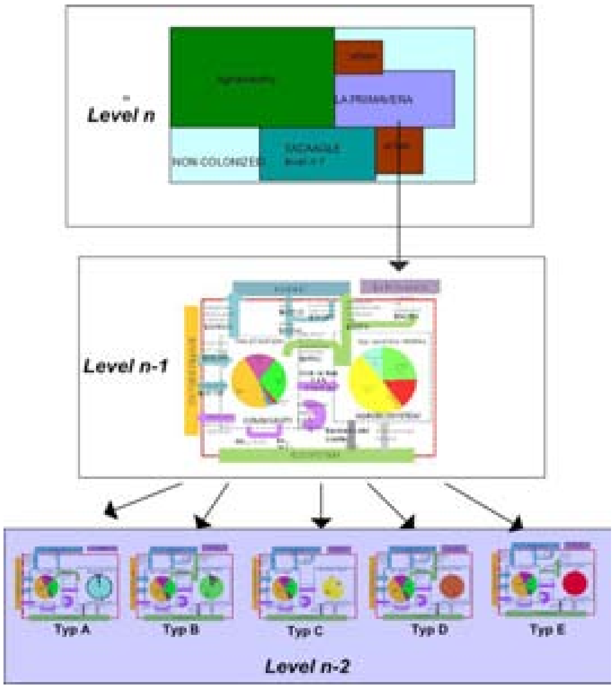


Figure 37 Multi-scale and our focal level at the household level

Source: own elaboration.

5.3. Results

In this section we first define the metabolic profiles of a set of household typologies. Then we establish a bridge from characteristics of these household to to characteristics of the community, integrating both socio-economic and biophysical information. Finally, this multi-scale analysis is confronted with existing trends in agricultural change to look at the implications of soy expansion.

5.3.1. The chosen typologies

Starting from the perceptions gathered in the community it was possible to identify five household typologies reflecting to the main economic activities and land use patterns found in the community: (i) forest management; (ii) traditional agriculture; (iii) livestock management; (iv) mix of livestock and agriculture; and (v) industrial agriculture (monoculture production) basically soy.

By using the MuSIASEM approach we can characterise each "household typology" with an expected set of characteristics referring to: i) the fund element human activity – a household type maps on to a given quantity of human activity (hours per year), which is allocated by the household on a set of categories of human activity. These different categories of human activity – e.g. physiological overhead, soy production – are then assosociated with characteristics menchmarks (technical coefficients) of flows per hour. An analysis based on the fund element human activity is useful to generate indicators of socio-economic performance; and ii) the fund element colonized land – a household type maps on to a given quantity of colonized land (hectares per year), which is allocated by the household on a set of categories of land uses. These different categories of land uses – e.g. residential, soy production – are then assosociated with characteristics menchmarks (technical coefficients) of flows per hectare. An analysis based on the fund element colonized land is useful to generate indicators of ecological impact.

For each community we provide: (1) the characteristics of the various household types – depending on initiating conditions; (2) the distribution of the households over the set of types – depending on initiating conditions; (3) the socio-economic factors and decisions about land-use, which are beyond the control of the households – depending on external boundary conditions (Gomiero and Giampietro, 1999).

In Table 13 can observed the number of the households and the number of hectares presented in the household typologies in both communities. This dataset was generated using the information provided in Tacaaglé by the Social Agropecuarian Program PSA and the MOCAFOR, afterwards rectified through participatory GIS methods and Google earth images analysis. In Table 1 the Energy Input Agriculture (EIA) is also observed. Three sets of practices can be considered: Low Energy Input Agriculture (LEIA) which is represented by human and animal labor; Medium Energy Input Agriculture (MEIA) where use of some harvesters mixed with human labor; and High Energy Input Agriculture (HEIA) which is totally mechanized can be identified.

Table 13 General information at typology level.

Typology	Name	La Primavera household	Ha	EIA	Tacaagle household	Ha	EIA
A	Forest	7	395	LEIA	-	-	
B	Traditional Agriculture	185	400	LEIA	8	673	LEIA
C	Livestock	5	1809	MEIA	4	3508	MEIA
D	Agriculture and Livestock	76	149	MEIA	53	874	MEIA
E	Intensive agriculture (soy)	173	594	HEIA	6	496	HEIA

Source: own elaboration.

Figure 38 shows the spatial distribution of the typologies in both communities. The smaller plots correspond to typologies D (agriculture/livestock) and B (traditional agriculture). The middle-size producers are the main farmers that are changing to typology E (monoculture). The expansion of soy monoculture (in red) can be clearly observed in La Primavera.

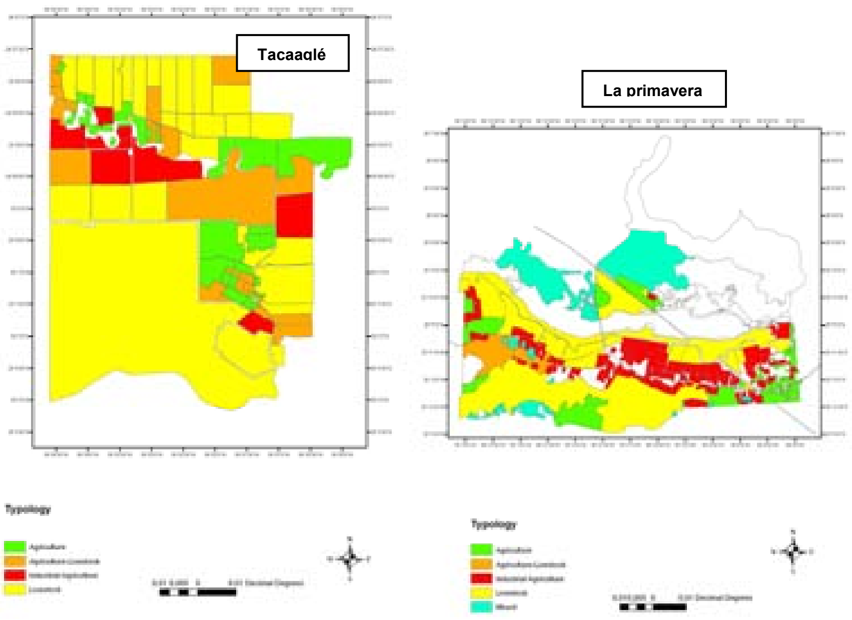


Figure 38 Spatial distribution of the typologies in Tacaaglé and La Primavera

Source: own elaboration.

Table 14 Human activity distribution.

	Human Activities	Typ A Prim %	Typ B Tac %	Typ B Prim %	Typ C Tac %	Typ C Prim %	Typ D Tac %	Typ D Prim %	Typ E Tac %	Typ E Prim %
HApo		**48.3**	**46.6**	**45.6**	**46.7**	**45.6**	**46.7**	**45.6**	**47.2**	**48.6**
HAuw	Subsistence crops	3.4	5.1	6.3	1.3	6.3	3.6	6.3	3.0	2.6
	Non-agriculture activities	3.1	1.3	2.1	5.3	2.1	2.1	2.1	1.7	2.1
	Home activities	9.9	9.9	9.0	9.8	9.0	10.6	9.0	10.6	10.3
	Others	11.5	10.3	12.0	10.2	11.8	10.1	11.9	10.3	12.1
		27.9	**26.6**	**29.4**	**26.7**	**29.2**	**26.5**	**29.3**	**25.7**	**27.2**
HApw		**2.1**	**5.3**	**3.6**	**5.0**	**3.7**	**5.3**	**3.7**	**4.5**	**1.7**
HAle		**19.1**	**19.2**	**18.9**	**19.2**	**19.0**	**19.2**	**18.9**	**20.3**	**19.3**
HAtr		**2.5**	**2.4**	**2.5**	**2.4**	**2.5**	**2.4**	**2.5**	**2.4**	**3.2**

Source: own elaboration.

Table 14 presents the distribution of human time allocation according to the categories defined in the framework of land-time budget analysis (Pastore *et al*, 1999; Giampietro, 2003) and with data from fieldwork observation.

Total Human Activity (THA) distribution is described in Chaptern 4.

Crucial to this analysis of metabolic patterns is the break-down of the Total Human Activity of the community into different compartments (associated with functional tasks). Beside the human activity going into work in agriculture, divided in cash-crops and subsistence and in work off-farm, the majority of human activity goes in Physiological Overhead and household chores, plus the residual of human activity going into Leisure.

Table 15 Distribution of the land use in Tacaaglé and La Primavera.

	Typ A	Typ B	Typ B	Typ C	Typ C	Typ D	Typ D	Typ E	Typ E
Colonized Land Use	Prim	Tac	Prim	Tac	Prim	Tac	Prim	Tac	Prim
	Ha	Ha	Ha	Ha	Ha	Ha	Ha	Ha	Ha
fruits/horticulture	8		50.7						
cotton, maize			349.7						
cotton		285.6							
sweet potatoe		54.4							
maize		9.6							
maize, cotton		41.6							
maize, batata		17.6							
pumpkin		3.2							
soy								496.2	594.3
cotton, maize, livestock						762.2	149.3		
soy-livestock						99.0			
pumpkin-livestock						12.0			
pasture-livstock				1598.9	111.1				
forest-livestock				1909.0					
forest	90.6								
houses	0.1	0.1	1.5	0.1	0.04	0.8	0.6	0.1	1.4
communal land	32.3	0.0	854.7	0.0	23.1		351.1		799.3

Source: Own elaboration

For rural systems we define mixes of techniques of agricultural production (traditional, industrial, subsistence) whose output can go either to the market in exchange of money (within this category soy and crops-livestock have been diferentiated), or be consumed directly inside the village (subsistence agriculture). In this last case, for the accounting of the income of the various households expressed in monetary flows, we account a virtual cash flow, equal to the monetary value of the consumed products (using the price that would have been paid in the market for that quantity of products).

A different analysis of monetary flows aims at characterizing cash flows. The cash flow obtained by selling agricultural production in markets can be used for the consumption of goods by the people in the community, or can be reinvested in agricultural production – e.g. buying material inputs such as fertilizers, seeds, pesticides, machinery or energy to run the machinery (e.g. oil for tractors, electricity).

The monetary flow accounts also for all the earnings obtained by the community from working activities performed outside the agricultural sector or by renting the land. The combined input of monetary flows coming fromf agricultural and non agricultural activities determines the monetary budget available to the community to buy goods and services obtained from the market. In this analysis we can notice that self-consumption can be considered as contributing to the income of the household, in terms of a virtual flow of economic value associated with the the self-consumed products, however, it does not contribute to the formation of a cash flow, needed to buy goods and services from the market.

Table 16 shows the distribution of monetary flows, considering the different typologies. The percentage is calculated with the fieldwork data gathered at the household level. The table shows, for example, that traditional agriculture in Typology C and Typology E provides no values for cash flow. Consumption data indicates that typology D represents a major diversity of self-consumption (agriculture, barnyard and livestock). The cash out for inputs in the different activities in the case of typology D are associated with all the activities (except soy), mainly taking place in traditional agriculture. Traditional agriculture is also relevant for typology B and A. The monetary flows in the typology E are in some part related to income from rental payments. National and provincial economical subsidies are an important part of the typology A and E.

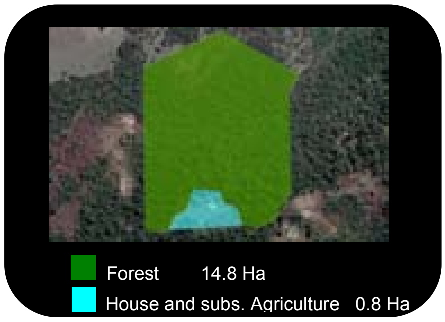
Table 16. Distribution of the land use in Tacaaglé and La Primavera.

	Typ A Prim %	Typ B Tac %	Typ B Prim %	Typ C Tac %	Typ C Prim %	Typ D Tac %	Typ D Prim %	Typ E Tac %	Typ E Prim %
Trad. Agriculture consumed by the community	98	65	34.9	-	-	22	15.8	-	-
Livestock consumed by the community	-	-	-	50	30	2.8	4.1	-	-
Barnyard animals consumed by the community	1	0.1	0.7	0.07	0.02	0.8	0.3	0.05	0.04
Cash out inputs of agriculture	-	12.7	50.7	-	-	22.5	12.3	-	-
Cash out inputs of soy	-	-	-	-	-	-	-	25.4	13.8
Cash out inputs of livestock	-	-	-	1	1	0.1	0.2	-	-
Cash out inputs of barnyard animals	-	0.04	0.3	0.04	0.01	0.5	0.1	0.03	-
Agricultural production sold outside	-	22.3	14	-	-	43.6	51.1	-	-
Soy production sold outside	-	-	-	-	-	-	-	74.6	86.2
Livestock production sold outside	-	-	-	49	69	8.3	16.3	-	-
Barnyard animals production sold outside	-	-	0.4	-	-	0.5	0.2	-	-

Source: own elaboration.

5.3.2. Typology analysis: the metabolic pattern of the five household types.

5.3.2.1. Typology A: forestry



Source: “Formosa, Argentina” 25º31’98”S 58º10´19”W. Google Earth. November 18, 2009[31].

2009[32].

Figure 39. Google earth image – example of the land use in typology forest.

In figure 39 we can observe the typology ‘forest’. This type is only found in the indigenous community La Primavera. The forest not only provides space for settling the community, but it also represents sacred land where they have historically apropriated the required resources and developed the traditional activities as hunting and gathering. The land is sloped, rich in vegetation, marshes and woodlands. The oldest people of the community remembers this landscape as the original land where they have been living.

Figure 40 maps key metabolic flows in quantitative terms. The main elements that can be visualized in the diagram are the i) FUND ELEMENTS (Human Activity and Land Use), and ii) the resulting benchmarks characterizing

[31] The left figure is a satellite image of one of the interviewed households, and the right figure represents the example of the land use pattern of one household.

[32] The left figure is a satellite image of one of the interviewed households, and the right figure represents the example of the land use pattern of one household.

the metabolism of the various FLOWS in density (flow per hectare) and intensity (flow per hour) over the two multi-level matrices.

The representation of the metabolic flows against the FUND Human Activity is useful to study socio-economic processes.

Looking at the flows given in Figure 5, there are arrows pointing outside and inside the different boxes. These arrows represent the interactions that the farming system has with:

- The biophysical context – e.g. the semi-colonized land affected and affecting the rural system;

- The human activity context.- e.g. the unpaid work time distribution in agricultural activities.

There is significant proportion of time spent in work off-farm and no significant cash income is derived from on-farm activities can be observed. In typology A in La Primavera, the time is not spent in paid work within the community, but in off-farm work. They spend less time in acquiring resources than other types. They also need more time to go to school or working demands because they do not have access to main services.

Most of the land use is actually forest and the community has an important flow of subsidies. Households keep subsistence crops, but the forest is managed by the community, guaranteeing households access to different resources and activities. Figure 4 shows, in the left image, the landscape pattern of the typology, and in the right image, an example of the land use. The area for housing and subsistence agriculture is small with only 0.5 to 1 hectares allocated to subsistence agriculture, and in some cases, farm animals.

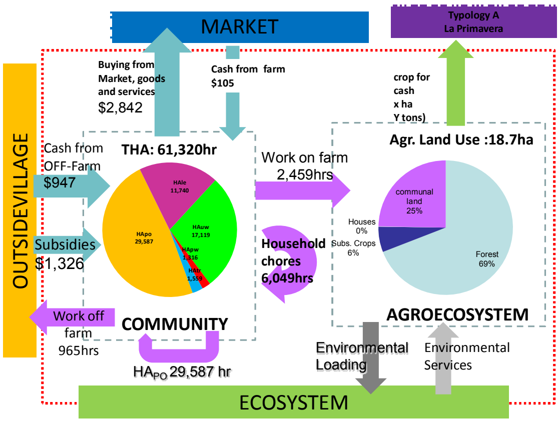
The diagram representation in Figure 5 includes an internal local market where the families exchange their production and services at household level. Accordingly, it integrates monetary income into the system, which is not produced directly by the work of the members of the community, such as subsidies, interests, or remittances from emigrants. The economy of this typology is subsistence-oriented (hunting, gathering and small-scale agriculture) with handycraft production. A small number of household members travel outside the community for work and some more off-farm income comes from selling timber, and granting access to loggers.

This typology is composed of the families with the lower income. Most of the households do not have access to basic services such as running water and electricity and are heavily dependent on subsistence activities such as hunting, gathering, fishing and subsistence agriculture.

This typology, however, has an important role in provision of environmental services. The fraction of the community concentrating households belonging to this typology is in the border with the Pilcomayo National Park. It is an example of Low Energy Input Agriculture, were human labor is used for farm activities.

Actually, there is a dispute over the territory of Pilcomayo National Park, since there is an overlap of land ownership between “Aboriginal Reserve La Primavera” and the National Park Rio Pilcomayo. Since the designation of Pilcomayo National Park, the local community has been prevented from free access to the resources within the territory, and access was banned entirely as of two years ago. This has had significant impacts on the community (socio-cultural and bio-economical). Typology A represents historical patterns of land use which have been used by nomadic cultures such as the Qom’s, and plays an important role as a reservoir of biodiversity.

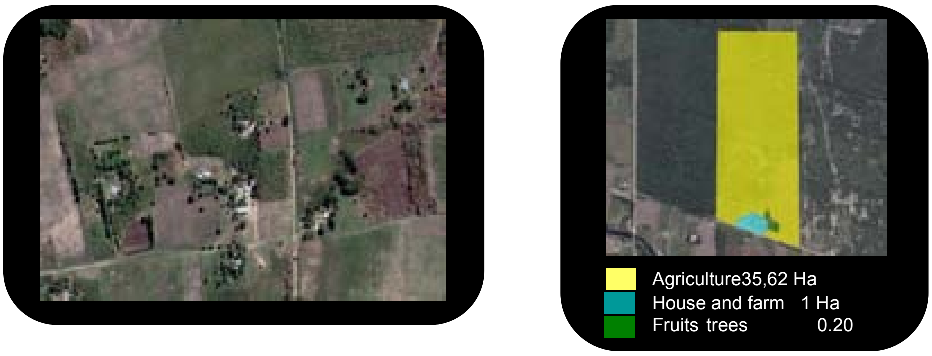
The deliberate deforestation of the land for conversion into a soy-based production system (typology E) impels the migration of former inhabitants, once used to gather and hunt in this territory (typology A). Expansion of Typology E (soy monoculture, see below) represents a threat to typology A, as the extension of the area under soy cultivation spreads to previously forested areas.



Typology A	La Primavera	
Household Size	7	people
Human activity budget	61320	hours/year
Land use budget	19	ha of colonized land/year
Population density	3	ha per capita (of colonized land)
*** Pace of economic flows**		
total income per hectare	2378	$/ha
Net Disposable Cash per hectare	2274	$/ha
*** Economic productivity of labor**		
Return of Work off farm	3	$/hours
Return of work on farm	0.04	$/hours
Average return of work for cash	3	$/hours

Figure 40 Metabolic Profile of the Typology A in La Primavera

5.3.2.2. Typology B: traditional agriculture



Source: "Formosa, Argentina" 25º11'50"S 58º08´19"W. Google Earth. November 18, 2009.

Figure 41 Google earth image – example of the land use in typology traditional agriculture.

Figure 41 shows an example of the traditional agriculture typology. This type is found in both communities, however with different characteristics in each of them. In La Primavera, families are settled in the most fertile areas of the community, being mainly small and medium producers. Being culturally hunter-gatherers, and lacking appropriate machinery, they often tend to rent out their land, finding a valuable source of income in this way, that is sometimes topped with other off-farm activities. On the other hand, the oldest locals of Tacaaglé consider this typology as the representation of the historical agriculture activity, but in recent years they have witnessed the transition to semi- or mechanized agriculture.

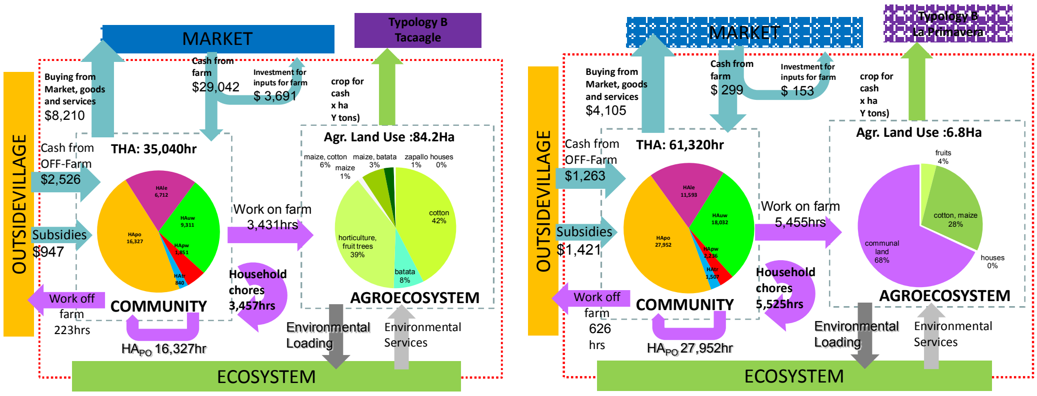
Figure 42 shows the metabolic pattern of the typology B with land use allocated to agricultural production. In general, a large number of households in this land, because it is the most productive land were identified. In the case of Tacaaglé a major diversity of crops cultivated can be observed.

In the typology B in Tacaaglé, the agriculture is a full time use demand which depends on the local / regional market and fine climatic factors for good production. Traditional agricultural activities require a large number of hours.

Most of the land is allocated to cultivation of crops for sale at the local market. A smaller area is used for subsistence crops including fruit trees and shade for the house. Most households in this typology also keep a small number of animals such as ducks, chickens and pigs. The farmers are small producers with two or three crop rotations in a land area ranging from 2 to 15 hectares. An agronomic institute (IPAF) is located in the community, providing technical support and therefore influencing production in the area. The current trend is to specialize in fruit trees for export and regional/national markets. The agricultural land of La Primavera is mainly for subsistence, but some members work their own land after renting it to external producers. This typology is also under the threatof Typology E of soy cultivation, because is located in the best land for agriculture.

The economic value of crops is higher in Tacaaglé. Regarding working time, La Primavera allocates higher amounts to work on the farm because they work the land themselves, even though production is intended for foreign investors (e.g. Banana production).

This typology shows a high level of self-suficiency in food consumption. It is also an example of Low Energy Input Agriculture and in some cases Medium Energy Input Agriculture. Finally, it also acts as a reservoir of biodiversity.



Typology B	Tacaagle	La Primavera	
Household Size	4	7	people
Human activity budget	35040	61320	hours/year
Land use budget	84.2	6.8	ha of colonized land/year
Population density	21	1	ha per capita (of colonized land)
*** Pace of economic flows**			
total income per hectare	28850	2834	$/ha
Net Disposable Cash per hectare	6274	2575	$/ha
*** Economic productivity of labor**			
Return of Work off farm	11.3	4	$/hours
Return of work on farm	1.8	0.1	$/hours
Average return of work for cash	13.2	4	$/hours

Figure 42 Metabolic Profile of the Typology B in Tacaaglé and La Primavera.

5.3.2.3. Typology C: livestock

Source: "Formosa, Argentina" 25º20'11"S and 58º13´54"W. Google Earth. November 18, 2009.

Figure 43 Google earth image – example of the land use in the livestock typology.

The third typology, in figure 43, presents households that use land for extensive livestock. This typology is present in both communities.

La Primavera inhabitants have either leased their land to non-indigenous farmers, or keep someone else's herds in exchange of a few "heads of cattle". They complement this by keeping some fruit trees or small gardens. In Tacaaglé, households belonging to this typology do not live near/within the fields. This tipology comprises middle-size or large-size farmers that migrate to urban areas. This typology has gained importance in the province and has expanded in the last years.

Figure 44 presents the metabolic pattern of the typology. Human activity in paid work in Tacaaglé is obtained from medium-size farmers. Most of the activity falls into livestock keeping, and they do not have much time for off-farm work. La Primavera has a larger fraction of off-farm work. This is due to the fact that most of the area is not suitable for crops or corresponds to flooded areas (wetlands) that are beneficial for livestock breeders.The land use allocated to extensive livestock is of lower quality for agriculture. In Tacaaglé, this land use implied by cattle breeding has been encouraged as an important activity for the province development.

In La Primavera the typology C is carried out by some indigenous communities, or land is rented to some *criollos*[33], in exchange of some heads of cattle annually.

This typology is very important for the local/regional market. The community of Tacaaglé registered an increase of this economic activity, as the soy expansion pushed the livestock production to the north of the country. Typology C does not include agricultural production, with the exception of crops for self-consumption in La Primavera. This typology can be characterized as an example of Low and Medium Input Agriculture.

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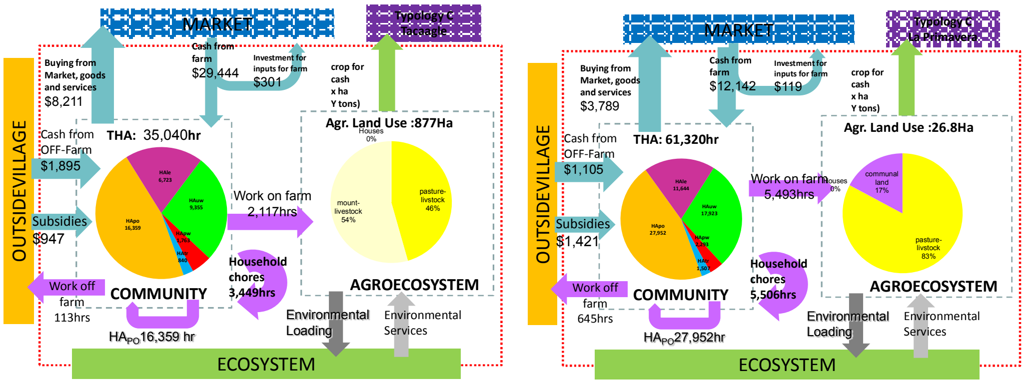
[33] The *criollos* is a term used by the Qom's to designate the Argentineans who immigrate to the East of Formosa Province. Most of the population in this region is from Paraguayan origin.



Typology C	Tacaagle	La Primavera	
Household Size	4	7	people
Human activity budget	35040	61320	hours/year
Land use budget	877	27	ha of colonized land/year
Population density	219	4	ha per capita (of colonized land)
*** Pace of economic flows**			
total income per hectare	32011	14553	$/ha
Net Disposable Cash per hectare	16978	10789	$/ha
*** Economic productivity of labor**			
Return of Work off farm	17	0.5	$/hours
Return of work on farm	14	2	$/hours
Average return of work for cash	31	3	$/hours

Figure 44 Metabolic Profile of the Typology C in Tacaaglé and La Primavera.

5.3.2.4. Typology D: livestock and agriculture

Source: "Formosa, Argentina" 25º11'32"S and 58º09´34"W. Google Earth. November 18, 2009.

Figure 45 Google earth image - example of the land use in the livestock-agriculture typology.

The fourth typology, in Figure 45, shows a mix of livestock and agriculture activities. Small farmers in this typology try to combine production of the two activities to maintain their animals and to generate subsistence crops. The larger fraction of agricultural land is allocated to producing cereals such as corn mainly used to feed livestock, while the smaller fraction of land is used for subsistence or crops for the local market. The livestock is sold, most of the time, in the local market.

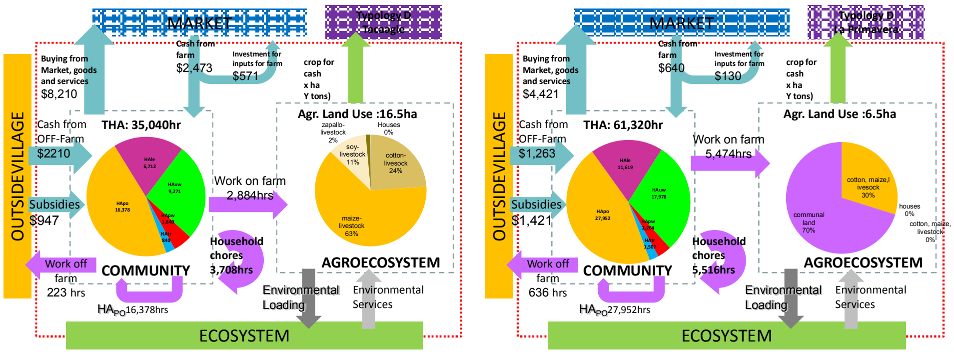
This typology is important for Tacaaglé, combining the two economic activities and self sufficient consumption. In la Primavera the locals have been influenced by foreing farmers and in some cases they continue developing this activities as an economic activity, but in most of the cases they rent the land or take care of the crops an livestock of the foreing farmers.

Figure 46 shows a whole metabolic pattern of typology D, livestock and agriculture production. Typology D is composed of medium and small farmers in Tacaaglé. In La Primavera the majority of the households rent the land to foreign farmers. This typology demands full time work, 50% of which is unpaid work. Small farmers in Tacaaglé use small machinary animal and human labor for agricultural activities.

The combination of livestock and agriculture (Typology D) is one of the most important activity in Tacaaglé community, a part of the land is designated for self-sufficiency agriculture and farm animals. The agricultural land in the majority of the cases use 50% to feed the livestock and farm animals. As it can be observed through the figure, livestock and agriculture activities have been more developed in Tacaaglé through a regime of crop rotation undertaken by small producers. On the other hand, this profile in general is not observed in La Primavera. The rotation is important to conserve the soils. Also wetlands areas can be identified.

This typology is important for the small and middle farmers, through the combination of the two economic activities. Agricultural production is an important flow of this typology, and in the case of the latter community, harvested crops are usually sold in outside markets by foreign producers. This typology is Low Energy Input Agriculture for the small producers and Medium Input Agriculture for the medium producers.

In la primavera Typology D is performed by the medium farmers in the area who rent the land and make their homes there. It should be noted that one of the greatest conflicts of the community is with the *criollos*, who are claiming lands for extensive livestock grazing.



Typology D	Tacaagle	La Primavera	
Household Size	4	7	people
Human activity budget	35,040	61,320	hours/year
Land use budget	16.5	6.6	ha of colonized land/year
Population density	4.1	0.9	ha per capita (of colonized land)
*** Pace of economic flows**			
total income per hectare	5,085	3,247	$/ha
Net Disposable Cash per hectare	3,881	3,036	$/ha
*** Economic productivity of labor**			
Return of Work off farm	9.9	3.8	$/hours
Return of work on farm	0.9	0.1	$/hours
Average return of work for cash	10.8	4	$/hours

Figure 46 Metabolic Profile of the Typology D in Tacaagléand La Primavera.

5.3.2.5. Typology E: monoculture (soy)

Source: "Formosa, Argentina" 25º11'46"S and 58º10´43"W. Google Earth. November 18, 2009.

Figure 47 Google earth image of the land use in the livestock typology.

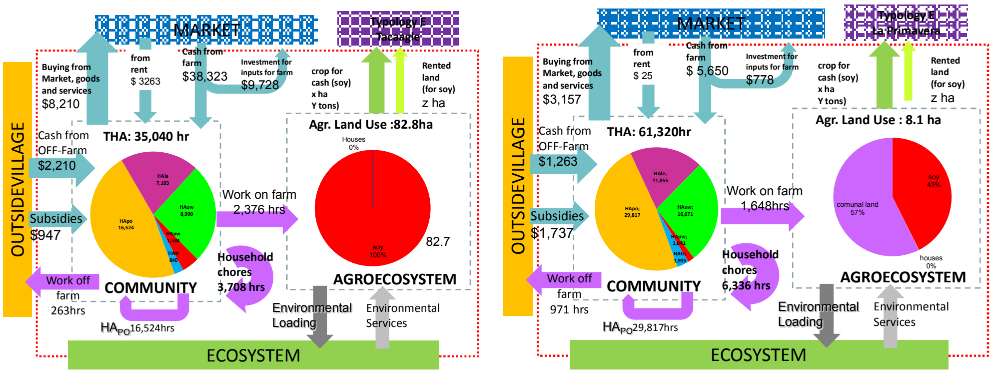
The last typology, soy monoculture, is presented in Figure 47. This typology can be seen in the two communities. In La Primavera, households have rented part of their land to agricultural producers of the region, but after the drop in cotton cultivation, the alternative has been to shift and rent land to companies for soy plantations, the community usually conserve they houses but with the increasing diseases they decide to migrate to forest land of the community. In Tacaaglé land is rented to medium-size producers and the locals usually don't live in this land.

The figure 48 shows the metabolic profile related to soy production (typology E). The human activity for time spend in soy cultivation not exist, basically the companies that rent the land do the work. In this sense the human activity for farming production don't exist, only in some household they have some subsistence crops. In this typology has major hours designated to transport, for example in the case of La Primavera need more time to obtain the subsistent resource (gathering, hunting, collecting firewood, go to the hospital between others)

The land use cultivated by soy covers more than 80% of the household plot. In some household they have subsistence crops around the house. Soy monoculture involves large areas of deforested land. The exceptions are a few houses that maintain a limited number of trees in their surroundings. In most cases subsistence agriculture is lost, as the residential areas are host only to houses, surrounded by soy.

Typology E is characterized by major flows and high exosomatic energy inputs (High Energy Input Agriculture). In addition, it congregates major negative socio-ecological impacts with less environmental services and in the case of la Primavera a major household density with not enough self-resources for consumption. Regarding the circulation of money, soy companies absorb money flows related to sale of crops while the community only receives income from land rental.

As it will be seen later, this is a very common typology. This typology has become more controversial lately after having been linked to major cases of sicknesses among peasants. An extend information is described in Annex 2.



Typology E	Tacaagle	La Primavera	
Household Size	4	7	people
Human activity budget	35040	61320	hours/year
Land use budget	82.7	8.1	ha of colonized land/year
Population density	20.7	1.2	ha per capita (of colonized land)
*** Pace of economic flows**			
total income per hectare	31778	7874	$/ha
Net Disposable Cash per hectare	22029	7095	$/ha
*** Economic productivity of labor**			
Return of Work off farm	8.4	1.9	$/hours
Return of work on farm	16.1	3.4	$/hours
Average return of work for cash	24.5	5.3	$/hours

Figure 48 Metabolic Profile of the Typology D in Tacaaglé and La Primavera.

5.3.2. Trends in soy expansion.

Through the analysis of typologies, the increasing importance for the communities of the typology concerning the expansion of soy has been observed. On the other side, when analyzing soy expansion at the regional level (Chaco region in Argentina), the process involves the use of the most fertile soils and wetlands which results in a displacement of livestock from the Pampa region to the Chaco region.

The soy expansion has occupied land previously used for: i) traditional agriculture in the case of Tacaaglé, ii) forest or agricultural land in the case of La Primavera. Red poligons in figure 38 represent soy cultivation in 2008-2009. Rented plots in La Primavera are small, but since they are next to each other, companies can take advantage of larger areas to reduce production costs.

As a result, typology E has expanded in both communities, although the trend is particularly clear in La primavera. The reason is twofold, more fertile land and inhabitants who are not culturally farmers, thereby facilitating the rental of land for this purpose. Regarding the increase of typology C caused by the expansion of soy in the Pampas, this process is more important in Tacaaglé can be observed. The outcome is the displacement of small farmers in favour of cattle breeders. Respondents to our interviews noted that the process was fostered by provincial government support to expand livestock.

Table 17Human activity distribution in the soy typology.

		Activities	Typ E Tac hr/year	Typ E Prim hr/year
HApo		Sleep	34.8	37.8
		Personal care	5.9	5.3
		Eat	6.4	5.6
HAuw	Subsistence crops	Self-land (Chacra)	-	-
		Communal Land	3.0	1.8
		Others	-	0.8
	Non-agriculture activities	Fishing	0.1	0.2
		Food gathering	0.1	0.3
		Small farm/tending animals	0.7	0.5
		livestock/tending animals	0.6	0.3
		Hunting	0.1	0.8
	Home activities	care of children	8.5	8.9
		Preparing food	1.3	0.8
		Cleaning the house	0.6	0.4
		Construction	0.1	0.2
	Others	Collecting firewood	0.5	1.3
		Collecting water	0.2	1.7
		Educational	7.3	5.7
		Health	1.1	1.7
		Communal gatherings	0.4	0.8
		buying/shopping	0.9	0.9
		handycraft	-	0.5
HApw		Comercial agriculture	2.5	0.1
		livestock	1.3	-
		others	0.8	1.1
HAle		Play	9.9	9.6
		Terere	2.9	2.9
		friend/familiar visiting	3.1	3.2
		Religious activities	4.3	3.6
HAtr		buying/shopping	0.8	0.8
		Health	0.9	1.6
		School	0.3	0.3
		others	0.4	0.5

Source: Own elaboration

In the table 17 the distribution of time use in typologies related to soy expansion can be identified. The human activity in unpaid work designed to subsistence crops decrease,consequence of less land for self production cutivation. Human time spent in paid work crop production decrease as a consequence of money receive from leasing the land, this is more evident in la Primavera. In Tacaaglé the farms that rent the land usually spend more time in work off farm, and emigrate to urban land. The time for tranport increase, La Primavera households spend more time to get food . The time spend in health is major, consequence of sickness increase related to the fumigations.

Table 18 Monetary flow in Typology E.

	Typ E Tac %	Typ E Prim %
Trad. Agriculture production	-	-
Soy production	99.9	100
Llivestock production	-	-
Barnyard animals production	0.1	-
Trad. Agriculture consumed by the community	-	-
Livestock consumed by the community	-	-
Barnyard animals consumed by the community	0.05	0.04
Cash out inputs of agriculture	-	-
Cash out inputs of soy	25.4	13.8
Cash out inputs of livestock	-	-
Cash out inputs of barnyard animals	0.03	-
Agricultural production sold outside	-	-
Soy production sold outside	74.6	86.2
Livestock production sold outside	-	-
Barnyard animals production sold outside	-	-
Land Rent to companies	50	2
Cash out to buy goods and services	31.5	38
Buying for the market	10	23
Work off farm	8	15
Subsides	0.5	21

Source: Own elaboration

Table 18 makes clear the degree of dependence in typology E for income from soy. 99% of agricultural production comes from soy, and in some cases the households have only 1% of land for self-consumption crops. Companies concentrate both the acquisition of technical inputs, and the commercialization of soy. Land-owners in La primavera get 200 Argentinean pesos per hectare, while this figure is 600 in Tacaaglé. In other words, the companies invest 3% in La Primavera of the total production sold outside and 45% in in 2008.

In reference to health and environmental impacts, interviews identified the following problems: i) higher death or malformation rate for farm animals, ii) lower yields in crops, and iii) increase of health issues during the time of spraying, including sterility and higher abortion rates. As mentioned before, these claims made by local peasants are difficult to test because of the lack of epidemiological records from local authorities or studies.

5.4. Discussion

This paper put in evidence the reality at community level. The analysis shows the soy expansion with the identification of typologies, this methodology also allow identifying another set of problems that coexist.

We can identify in typology E the time related to subsistence crops is decreasing, particularly in La Primavera, this sentence implies impacts in the food sovereignty. Regarding typology C, we identified is expanding and consequently the time use in activities related to farm work, increasing off farm work.

A big difference between the two communities is the human activity for paid work (Arizpe *et al*. 2011). In La Primavera most households do not work their land for productive activities, instead renting their land to foreign companies or land owners. In addition, relates more off-farm work typology E is identified. Finally, handicraft is disappearing; this is an important activity in the typology A as well as maintaining the natural resources in this area.

La Primavera and Tacaaglé have similar patterns of land use, with the exception of typology A (forest), observed only in La Primavera. The typology A has been hazard mainly by the typology E (soy expansion). The households of typology E are colonizing typology A, less land for hunting and gathering is observed.

In typology E major changes compared to the other typologies are identified. The changes are more evident in La Primavera which is more populated. In summary are identified i) people travel long distances (bicycle or motorcycle) to get resources (food and energy sovereignty) ii) household migrating to other land (typology A) or urban areas (Tacaaglé) consequence of reducing land for subsistence crops and barnyard animals iii) increasing of pollution by chemicals used in soy production, iii) deforestation. Land use in typology B has been very important since the boom of cotton production. Actually this typology has been replaced by the typology E or C. In Tacaaglé continues being important economic activity specifically for local market.

Land use for livestock can be seen in typology C and D the Indigenous community are trying to access and claim the lands back to account for population increases and subsequent need for more land, while the *criollos* argue they have long established that the land belongs to them. In reference to livestock it is needed to pay attention that is an important activity at province level, and the soy expansion in the Pampa's implies the expansion of livestock in the North of Argentina.

Tipology E has major economic benefits since it is one of the most important national crop . But to carry out this study the benefits are not for small producers and small/indigenous communities is concluded. The farmers at local level generally rent the land at a very low price and the impacts are larger. The flow of money is aparently much higher than in other typologies, but not for the locals. Energy inputs are much higher due to the use of machinery, fuel, fertilizer, etc., and also a lower demand for laborers. The effects on populations are higher, since there is pollution in the chacras near their crops, barnyard animals and human health among others – which results in increased time spent in migration to access non-contaminated resources and other jobs.

The typology involving livestock (typology C and D) are important economically, but is linked to impacts on wetlands. The typology D in Tacaaglé is worked by small producers who do several crop rotations, while type C is undertaken mostly by medium and large producers

With the analysis of flows-funds at typology level, the different scenarios within the 'community' can be identified. As it is remarked in the analysis is important to consider some variables as human activities useful to identify differences between the typologies. Using typologies, the areas with major impacts can be identified, for example the health problems was mainly in typology E, also a poor knowledge of cultural aspects compared to typology A can be identified, where the indigenous households and farmers have significant ethno-medicinal and a major cultural customs.

The use of typologies as a strong methodology for farming systems analyses, and rural and regional development is considered. The typologies analysis sumarize the characteristics of households and help us to upscale and visualize more clearly the soy expansion process and the implication of this phenomena.

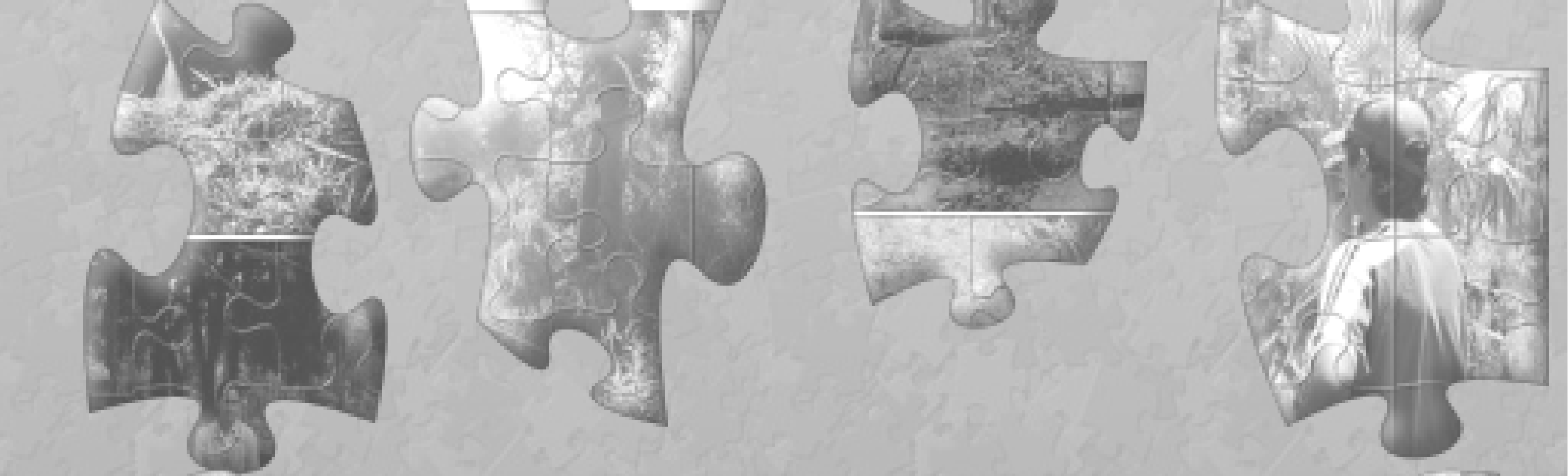
The MuSIASEM integrated analysis in local scale for a better understanding of households is applied,. Ideally, a hierarchy of typologies could be established to inform policy and program development at the national, regional, and local scales about the different trade-offs of their metabolic profiles. Its important remembers that typologies represent a snapshot of a rural community at a single point in time.

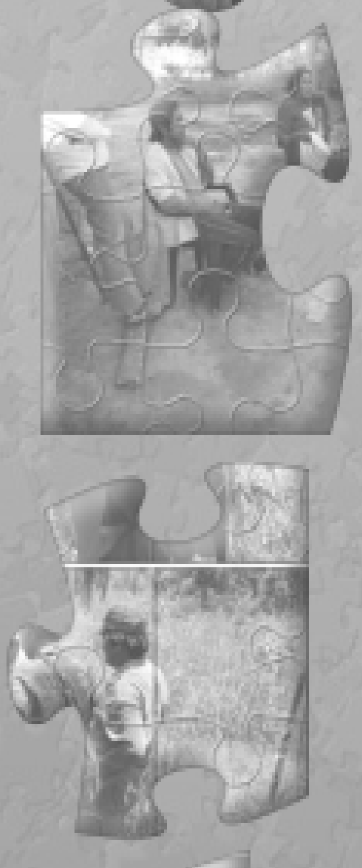
5.5. Conclusions

The analysis at housdehold level is important to understand what is happening within the communities. If we study only at community level, it doesn't show the household reality, for example in La Primavera the economic benefits of farming production go to the external land owners and companies is observed.

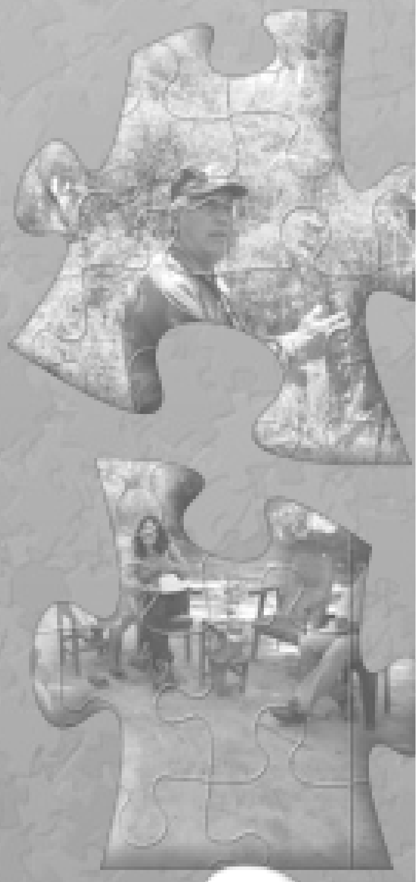
In this paper the impacts and where these are located can be identified. For example, there are major ecological, social, cultural negative impacts in the Typology E. This seems to be the case also for the Typology C that is expanding rapidly. Also this methodology allows us to identify the Energy Input Agriculture.

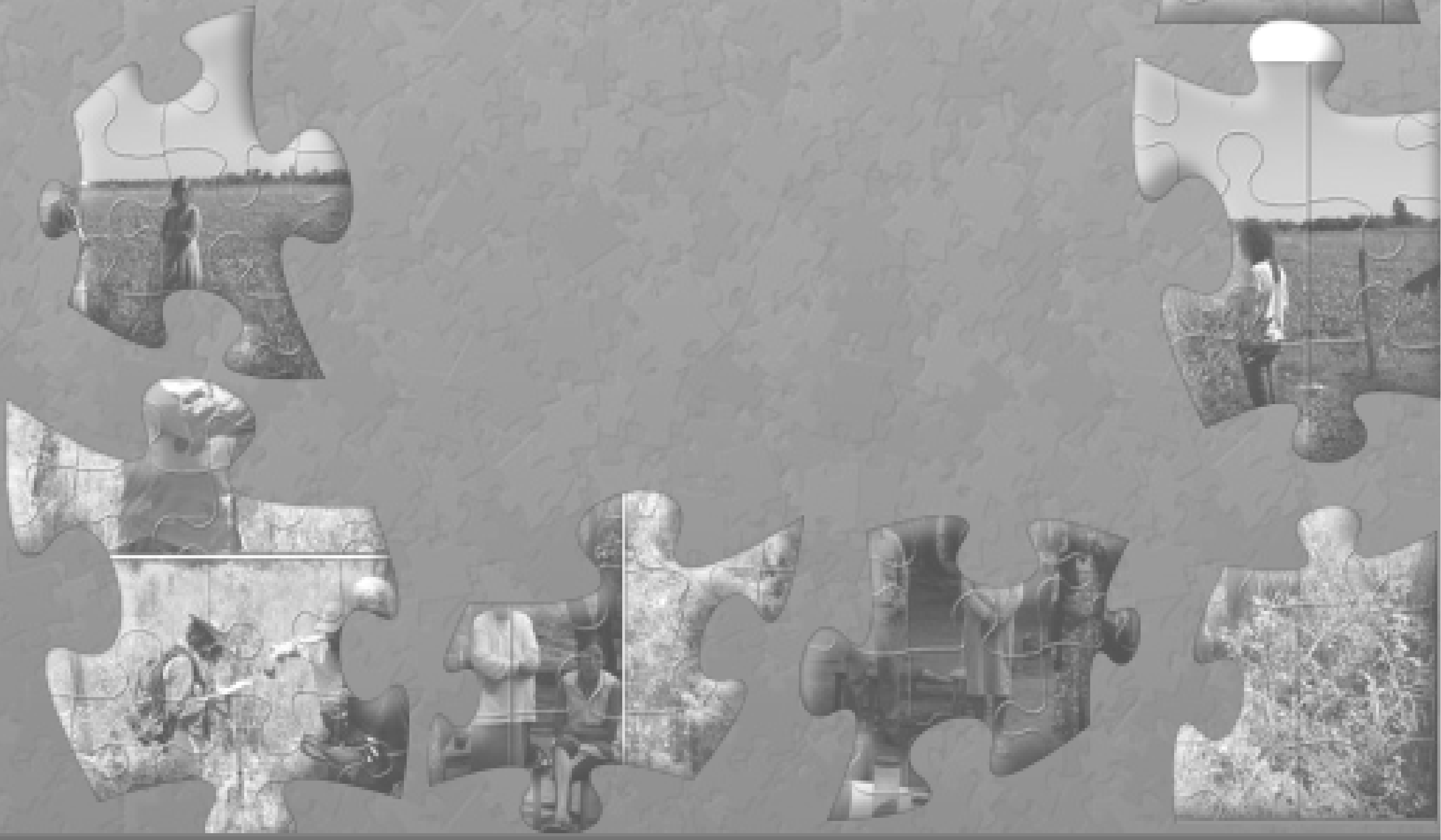
The government of the province of Formosa has a plan to open to new investors, primarily extensive livestock rising and in areas with fertile soils the expansion of crops like soy and BT cotton. Few or almost null development programs in the region advise in technical issues to the medium and small producers in recent years, realising a phenomenon of disappearing. In this sense it is important to perform an up scaling analysis to better understand the alternatives that can benefit both the local and the provincial development and generate sustainable scenarios in rural systems.





CONCLUSIONS





6. Conclusions

6.1. Methodological conclusions

This thesis has attempted to understand the implications of rural change based on a multi-scale analysis of societal metabolism integrated with an analysis of political ecology. The application of these methodologies is crucial to determine such transformation from a holistic perspective. The research contributes to the understanding of the role of the main actors in agricultural development and decision making processes from a biophysical and political ecology point of view. Parts of the thesis focus on the soy expansion as a representative transgenic production model for change in farming systems in South America.

The thesis applied innovative methodological tools in order to understand offside effects to soy expansion. Linking human activity with land use (land time budget analysis), the thesis identified different typologies within each agricultural system. These typologies provided relevant information for the implementation of local agricultural development scenarios.

1. An important methodological contribution is the use of various participatory methods combined with the methodology of Multiscale Integrated Analysis of Societal and Ecosystem Metabolism (MuSIASEM), which was used for local studies at the community and household level. This combination allows drawing a more realistic picture of the agricultural communities under study. The methodology was adapted to fit both communities. First, in Tacaagle, interviews, questionnaires and an analysis of local statistics were undertaken. Second, in the community of La Primavera, in-depth interviews and participatory processes involving mapping and participatory video exercises were used for data collection purposes. Notably, in both communities, participative observation was used for a closer approximation of household behavior.

2. Another important contribution is the use of fund-flow analysis within agricultural systems in order to understand technological change, and the implications of industrial agriculture at different scales.

In general, limited information is available for biophysical studies in the agricultural sector. Furthermore, most studies analyzing rural metabolism are carried out at a national scale. Therefore it is of great importance to collect own primary data at the local and regional scales as has been done in this thesis. The application of the aforementioned methodologies nevertheless faces constraints if applied at a more local level. In this sense it is important to continue developing adequate methodologies and frameworks for local scale scenarios and for being able to interlink multiple scales of a system.

6.2. Lessons learned from the case studies

Nowadays the so called "*deep farming sector*" where it seems that time has never passed, still exists. In this thesis, two case studies demonstrate the features of such agricultural systems, namely agricultural activity in the communities of Tacaagle, La Primavera, Argentina and Xmaben, Mexico[34]. One can notice in these communities that they show a close human-nature relationship.

First, in the Chaptern 4 and 5 can observe that most of the problems they have to continue using the *traditional* farming system is due to factors such as population growth, availability of land, persistent weather changes (hurricanes and droughts), and the availability of only few subsidies. Today, Xmaben even considers the mechanization of maize production as a solution in order to cover primary production for their local population. Notwithstanding, Farmers believe that few mechanized hectares can be sufficient for such production and also continue with other agricultural activities such as beekeeping and agro-forestry.

[34] The case study of Xmaben, México was developed during the PhD but is not included in this thesis. In the Annex 4 is the resume of the draft paper to present in the special issue proposed by the rural system group.

Second, in Chapter 4 is observed that community of Tacaagle, farmers suffered the collapse of cotton production which particularly impacted the economic well-being of many small producers. Some consequences have been the disappearance of this particular crop in the local-regional market. As a consequence farmers face problems in reconverting their land use. Also, it seems that governmental pressure supports plantations of only certain crops which are particularly more profitable for the region and country in terms of taxes. In many cases it is observed that there is an abandonment of small producers because they are considered as "less productive" by the government, clearly showing development is a multi-scale issue. If the Government cannot claim taxes because communities apply traditional agriculture with a high level of subsistence, it will look at those development paths as inferior, regardless of the fact that they may be able to support many more families in the countryside. Finally, Chaptern 2, 4 and 5, I observe an increase in exosomatic energy use which is implied by agriculture technologization in the form of irrigation, fertilizers, fungicides, and tractors. It seems that competitive market discriminates smallholders, and forces them to convert to medium-sized producers in order to maintain their economic subsistence.

In summary, *s*mallholders offer a greater diversification of crops. This implies a lower productivity of the crops that are profitable. For example, in Argentina, medium size farmers use the technique of crop rotation, such as soybean - wheat - maize, thereby giving more organic matter to soils. Thus, for smallholders it is important to consider government support for the profitability of their products. In contrast, in Europe one can also observe that subsidies are essential for the maintenance of agricultural fields. Also we observe organic agriculture carried out by small and medium producers, offering an alternative to maintain the agricultural system without much exosomatic energy.

Smallholders have always been attached to their land, as land has a cultural value for them. However, in many cases, as in Argentina and Paraguay (Chaptern 3) , where the lack of resources led them to sell or rent the land, they often return to their homeland to restore their holdings and start producing. In cases such as the La Primavera community, land have been directly owned by the community, but the lack of funding led them to rent the land beyond knowing the full consequences of that fact. The smallholders rented the land arguing that subsistence crops were not enough for getting money to pay for resources (electricity, transportation, among others). I further acknowledge that traditional agriculture is not the panacea for many smallholders. For examples in Tacaagle farmers need a minimum of 20 or 30 hectares to maintain the economic well-being of their families. Finally, I point out that in recent years the phenomenon of land grabbing has become common in the region. It is well known that land grabbing is implied by the market economy model that goes beyond food, which has been analysed in Chapter 2.

Policy recommendations regarding the expansion of soy at global and local level:

First, on a global-national scale it is important to consider different visions in order to generate less negative regional and local economic growth.

Second, on a regional scale it is recommended to have balanced power among decision-making actors. Also it is important to continue with participatory processes that are truly representative for the entire local population.

Third, on the local scale, farmers should be informed about the different trade-offs that technological innovations can have with respect to the expansion of crops such as soya. Another recommendation is to differentiate among locations for different production, taking into account local culture and specific economic situation.

For Argentina, it is important to note that current governmental plans for the province of Formosa suits national needs only, such as soy expansion, the reason being that it provides the government revenues from taxes, and also some surplus for the rest of the economy. However, Formosa province is formed mostly by small and medium scale producers who will be displaced then from their historical agricultural activities. I believe that it is not adequate to consider rural development plans without basing them also on participatory processes at the local scale. It is more appropriate to develop rural development plans suitable to local needs and considering its bio-physical constraints.

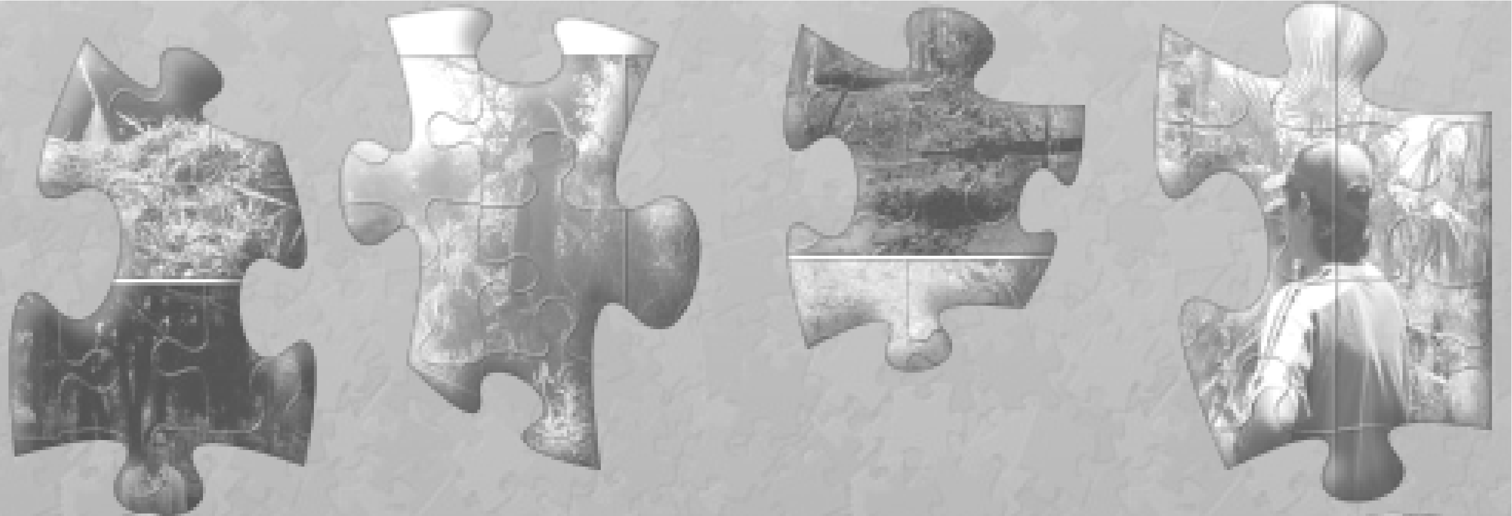
6.3. Other research behind this thesis

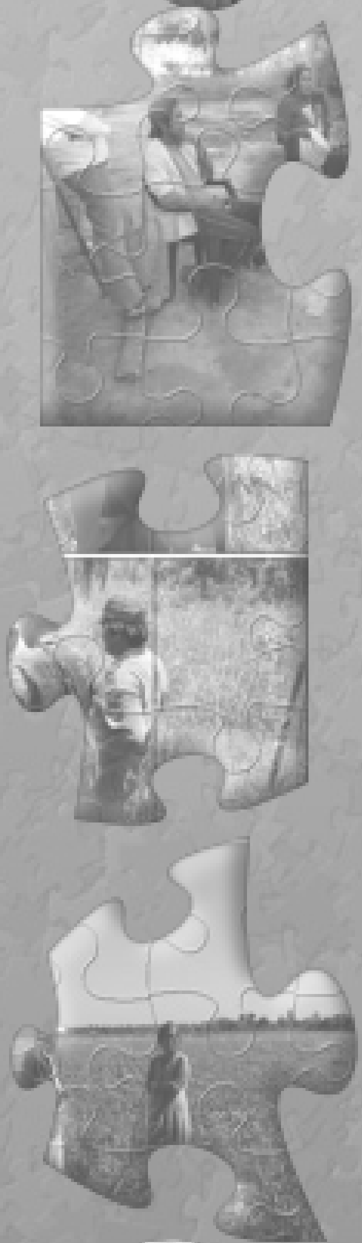
During the PhD formation other research articles or draft papers have been developed which are not reflected in this thesis. Nevertheless, it is important to mention them since they are part of the doctoral work as well as the evolution and maturity of this thesis.

- A paper related to the impacts of soy expansion is found in ANNEX 2 and has also been published in the journal *Ecología Política*. In this article the health impacts associated with the use of toxic agrochemicals is analyzed.
- Other studies were conducted at various local levels. These study cases are related to agricultural expansion in Mexico. One study case analyzing agricultural conversion of sugar cane, ANNEX 4, explores the historical process and the political implications of the agricultural reconversion of sugar cane from a local-regional production to industrial production serving bio-ethanol production. I conducted another study in the Mayan region applying MuSIASEM and adding some methodological improvements. ANNEX 3 contains the abstract of the paper which will be part of a special issue proposed by the Rural System Group, at ICTA-UAB
- A paper providing the continuation and conclusion of the work that was developed at local scales in Argentina. In this paper I upscale metabolic profiles for development scenarios (Arizpe *et al*, 2011). Methods applied are: i) selection of indicators, ii) the Amoeba representation of the interaction between humans and environment (Giampietro *et al*. 1999; Pastore *et al*. 1999); iii) impredicative loop analysis (Giampietro, 2003) and iv) seeds analysis.

A final reflection in this thesis is that nobody can predict the future of agriculture. Farmers experience big differences depending on their local contexts which is reflected in the different case studies. It is important to study alternative system of agricultural production capable of generating a diversity of performances.

It is also important for socio-ecological sciences to consider political analysis. Most of the rural development programs are formulated by top-down participatory processes, facing severe limitations in contexts of ecological distribution conflicts coined by substantial power inequalities. Thus, it is essential that bottom-up participatory processes are more appreciated in order to empower local stakeholders.





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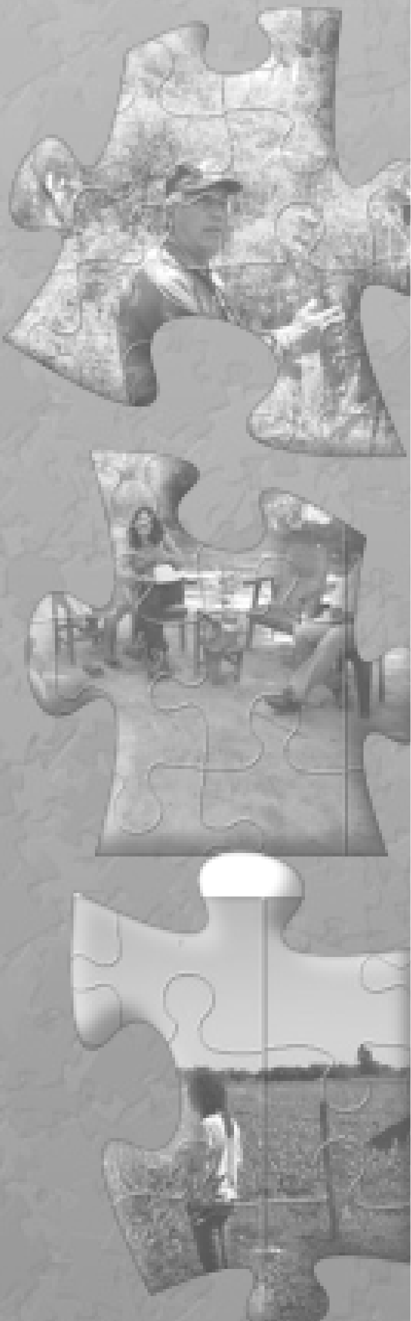

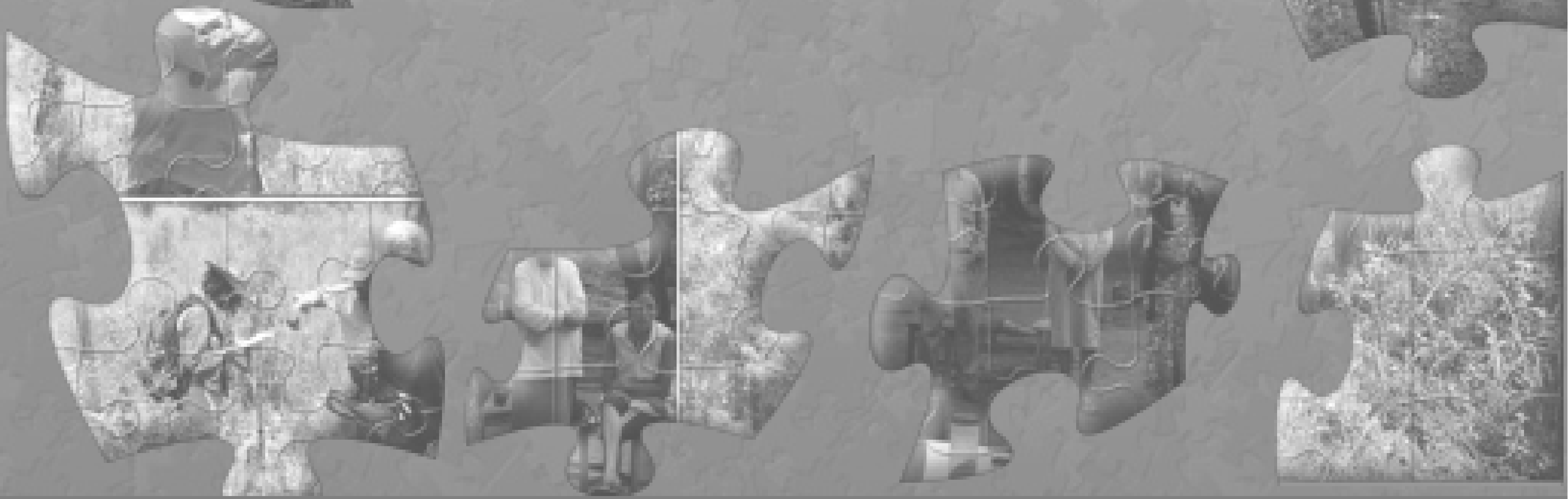

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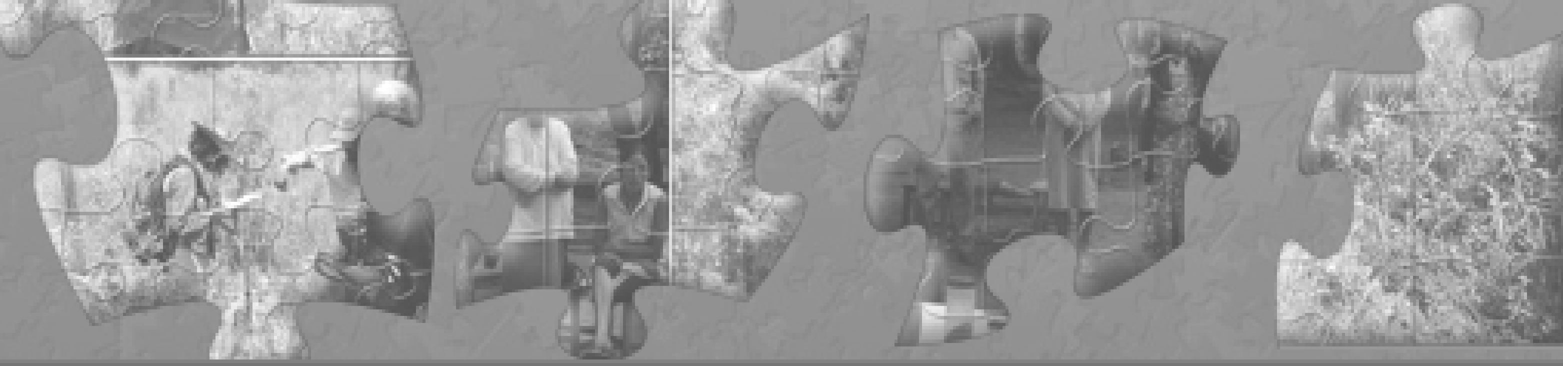
ANNEXES



8. Annexes

ANNEX 1: Land-time use, energy and monetary flows questionnaire

Cuestionario para conocer los usos del tiempo –tierra, flujos energéticos y monetarios (Comunidad indígena)

Nota: Realizar la entrevista por lo menos a 3 integrantes de familia

Numero de cuestionario:

Nombre de entrevistador:

Fecha:

Localidad __________

Región______________

Sr./Sra. Nosotros trabajamos para conocer los impactos y posibles impactos socio-económicos que se producen por la expansión de la frontera agrícola del cultivo de soja. Hoy en día Argentina es uno de los mayores exportadores de soja, sin embargo no se toma en cuenta la soberanía alimentaría y soberanía energética, principalmente de los pequeños y medianos productores, así como la importancia de la agricultura familiar. Es importante conocer desde una escala local los usos del suelo y del tiempo, producción de los alimentos, manejo de la chacra…, para poder dar alternativas o escenarios futuros. Agradecemos la disposición de algunos minutos para realizar una entrevista basada en el siguiente cuestionario.

Cuestionarios a diferentes integrantes de la familia

Nombre____ H M

Edad________

¿Dónde nació?

¿Cuándo llego a éste lugar?___________¿Dónde vivía antes?_____________

Integrantes por familia______________________

Idioma ___________

	Fam. 1 H	M	Fam. 2 H	M	Fam. 3 H	M
0-5						
6-11						
12-17						
18-65						
65-						

¿Cuántos van al colegio?___________

¿Hasta qué curso de la escuela fueron?_________________

¿Alguien de su familia trabaja afuera de la chacra? ______¿Cuántas veces por semana?_________ ¿Todo el día o parte del día?______

¿Algún miembro de la familia se fue a vivir a otro lado?________ ¿A dónde?______

Cuando llego a esta tierra, ¿cómo era? (había más agricultura, ganadería, monte…)_____

¿Qué se cultivaba?_______

Actividades generales actuales (marcar con X)

Actividades realizadas: agricultura___, ganadería_____, cría de animales de granja____, caza___, pesca____, recolección_____, otras________

Solo campesinos

¿Cuántas hectáreas son destinadas a los diferentes cultivos?_____________

¿Realiza rotaciones de cultivo?________ ¿Cuántos cultivos rota?______________¿Cuáles? __________

Si hay soja, ¿Cuántas hectáreas son destinadas al cultivo de soja?_________________

Si tiene soja o hay alrededor, ¿Desde cuándo se hace soja en ese lote y bajo qué manejo (ej siembra directa, labranza convencional)? ______________

Producto	Tierra (ha)	Autoconsum. %	Comercializac. %	Siembra (meses)	Cosecha (meses)	Producción (toneladas)	Kg /ton que vende	Precio Kg/ton	Fertilizac. kg/ha	Pesticida kg/ha
Algodón										
Maiz										
Mandioca										
Poroto										
Calabaza										
Zapallo										
Batata										
Caña										
Girasol										
Soja										
Frutales: Melon Sandia Mandarina Pomelo naranja banana	**Num plantas**									
Verdura: Tomate Lechuga Repollo Zanahoria remolacha	**ha**									
Pastura naturales										

¿Qué cantidad de veces come por día?

Otras actividades	Producción	Precio $/kg	Kg de venta	% Auto-consumo	HA

	anual kg				
Ganado					
Granja					
Pesca					
Industria/empresas					
Cosecha de Miel					
Animales o Carne de Monte / silvestre Caza					
Productos forestales Frutos Madera; leña Postes Otros					

Actividades humanas (tiempo) Diferentes integrantes de familia

¿Qué hace en un día normal? Ej. Dormir, higiene personal, lavar, trabajar la chacra

Horario **H/M edad___**	**H/M edad**	**H/M edad___**	**H/M edad___**	**H/M edad___**
5am				
6				
7				
8				
9				
10				
11				
12				
13				
14				
15				
16				
17				
18				

19				
20				
21				
22				
23				
24				
1				
2				
3				
4				

¿Cambian sus actividades en diferentes meses del año? ________ ¿Cómo?_______

Transporte- distancia

De la casa a:	Km	Dias por semana	Costo de movilización $	Tipo de transporte Moto, bicicleta, auto, caminar, otros	Tiempo (h/min)
Trabajo afuera					
Chacra (en otro lugar)					
Almacen					
Escuela					
OTROS					

Variables	**H / M (edad___)** **Horas**	**H/M(___)** **Horas**	**H/M(___)** **Horas**	**H/M(___)** **horas**
Usos del tiempo %				
Tiempo destinado al trabajo (pagado)				
Tiempo destinado a cultivo (pagado)				
Tiempo destinado al trabajo (hs/semanas/meses)				
Cultivos de susbsitencia				
Cultivos para comercio				
Trabajo no agrícola				

Trabajo ganado				
Pesca				
Recolección				
Tiempo invertido en educación				
Tiempos de colecta en el monte				
Tiempos dedicados a Casería en el monte.				
Otros trabajos				
Otros				
destinado a los niños				
Preparación de comida				
Almacén				
Transporte				
Recolección madera				
Religión				
Diversión/amigos				
Dormir				
Jugar				
Escuela				
Otros				

Caracterización económica

Flujo Monetario	**mes/ $ pesos**			
Trabajo no agrícola				
Agrícola				
Ganadero				
Industrial				
Otros				
Económico				
Subsidios/planes sociales				
Ingreso promedio hogar				
Ingreso promedio individuo Salario fijo Empleo temporal				

Ingreso de animales de granja (**anual**)				
Ingreso vacuno (**anual**)				
Ingreso granja (huevo, miel) (**anual**)				
Ingreso cultivo vendido (**anual**)				
Maiz				
Algodón				
Sandía /melon				
Zapallo				
Calabaza				
Soja				
Batata				
Poroto				
otros				
%subsistencia				
Industria/empresas				
Envió de dinero de algún familiar				
Otros				
Gastos producción agrícola	**(del periodo de cultivo)**			
Combustible				
Fertilizante				
Plaguicida/pesticida				
Contratar tractor(combustible incluido)				
Jornaleros				
Gastos de semilla				
Plantación				
Cosecha				
Maquinaria:Cosechadora				
Maquinaria: Pulverizadoa/Fumigadora				
Herramientas (vida útil)				
Transporte				
Gastos producción pecuaria				
Vacunas				
Infraestructura(gallinero, alambrado..)				
Compra de animales				

Alimentación				
Gastos en hogar	**Mes/$**			
Comida				
infraestructura Casa/hogar				
Productos limpieza				
Ropa, calzado				
Educación				
Salud				
Religión/cultura				
Servicios básicos: Electricidad				
Agua				
Gas				
Leña				
Otros gastos				

Herramientas de labranza; azada____ arado de mancera___ maquinaria_______ otros____

Consumo	**semana/mes**	**(litros, kilos)**	**pesos $.**	**Autosufic.**
Cereales				
Arroz/fideo				
Harina				
Maiz				
Otros				
Carne				
Hortalizas:Frutos y verdura				
Huevo				
leche				
Miel				
Carne de monte				
Harina de algarroba				
Cosecha de la algarroba				
Mistol				
chañar				
Otras				

Agua				
Leña/cocinar				
Electricidad				
Gas/combustibles				
Otros				

¿Desechos generados por día/semana/mes?______________

¿Qué hace con los desechos?____________

Otros	
Conflictos asociados a la agricultura (años) U otros conflictos	
Empresas involucradas	
Tenencia de la tierra (ocupante, propietario o comunal)	
Propietario/locatario Arrendatario	
Pertenece a alguna asociación u organización	
¿Arrienda su tierra? ¿A quién?	
¿Pertenece a alguna cooperativa?	

Vivienda tipo __________________-material (palma, material, otro)_________

¿Tiene electrodomésticos? ¿Cuáles? ¿Cuántos?

Freezer		Secador de cabello	
Heladera		Radio	
Microondas		Licuadora	
DVD		Celular	
TV		Computadora	
Juegos/nintendo		Incubadora	
lavadora			

¿Cuantos focos tiene?

¿Qué potencia?

¿Utiliza motor de agua?¿Qué potencia?¿Cuánto lo usa?

¿Utiliza bomba?¿Qué potencia?¿Cuánto la usa?

Agua

Pozo_____ perforación___________ represa________aljibe________laguna_____

Fuera del terreno ______ ¿cuál?____________

Usos de agua	Litros	Costo	Tiempo
Tomar/bebeR			
Agricultura			
Cocinar			
Limpieza			
Otro			

Clima

¿A tenido algún problema o efecto en su cultivo con las lluvias, granizadas, heladas, nortes, sequias…? ¿En que meses y años recuerda que fue más fuerte (severo)?

¿Encuentra que ha habido algún cambio en el tiempo en los últimos años?

¿Qué opina del cultivo de la soja?

¿Se ha visto afectada por ella?

¿Conoce casos de ese cultivo y cómo afecta o beneficia a esas familias?

¿Se han tomado algunas acciones en el caso de haberse presentados problemas?

¿Qué futuro ve usted si se expande la soja?

Ficha técnica_cultivo

Para cada cultivo	Nombre/ Variedad	cantidad	Precio	Días/Hombre	Horas/Tractor
Aplicación de herbicidas					
Semilla					
Siembra					

Para cada cultivo	Nombre/ Variedad	cantidad	Precio	Días/Hombre	Horas/Tractor
Cosecha					
Almacenado					

Ficha técnica (Tomarla con GPS)

Superficie total____________________

Superficie destinada a cultivos ______ ,____________,_______

Algodón_______Maíz….__________

Superficie destinada a ganado________

Superficie destinada a la granja________

Superficie destinada a la huerta___________

Superficie destinada a árboles frutales________

Superficie destinada a casa___________

Superficie de monte_________

Altura (altímetro). _______________-

ANNEX 2: The expansion of the pesticides and human health impacts35

La expansión de los agrotóxicos y los impactos en la salud humana.

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Resumen:

En éste articulo se aborda el conflicto que genera el uso de agrotóxicos en el norte de Argentina, su repercusión en la salud humana y el marco geopolítico que da dicho incremento de insumos en la agricultura, así como los impactos socioeconómicos de diferentes grupos sociales.

Palabras Clave: agroquímicos, glifosato, soja, intoxicación, Argentina

Los efectos de los agroquímicos en la salud.

El Glifosato es un herbicida de amplio espectro, no selectivo, esto es que elimina a gran parte de las plantas no deseadas. Fue creado en la década de los sesenta en pleno auge de la revolución verde, por la compañía Monsanto. En la actualidad se utiliza como un insumo para la producción de soja transgenica. Sin embargo no es el único agroquimico utilizado en éste cultivo, ya que además se aplica otro herbicida llamado 2,4-D y el insecticida Endosulfan.

Según Monsanto el Glifosato no causa riesgos en la salud. Sin embargo, la Agencia de Protección Ambiental (EPA) del gobierno norteamericano lo reclasificó recientemente dentro de la categoría "altamente toxico". Un estudio sobre los efectos del cultivo de soja indica que, desde el año 1995, en que se aprueba la soja transgénica y se produce su extraordinario crecimiento en cuanto a superficie sembrada, comienzan a hacerse notar enfermedades vinculadas a la gestación, y a diversos tipos de cáncer cuya frecuencia es llamativa (Gianfelici , 2008:15).

[35] Arizpe N. and Locatelli F., 2009. La expansión de los agrotóxicos y los impactos en la salud humana. Revista *Ecología Politica* Número 37.

La línea Roundup que contiene el glifosato así como su metabolito el ácido amino-metil-fosfónico (AMPA) y los coadyuvantes como el polioxietileno amina (POEA) son altamente tóxicos para las células humanas, en concentraciones muy por debajo de los niveles recomendados para uso agrícola (Ho y Cherry, 2009). La formulación de glifosato así como mezcla del compuesto glifosato-endosulfán-cipermetrina inducen un incremento en el daño del ADN (Poletta et al., 2009).

	Severidad		
Sistema orgánico	**Alta**	**Moderada**	**Baja**
Sistema gastrointestinal	• Hemorragia masiva	✓ Vómitos ✓ Diarreas	✓ Nauseas ✓ Dolor abdominal ✓ Vómitos ✓ Diarreas • Anorexia • Constipación
Sistema respiratorio	✓ Edema pulmonar • Paro respiratorio	✓ Dolor del pecho ✓ Depresión respiratoria ✓ Disnea, falta de respiración	• Tos • Dolor en el tr superior al resp irritación • Disnea, falta respiración
Sistema nervioso	• Coma • Parálisis, generalizada • Crisis convulsiva	• Confusión • Alucinación • Crisis convulsiva ✓ Pérdida de conciencia	• Hiperactividad ✓ Dolor de cabeza ✓ Mareos • Transpiración pro
Sistema renal	✓ Insuficiencia renal • Anuria	• Hematuria • Oliguria • Proteinuria	• Poliuria
Efectos locales en la piel	• Quemaduras de segundo grado • Quemaduras de tercer grado	• Ampollas • Quemaduras, segundo grado • Quemaduras, tercer grado	✓ Irritación • Edemas de la piel • erupción • Urticaria
Efectos locales en el ojo	• Perforación/ulceración corneal	• Abrasión corneal • Quemadura corneal	✓ Irritacion • Lagrimeo • Dolor
Otros efectos	✓ Diversos tipos de cáncer ✓ Malformaciones en recién nacidos.	✓ Reacciones alérgicas	• Fatiga • Malestar general

Cuadro 1. Signos y síntomas causados por las intoxicaciones agudas por plaguicidas, recalcando los síntomas registrados en Argentina y Paraguay. Basado en: OPS (2001), Palau *et al.* (2007) y Gianfelici (2008).

Un estudio realizado en Paraguay (Palau *et al.*, 2007), demostró que la salud, afectada por la aparición de síntomas y enfermedades, está correlacionada positivamente tanto con la pobreza como con la distancia donde se realizan las fumigaciones. Por ejemplo, al realizarlas a menor distancia de los hogares o escuelas, existe un mayor número de síntomas. Por otro lado, la afectación no sólo se da por exposición directa, sino que está vinculada a la contaminación de agua ya sea en el subsuelo como en aljibes y fuentes superficiales cercanas.

Los agroquímicos entran para quedarse.

El Glifosato hace su aparición masiva muy recientemente como producto clave para la agricultura en los años noventa; cuando la Empresa Monsanto crea por medio de la biotecnología la soja resistente a éste herbicida (soja RR), lanzando al mercado un "paquete tecnológico" de semilla más herbicida, que sumando a nuevas técnicas de agricultura como la siembra directa, genera en el sector agrícola menores costos de siembra y mantenimiento del cultivo, lo que ha significado un éxito rotundo en sus ventas. Monsanto logró en 10 años ser la dueña de más de 50 empresas semilleras en el mundo. El nuevo posicionamiento incluye la estrategia de controlar el mercado de semillas con la imposición de sus productos transgénicos (Jaña, 2009).

El monocultivo de soja considera en su modelo nuevos actores como los denominados "pools de siembra"[36]. Durante la campaña 2008-2009, en Argentina se han cosechado 45 millones de toneladas de soja en una superficie de 16 millones de hectáreas, desplazando cultivos tradicionales (Isaía y Aruguete, 2009). Es importante destacar que no solo la soja demanda el uso de agroquímicos, sino también el maíz, el girasol y el algodón entre otros, pero éstos lo hacen en menor proporción. Los agroquímicos más utilizados en los campos argentinos son el glifosato y el endosulfan, del primero se aplicaron 200 millones de litros para el año 2007, siendo que en 1991 solo se habían aplicado un millón de litros (FOCO, 2008).

Foto 1 Implemento utilizado para la aplicación de agrotoxiocos, comúnmente llamado "mosquito". © Nancy Arizpe.

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36 Los pools de siembra consisten en empresas de inversión con múltiples socios que no necesariamente provienen del sector agrario; buscando la reproducción de su capital en sectores con alta rentabilidad. Éstas empresas se caracterizan por: rentar tierras, contratar técnicos y producir soja sin importarles mucho la rotación de cultivo y por consiguiente el recurso natural que explotan, además de no considerar a las actividades de los pobladores.

Pero, ¿cómo se controlan las fumigaciones? Más allá del mercado internacional que frena o que presiona a los agricultores a realizar cultivos en rotación, existen ejemplos de intentos de control. Se puede mencionar, como ilustración lo sucedido en un municipio de Argentina, donde tras varios años de denuncias, en el 2009 la justicia ha impuesto restricciones de aplicación a los productores de soja. Así, se prohibió la aplicación de agrotóxicos[37] a menos de 500 metros de zonas urbanas, si se aplicaba en forma terrestre, y a menos de 1500 metros si la aplicación era aérea, suponiendo lo contrario un delito penal de contaminación ambiental y de peligro para la salud. Siendo positivos, esta medida sienta precedente para muchas denuncias en todo el país. Sólo habría que cuestionarse, ¿dónde quedan las zonas rurales?

En Paraguay es también importante destacar la participación de las organizaciones campesinas que desde el año 2004 vienen denunciando el uso indiscriminado de agrotóxicos en todos los casos relacionados al cultivo de soja. (Celema *et al.,* 2008). En el 2008 el nuevo gobierno paraguayo da un giro a su política y realiza un acercamiento hacia estos conflictos rurales. Pondera a las organizaciones y movimientos campesinos que venían pidiendo una Reforma Agraria, reforma que incluía el cese del uso indiscriminado de agrotóxicos. Sin embargo a pesar del cambio presidencial, aún continúa una gran represión sobre estos movimientos sociales, que desean y luchan por el cese de fumigaciones, topándose con el amplio poder latifundista (*www.lasojamata.org*).

Impactos sociales por el uso de agroquímicos.

El uso de agrotóxicos en Argentina y Paraguay es uno de los temas actuales que se debaten en la esfera política, pretendiendo mantener, a escala regional y nacional, una estabilidad económica del agro, sin considerar sus graves repercusiones, tanto a nivel socio-cultural como ambiental. ¿Quiénes son los que más sufren el impacto de estos agrotóxicos? Como siempre los pobladores locales, los campesinos, que a diario están en contacto directo con el cultivo sin medidas de precaución. Se ven así afectados irremediablemente ya sea por la dispersión de agrotóxicos ocasionada por los vientos, o por el escurrimiento del agua contaminada, que contamina el subsuelo.

En muchas de estas poblaciones afectadas, existe una gran discusión en torno a los impactos en la salud humana o en la producción y alimento de autoconsumo, referidas a la contaminación por agrotóxicos. En un balance positivo, vemos que muchas de éstas poblaciones se encuentran respaldadas por organizaciones y movimientos sociales, ONGs que dan seguimiento a un proceso judicial por los graves impactos generados en detrimento de la salud o de sus productos de autoconsumo y comercialización. Un caso es el de Lomas Senes, en Argentina,

[37] El término agrotóxicos es referido a los agroquímico que se ocupan para designar a los diferentes biocidas industriales que se aplican en la agricultura, y que tienen efectos tóxicos principalmente a la salud humana y organismos vivos en el medio.

donde en 2003 el Movimiento Campesino de Formosa (MoCaFor) presionó para llegar a un proceso judicial debido a que 23 de sus familias fueron contaminadas, además de tener impacto en la producción. Una vez más, en marzo de 2009 se vuelve a repetir la idéntica situación de contaminación. Nuevamente los pobladores sufrieron diferentes síntomas de contaminación como erupción en la piel, llagas, quemaduras, dolores de cabeza y garganta, irritación en la vista (ardor, lagrimeo), desgano, falta de apetito, entre otros. Además, se observaron otros impactos en sus granjas, como la mortandad de gallinas y patos, así como efectos de contaminación en los cultivos de subsistencia o comercialización local como el algodón, mandioca y batata. El MoCaFor ha sido uno de los actores principales que ha llevando el caso para abrir una orden judicial. Sin embargo, la falta de dinero para realizar análisis de sangre, agua y suelo ha sido un obstáculo para detectar los agrotóxicos.

Pero más allá de los síntomas indicados está la muerte prematura de niños. Tal es el caso de la comunidad campesina Leopoldo Perrier en Paraguay, donde en 2007 murió un niño de 3 años, a consecuencia de las intensas fumigaciones. A pesar de las reiteradas denuncias, los diagnósticos insuficientes no dieron evidencias suficientes para una orden judicial. Sin embargo las ONGs lograron impulsar la exhumación del cadáver mediante orden judicial, demostrando después de la necropsia altos niveles de agrotóxicos en el cuerpo. En Paraguay en el año 2004, fueron detectadas más de 400 muertes ocasionadas por el incontrolable uso de agrotóxicos en las zonas rurales marginales. La denuncia fue hecha por la Comisión de Derechos Humanos del Paraguay (CODEHUPY).

En este contexto podemos observar que tanto en Argentina como en Paraguay los movimientos y organizaciones de base, son en la actualidad la voz de los sin voz que reclaman el daño de la intoxicación propiciada por las irresponsables pulverizaciones. A partir, de procesos de concientización y participación desde abajo, se ha logrado rechazar tanto la contaminación del medio ambiente así como los daños ocasionados por el uso de los agrotóxicos. La presión y organización de estos movimientos sociales ha desencadenado una toma de conciencia de los gobiernos de ambos países para la toma de medidas más justas en favor de estos pueblos marginados.

Avance de la soja dentro de comunidades indígenas.

El acaparamiento y arrendamiento de las tierras en las zonas indígenas ha sido propiciado por las empresas agrícolas. Buscando favorecer sólo su beneficio, ocultan y aprovechan la ignorancia de estas regiones para no dar a conocer los efectos dañinos que producen los agroquímicos, frente a un estado que no actúa a través de las instituciones encargadas de asesorar a los pequeños productores. Debemos destacar que estas poblaciones indígenas marginadas no cuentan con la posibilidad de tener una asesoría técnica o un seguimiento jurídico debido a la pobreza y lejanía de sus pueblos.

Foto 2 Niña indígena en un lote de soja en el norte de Argentina. © Arizpe Nancy.

La colonia La Primavera, ubicada en la provincia argentina de Formosa[38], es un caso que refleja el de muchas colonias aborígenes Tobas, Wichís y Pilagas que se ven presionadas por el modelo sojero de uso irracional de agrotoxicos que por ende acarrea graves consecuencias desatendidas por la provincia y la nación. Dicha comunidad se encuentra en la actualidad en una disyuntiva entre obtener dinero, alquilando la tierra para subsistir, debido a que no tienen los instrumentos básicos para realizar la agricultura tradicional ni un mercado para comercializar.

Por otro lado, se ven forzados a vivir con los agrotóxicos que los daña permanentemente en los últimos años. Una de las respuestas principales de las comunidades ha sido la migración con la familia, fuera de área de cultivos. Empíricamente ellos han observado que, en las zonas próximas a las plantaciones de soja sufren síntomas como dolores de cabeza, envenenamiento en niños y ancianos, hay mortandad de peces, y disminución de cultivos de consumo familiar como la mandioca y la batata. A pesar de tener 5000 habitantes, ésta comunidad no cuenta con ningún centro de salud, por lo que la atención especializada a esta problemática se vuelve casi nula. Además, la colonia ha limitado sus formas de vida, comunes en otros tiempos, debido a la presencia de agrotoxicos. Tal es el caso de la caza, la recolección y la pesca, debido a la contaminación de lagunas, que por otro lado es su fuente de agua diaria, además de sus aljibes comunitarios.

Por último, el modelo sojero ha llevado a la perdida de la soberanía alimentaría puesto que los integrantes de la comunidad tienen que alquilar la tierra que utilizaban para huertos de autoconsumo. Si, en el mejor de los casos los conservan, la contaminación fuerza a la población al consumo dependiente del comercio como única opción.

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38 Formosa, ubicada en el norte argentino, es considerada la provincia con mayor índice de pobreza. Tiene una población indígena importante y posee un elevado número de conflictos asociados a la tierra.

Foto 3 Isla de soja. © Nancy Arizpe.

La aplicación de insumos que conlleva el modelo de los cultivos transgénicos además de generar severos problemas de salud, provoca una modificación en los patrones de producción en zonas que antes no eran agrícolas, que trae como consecuencia la deforestación de grandes extensiones, creando en algunos casos las llamadas "islas de soja".

Por un lado, las organizaciones y movimientos sociales tienen un papel importante en la lucha por atenuar la grave situación de la salud en el área rural, tradicionalmente desprotegida por falta de planificación gubernamental en las políticas públicas, además éstos mantienen una comunicación respecto a los impactos del uso de agroquímicos, para que la población comprenda la dimensión real que tiene su uso. Y por el otro, hay que cuestionarse ¿cómo disminuir el uso de agroquímicos? si el sector empresarial agrícola está por encima de los gobiernos, como ocurrió a inicios de 2008, cuando el gobierno argentino buscaba aumentar las retensiones de exportación de la soja principalmente. Más allá que su objetivo no era la reducción del uso de agroquímicos, éste se vería disminuido con dicha medida. Sin embargo esto no se consiguió, lo que demuestra el poder real que poseen las grandes empresas agrícolas que reaccionan rápidamente cuando ven amenazada su extraordinaria rentabilidad. Cabe reflexionar que escenarios futuros tiene la contaminación por agroquímicos en estos países cuando los gobiernos locales no pueden hacer frente a las grandes empresas que están detrás de la agricultura industrial.

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ANNEX 3: Could mechanization be a solution for poverty in a Mayan community? Mennonite's Vs. Maya's agricultural production systems

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Summary

In this paper, the metabolic transition from traditional milpa[39] to mechanized agriculture (Mennonite's production) in a Mayan community is analysed, considering the main agricultural conflicts. In this sense, patterns of energy consumption in productive activities are linked to land-time changes to identify metabolic pathways, transitions and plausible future scenarios considering the different narratives and the main conflicts of the local population.

The above objective involves the application of the Integrated Multiscale Integrated Analysis of Societal and Ecosystem Metabolism (MuSIASEM, Giampietro, 2003) and other approaches as political ecology to analyze the main conflicts implicated in the technologization of agriculture.

Keywords:

environmental conflicts, milpa, Mennonites, Mayas, integrated analysis,

Abstract

Introduction

The agricultural production in Mexico has different patterns, for example, traditional-subsistence agriculture as well as monoculture/mechanized agriculture. The first implies lots of labor and is basically for subsistence and local markets, and it includes indigenous farmers/peasants, with low energy input agriculture (LEIA). The second is an industrial agriculture, which implies more technical inputs, less labor with high or medium energy input agriculture (MEIA-HEIA). These differences imply social inequalities (poverty) and different consequences such as major biodiversity loss and land degradation.

[39] Historical Mexican form of production based in maize

The case study considers at the local scale the analysis of the Xmaben community where ten years ago, the Mennonites[40] joined the local Maya population. At the regional scale the analysis of other Mennonites communities which have expanded during the last ten years is also included.

Xmaben is located in the municipally of Holpechen in Campeche State in Mexico. Campeche is one of the poorest States with an important number of indigenous Mayas. The community area is important for conservation policies because it is in the focal area of the biologic corridor, and it is near the Calakmul Biosphere Reserve.

The community has an ejidal[41] land with 36,808 hectares. In year 2000 an agreement was reach on a 5,000 hectares transfer to the Mennonites. The Mayan population is around 1,123 people (Porter et al., 2006) with 230 households (local data) while the Mennonites population is approximately 850 people.

The main economic activities are agriculture, apiculture, livestock, forestry and timber sales. The Xmaben community started with the gum production in the 30's, activity that disappeared with the price fall of the 70's. Apiculture, livestock and timber sales remain as the main economic activities. Milpa represents the fundamental source of subsistence and food sovereignty.

The Mayas have a different classification of soils which is linked to the different agricultural activities, and also they have different uses i) the *milpa,* with 1 to 2 hectares per family and for which the distance to the house is from 1 to 20 kilometers, is the base for the main crops such as corn, beans and ibes ii) the *solar*, a land around the house with fruit trees, medicinal plants, vegetables and herbs, poultry, pigs and others, where women are the main workers (unpaid work), iii) the area designated to the forest (*terreno*) which is 1 or 2 kilometers away and where they have mainly fruit trees and horticulture (chili, tomato, beans) iv) the *mount* where they practice hunting and gathering and also timber sale, and apiculture.

Following the recent increase in population (40% in the last ten years), there is not enough space for milpa (slash and burn), and deforestation caused by livestock herding fast produced soil erosion which in the case of the jungle vegetation is very sensitive . As a consequence, an important part of the community does not have enough food for their subsistence; moreover this situation is worsened by the increase of the climate variability (hurricanes and tropical rains).

Another trigger for deforestation is the entry of Mennonites in 2000 by means of buying 5000Ha of land. The main problem is the agricultural practice employed.

[40] The Mennonites are farmers, direct descendants of the sixteenth century Anabaptist movement. In Mexico there are 80,000 Mennonites registered. The main purpose of their religion is the production of the land.

[41] A natural set of land, forest, water bodies and, in general, all resources that constitute the patrimony of a farm population centre, which is owned communally.

This kind of influence changed the land use in the region and influenced the indigenous culture.

This paper will link the main socio-ecological conflicts with the different uses of time, land, cash flow, energy flow, biomass among others, as well as different agricultural practices.

Methods

The methods include observatory participation. The data collection was through depth interviews and questionnaires, the sample considers 40% of the households in the community of Xmaben, and each household interview considers a questionnaire for women and men.

For regional scale we include a database from INEGI, SAGARPA, CFE and local censes. The analysis of land use includes topographic maps and land use change maps from INEGI considering the GPS information collected. The software used was ARC VIEW and Google Earth.

With the data obtained we reconstructed a narrative that considers the different perceptions of the local as well as the resulting integration of quantitative models represented by the energy involved (exosomatic/endosomatic). Along with the consideration of the main environmental conflicts, this allows creating future development scenarios for decision making in an integrative way.

Results

The results show a comparison of the main Maya activities (milpa, solar, apiculture, timber sale, agro-forestry land, and livestock) based on a Low Energy Input Agriculture compared with the ***Mennonites*** production (extensive agriculture) which implies a High and Medium Energy Input Agriculture.

At the local scale we consider the endosomatic energy that is related to the diet-food sovereignty, the exosomatic energy (inputs for agriculture, fuel wood, transport etc.), the differences in labor, monetary flows, and energy among others.

At the regional scale we focus on exosomatic energy to emphasize the mechanized production (modern agriculture) and the main impacts generated by deforesting the jungle. We also include as drivers of change the main policies implicated in the decision making and the regional market, which has different implications for both the Mayan and Mennonite communities, and the relationship between them.

The analysis of scenarios and perceptions-narratives tries to answer the following questions:

- Why the Maya consider moving from Milpa to mechanized agriculture an option?

- Could the metabolic transition be a solution for food sovereignty and poverty?

- Which could be the socio-cultural impacts, economical impacts and biophysical?

- Why the government promotes different policies for Mayans and Mennonites? (The government considers a success the Mennonites' practice and gives them technical and financial support. Moreover, it subsidizes Mayan people for activities that are not related to their culture and tradition, for example via payment for environmental services' schemes).

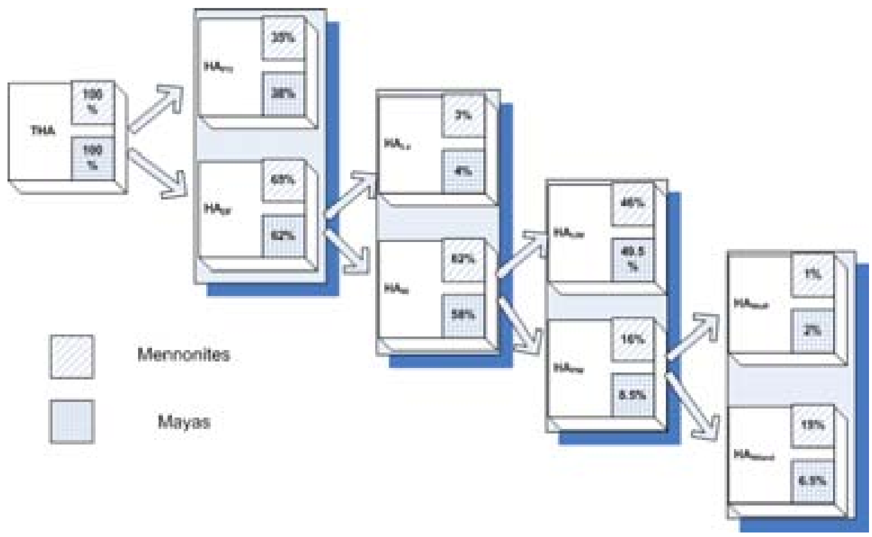
The local narratives identified are:

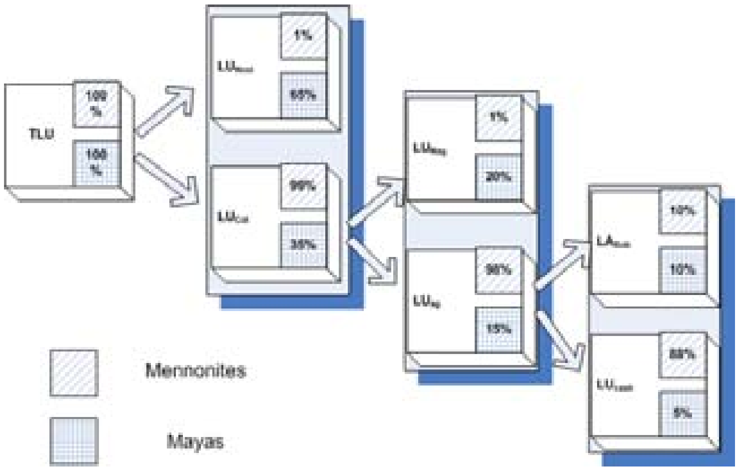
i) Using livestock for savings and the implications of deforestation (increasing the metabolic pattern),

ii) Mechanization of agriculture-timber sales and the implication of deforestation, climate variability and their socio-economical implications (loss of production),

iii) Increased financial dependency on subsidies, articulated by local-regional policies through payments for environmental services, and finally

iv) Rise of conflicts between Mayan population and NGOs and scientific researchers

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ANNEX 4: Reconversión cañera y biocombustibles en Veracruz, México ¿Para quién?42

Nancy Arizpe y José Agüero Rodriguez *

En este artículo se aborda el conflicto de la expansión y tecnologización de la caña de azúcar para la producción de bioetanol en México como parte de un plan nacional de desarrollo económico / rural de "reconversión de tierras". Se pone énfasis en el caso pionero de dos factorías en la cuenca del Papaloapan, región del centro de Veracruz.

1. Desarrollo rural y neoliberalismo en el sector cañero

México se ha caracterizado por ser un país exportador neto de energía primaria, fundamentalmente por el volumen de exportaciones petroleras (Becerra, 2009). En los últimos años se discuten y realizan programas para llevar a cabo una reconversión de tierras que implica la generación de energías alternativas como biocombustibles. Uno de estos programas es la producción de etanol a través de la caña de azúcar, específicamente en Veracruz la reconversión de bosques y agro-ecosistemas cafetaleros en monocultivos de caña es una constante.

La industria azucarera es importante para la economía mexicana. El cultivo rinde anualmente 120 toneladas por hectárea (Viniegra-González, 2001). No obstante, la industria cañera tiene severos impactos ecológicos y sociales (Domínguez, 2001). Históricamente el campesinado mexicano ha protestado por los impactos que generan el cultivo y la industria cañera[43].

El sector cañero desde los años noventa ha sufrido una profunda crisis debido al incremento en las importaciones de azúcar y sacarosa de maíz venidas de Estados Unidos (EU) y Centro América en una competencia desleal por las restricciones impuestas por el Tratado de Libre Comercio (TLC). Por un lado los agricultores no pueden recibir más subsidios en la producción y comercialización del producto, y por el otro agobian los aranceles de importación a los productos agrícolas. A todo esto se añade la aceptación de acuerdos ambiguos sobre las cuotas de exportación del azúcar.

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[42] Nancy Arizpe, Jose Agüero 2011. **Reconversión cañera y desarrollo económico y rural, ¿Para quién?** *Ecología Política* Número 37. Páginas????

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[43] La primera protesta de Zapata en Morelos fue contra un ingenio azucarero. "Los pueblos fueron despojados también del agua, para regar los cañaverales y generar fuerza motriz en los ingenios azucareros"

Actualmente la industria cañera se ha visto asechada por la producción de jarabes (fructuosados) que EU introdujo y desplazo al producto principal que era el azúcar granulado; de ésta manera el azúcar importada ha obtenido un precio más bajo que le permite desplazar relativamente la industria nacional que subsiste, castigando así con sueldos bajos a cortadores y obreros de la industria, (Viniegra-González, 2001; Bravo y Cortes, 2009).

No obstante, sigue siendo una fuente importante de ingresos para la industria y el sostenimiento del empleo regional. La industria cañera actualmente ocupa una superficie de 812 mil Ha, en 15 estados de la república, operan 67 ingenios azucareros, genera 440 mil empleos directos y 2.5 millones de empleos indirectos (UNC, 2010). Veracruz es el principal productor con 19 ingenios azucareros, aporta el 44% del azúcar nacional, tiene 250 mil Ha. sembradas (Buzos, 2010). Sin embargo, sin los apoyos necesarios y su necesaria reconversión tecnológica difícilmente podrá subsistir por mucho tiempo.

2. ¿Bioetanol por qué y para quién?

En México, desde hace varios años, se produce etanol de caña de azúcar en los diferentes ingenios del país que cuentan con destilerías, sólo que su uso es para bebidas embriagantes e industriales.

Ante tal problemática, han surgido dificultades de ascender a una producción rentable y limpia de la caña de azúcar, quedando como única opción de las Instituciones Gubernamentales la reconversión industrial para producir bioetanol.

Las normas establecidas para tal fin y los incentivos son relativamente recientes en México, pero ahora se perfilan como una prioridad para la reconversión energética enclaves importantes en el norte, centro y sur de México con plantas exóticas alrededor de la producción de la caña de azúcar (Wilson, 2008).

En México se ha venido construyendo un marco legal e institucional sobre el etanol. Existe una Ley de Desarrollo Sustentable de la Caña de Azúcar (2005); una Ley de Promoción y Desarrollo de los Bioenergéticos(2008); una Norma Oficial Mexicana 086, (2006). Así también estudios como SENER y PROINBIOS apuntan a la producción de etanol a gran escala como combustible en transportes[44] (SENER, 2006; SAGARPA, 2007; Aguilar, 2007; GAIN, 2007).

Figura 1. Construcción de la Central Energética del Golfo

[44] Pretendiendo producir alrededor de 40 millones de litros para 2015,700 millones para el 2020. En 2024, pretenden cubrir el 50% de la demanda con este tipo de combustible.

De esta manera se han venido realizando una serie de pasos para la reconversión del campo, con énfasis en la producción de biocombustibles. Donde en 2011 se pretendió incorporar una Mesa Redonda sobre Biocombustibles Sostenibles RSB.

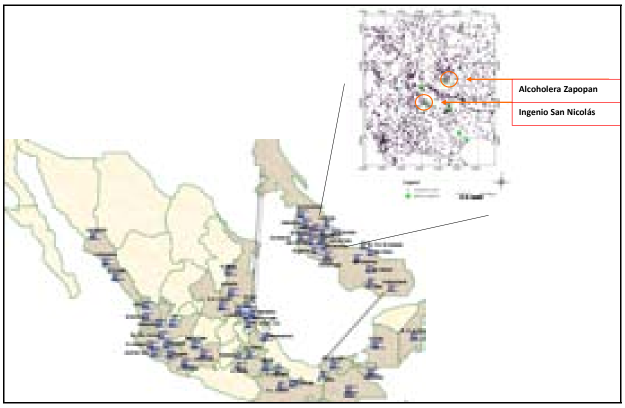
La incorporación a de estos planes supondría un acaparamiento de tierras (Graina, 2011) y una industrialización de la agricultura que implicaría la "transformación de la agricultura de una producción de energía en un consumo de energía" (Martínez-Alier, 2011). Al respecto, los grupos opositores45 han manifestado su rechazo, en una declaración publicada, donde llaman a prohibir de inmediato el acaparamiento de tierras." (GRAIN, 2011a; GRAIN 2011b)

3. El caso de la Región Córdoba Veracruz y los impactos reales

Los estudios nacionales sobre la producción de azúcar que se han hecho evaden frecuentemente los impactos a escala regional o local que afectan a los campesinos y ecosistemas. Un ejemplo de ello es la región Córdoba-Orizaba, en el centro del estado de Veracruz, México que se caracteriza por su producción tradicional de caña de azúcar, alcohol y bagazo para la producción de papel.

Figura 2. Mapa de la Industria cañera y región estudiada.

[45] Amigos de la Tierra Internacional, la Campaña Global por la Reforma Agraria, el Centro de Estudios para el Cambio en el Campo Mexicano, FIAN International, Focus on the Global South, el Foro Mundial de los Pueblos Pescadores, GRAIN, La Via Campesina, Land Research Action Network y Rede Social de Justiça e Direitos Humanos



En diciembre de 2007 a un año de la entrada en vigor para eliminar las barreras arancelarias del edulcorante y la apertura comercial de EU para el libre mercado de la caña de azúcar, the American Sugar Refinig INC, uno de los mayores consorcios mundiales que monopoliza la producción, distribución y venta azucares en el orbe, adquirió uno de los ingenios azucareros pioneros en la producción de bioetanol en México: el ingenio San Nicolas, localizado en Cuichapa, Veracruz. Para este entonces sólo el Ingenio la Gloria y San Nicolas producían en conjunto 36 millones de litros anuales del etanol (Enriquez Poy, 2007).

Aunque la trasnacional American Sugar Refinig INC, perteneciente al grupo Florida Crystals Corporation es líder mundial en el control de la producción y el mercado del azúcar, su interés futuro es la producción de bioetanol. Especialmente en México, las inversiones de Florida Cristal en 2010 fueron una producción de 50 mil litros diarios de etanol[46].

Otra empresa que producirá bioetanol es la alcoholera de Zapopan S.A. de C.V. ubicada en Atoyac, Veracruz, filial de la poderosa Alcoholera Zapopan. Durante 2010 invirtió en la construcción de una planta energética para producir energía eléctrica a partir del bagazo de la caña y bioetanol, adquiriendo y rentando parcelas e insumos para la producción propia de caña de azúcar. El proyecto implica duplicar sustantivamente la producción de azúcar y la incorporación de biocombustible. Asimismo, requerirá de estrategias propias para controlar la producción a través de la compra y arrendamiento de parcelas y un control propio de las labores culturales del cultivo para que no quede a expensas de los vaivenes económicos de los productores. La producción de bioetanol de sólo dos plantas procesadoras requerirá incrementar sustantivamente la producción de caña de azúcar en cerca 12 mil has.

Tabla 1. Producción estimada de las empresas cañeras-bioetanoleras Zapopan y San Nicolás en el proceso de reconversión 2010-2011 (Elaboración propia con fuentes hemerográficas y trabajo de campo).

Empresa	Zafra 2009-2010 Ton/MT	Ha Promedio	Zafra 2010-2011 Ton/MT	Ha Prom.	Producción aprox. bioetanol

[46] http://www.enlacecordoba.com/noticias-cordoba/noticias-cordoba/1711-con-una-inversion-de-60-mdd-el-ingenio-san-nicolas-producira-etanol.html

	estimado	(75 ton/Ha)	Estimado	(75 ton/Ha)	
Alcoholera Zapopan	500 mil	6.666,6	1.200 mil	16.000,0	50 mil/l/d
Ing. San Nicolás	611 mil	8.146,6	800 mil	10.666,0	50 mil/L/d.

Sobre la expansión territorial y de competencia que estas dos empresas impulsan actualmente para fomentar la producción de biocombustible con caña, se han manifestado las primeras inquietudes y controversias por parte de las organizaciones de productores cañeros en la región de la cuenca del Papaloapan ya que los productores, aunque pueden vender libremente de acuerdo a la legislación, cuentan con contratos de compra venta que comprenden compromisos crediticios de avío en especie y acuerdos de entrega de sus cosechas a determinados ingenios. Al respecto, las organizaciones cañeras han manifestado que el crecimiento de la cobertura de estos ingenios pondrá en grave riesgo la disponibilidad de materia prima para la producción del dulce e implicará una competencia desleal para los ingenios tradicionales que se dedican a su producción[47]. Asimismo, los efectos no solo son de competencia por la cobertura territorial, la producción de caña, sino por los efectos socio-ambientales probables que esto traería consigo.

En el nivel regional, el monocultivo cañero incide en la calidad del suelo y tiende a expandirse la frontera agrícola, y su producción requiere de fuertes cantidades de agroquímicos y pesticidas que se vierten a los suelos, el aire y las fuentes hídricas regionales. Así mismo, la producción cañera y los procesos de producción industrial se caracterizan por el uso intensivo de agua para ambos procesos que convierten a esta industria en una de las más demandantes del líquido regional. En la región Cordoba-Orizaba la producción y transformación de la caña de azúcar, la industria alcoholera y la papelera Kimberly Clark, son las industrias que más agua utilizan en sus procesos productivos, por lo que las externalidades provocadas en ambos procesos de producción y transformación son preocupantes. Las tres industrias se consideran altamente contaminantes del agua (CNA, 2007).

Figura 3. Entrega de caña de azúcar en el Ingenio San Nicolás.

[47] El Sol de Córdoba 5 de agosto de 2010 http://www.oem.com.mx/diariodexalapa/notas/n1733619.htm

En el caso de la industria azucarera se depositan anualmente cantidades exorbitantes de melazas a los ríos y arroyos de las subcuencas del rio Blanco y Jamapa-Atoyac. Estas aguas que desembocan en cerca de 15 municipios agrícolas y ganaderos, aguas abajo, así como a la zona urbana de Boca del Río, Veracruz han generado una fuerte reacción social de productores y consumidores domésticos y de servicios al perjudicar la calidad de agua de huertos que requieren inocuidad como son la producción de limón persa para la exportación, la salud animal de una rica zona ganadera, áreas de servicios turísticos, pescadores y consumo domestico de municipios y pueblos asentados a las orillas de la subcuenca. En resumen, una zona de alta conflictividad alrededor del uso del agua

La descontaminación de los ríos y la protección de los mantos acuíferos son demandas centrales porque afectan el interés colectivo de productores y consumidores del vital líquido (Agüero, 2010).

4. Discusión

El impulso a la producción de biocombustible a partir de la caña d azúcar es un proceso complejo para las expectativas de los productores, las políticas públicas y los industriales del azúcar en México. A pesar del discurso oficial que alimenta la idea que la producción de bioetanol es una ocasión invaluable de inversiones y agro negocios, que contribuye a la disminución del calentamiento global con energías limpias[48]. Estas expectativas, más bien están siendo revisadas y aprovechadas por empresas trasnacionales que ven en estas posibilidades francas oportunidades de invertir en México.

Producir biocombustibles implica duplicar o triplicar la superficie sembrada de caña. Incrementar la brecha agrícola envuelve el mayor desplazamiento de los cultivos tradicionales como la producción de maíz o frijol para el consumo básico de la población. Disminuir la superficie cafetalera, de por sí en crisis desde la década de los noventa y por lo tanto afectar, aún más, los ecosistemas cafetaleros.

De acuerdo con las declaraciones de empresarios, la reconversión impone que las empresas tengan un pleno control de los procesos productivos, por lo que la estrategia es la compra de tierras, el arrendamiento y los contratos con productores de tal manera que la empresa garantice sus cosechas sin depender de las decisiones externas y los vaivenes del mercado. Esta tendencia puede derivar en la reconcentración de tierras agrícolas por estas grandes transnacionales.

En relación con los efectos ecológicos regionales también se perfila un panorama nada halagador. La producción tradicional del azúcar en sus diversas fases es emisora de efectos perniciosos que aún no han sido resueltos, sus actividades se consideran de las industrias más contaminantes por la *Comisión Nacional del Agua* (CNA) (CNA, 2007) y la *Secretaría de medio ambiente y recursos naturales* (SEMARNAT) de México. Desde la producción primaria que implica el desmonte hasta la utilización de grandes cantidades de fertilizantes y pesticidas y finalmente la quema, son procesos que saturan las tierras, eutrofican las aguas, causan daños a flora y fauna, erosionan las tierras y destruyen el habita de flora y fauna nativas. También la producción industrial implica contaminación en zonas de riego o a las tierras agrícolas. Así como alto impacto a los cuerpos de agua.

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[48] http://www.oem.com.mx/diariodexalapa/notas/n502219.htm

La política de biocombustibles no es una solución para el problema de la energía (Russi, 2008; Giampietro, 2009). El gobierno mexicano plantea una alternativa como mitigación al cambio climático, sin embargo el ahorro total de energía (y de CO_2) es muy bajo o incluso negativo. Además de que se requiere grandes cantidades de suelo agrícola, deforestación, contaminación, reducción de seguridad alimentaria. Además de los salarios bajos para los que lo cosechan.

Por otro lado, tomando en cuenta los estudios de Giampietro (2009), se afirma que no es viable energéticamente la producción de etanol, recalcando que es poco probable que el paradigma de la agricultura industrial contribuye a solucionar los problemas del desarrollo rural en los países en desarrollo (excepto en nichos especiales).

El plan de reconversión de caña de azúcar para bioetanol y su proceso a escala regional-local conlleva al incremento de: impactos ecológicos, degradación de suelos, pérdida de biodiversidad, contaminación de ríos/cuencas; impactos sociales, incremento de enfermedades respiratorias por zafra, reducción de mano de obra y empleos locales substituidos por maquinaria, pérdida de soberanía alimentaria; impactos económicos, mayores ingresos para las corporaciones/empresas y menor ingreso a los pequeños productores; impactos políticos, reajuste en las normativas ambientales, ruptura de sindicatos y organizaciones sociales, flexibilización de los productores, explotación del trabajo jornalero, por lo que es necesario emprender una vigilancia estrecha sobre sus probables consecuencias.

Agradecimientos

Agradecemos a los campesinos entrevistados de la región Córdoba-Orizaba así como a las Asociaciones de Cañeros. José Agüero R. proyecto Riesgos socio-ambientales, vulnerabilidad y desarrollo sustentable" PROMEP 103.5/10/5000 PTC 414. Nancy Arizpe es Becaria FI y grup de recerca 2009SGR-517.

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ANNEX 5: Curriculum Vitae

PERSONAL **I**NFORMATION

Name	**Nancy Guadalupe Arizpe Ramos**
Address	Sanatori 10, Sant Cugat 08196 Barcelona, España
Telephone	(+34) 652817276
E-mail	nancy.arizpe@gmail.com, NancyGuadalupe.Arizpe@uab.cat
Nationality	Mexican
Date of birth	25/08/1980

1.1. ACADEMIC EDUCATION

• Dates (from – to)	From ¨September 2008 until now
• Name and type of organization	Institute of Environmental Science and Technology (ICTA) Autonomous University of Barcelona (UAB), Spain.
• Name	**PhD Candidate in Environmental Sciences**
• Dates (from – to)	From 2007/2008
• Name and type of organization	Institute of Environmental Science and Technology (ICTA) Autonomous University of Barcelona (UAB), Spain.
• Name	**Master in Environmental Studies**
• Dates (from – to)	From September 20011/July 2012
• Name and type	Escola de Mitjans Audisuals EMAV, Barcelona Spain
• Name	**Postgraduate in Audiovisual Production**
• Dates (from – to)	From September 2007/September 2008
• Name and type of organization	Faculty of Communication Sciences, Autonomous University of Barcelor Spain.
• Name	**Postgraduate in Photojournalism**
• Dates (from – to)	2001-2006
• Name and type	National School of Anthropology and History (ENAH), Mexico
• Name	**Bachelor Degree in Physic Anthropology**
• Dates (from – to)	From January 2000-2005
• Name and type of organization	Faculty of Science. National Autonomous University of Mexico (UNAM), Mexico
• Name	**Bachelor Degree in Biology**.
• Dates (from – to)	September 1998 to 2003
• Name and type	National School of Music (ENM, UNAM), Mexico
	Technical Bachelor in Music (Percussion)

1.2. Participation in projects, contracts and research agreements (indicate the funding entity)

-**Member of the Research Group of Catalan Govenment**
Economia Ecològica (ECONECOL) del Dr. Jeroen van den Bergh,
Reference: 2009SGR-517

- **Scholarship: Becari FI Modalitat B (2009-2011)**
Reference: SEJ2006-15219 Funding: Generalitat de Catalunya

- - Scholarship: BE-DGR (2010)
Reference 2010 BE1 00381 Funding: Generalitat de Catalunya

- Project Fundación Autónoma Solidaria, UAB (Agoust – September 2010) Participatory Mapping
Reference: **CONSERVCOM project** Funding: FAS, UAB

- Project: Metabolismo Social y Conflictos Ambientales
Reference:CSO2010 21979 Funding: MEC

- Project: Metabolismo social, tendencias, conflictos y respuestas. Ministerio de Educación España. (UAB Barcelona, España)
Reference: SEJ2006-15219 Funding: MEC

- -: Erasmus Exchange in IFF, Wien. (April-August 2009)
Reference Erasmus UAB Funding: European Union

- Project ALFA SUPPORT - Sustainable Use of Photosynthesis Products & Optimum Resource Transformation". (UAB Barcelona, España) September/ March 2008.
Referencia AML/19.0901/06/18414/II-0545-FA-FCD-FI Funding: European Union

- ALARM Assessing Large scale Risk for the biodiversity with tested Methods (UAB Barcelona, España) March/July 2007
Referencia GOCE-CT-2003-506675, Funding: European Union

1.4. Publications and scientific results (for journals, where appropriate, indicate impact factor, area and quartile)

Arizpe Nancy, Ramos-Martin Jesús and Giampietro Mario 2012 **Characterization of the metabolic profile of two rural communities threatened by soy expansion in the North of Argentina**. Submitted to Agriculture, Ecosystems and Environment

Arizpe Nancy, Ramos-Martin Jesús and Giampietro Mario 2012 **Scaling societal metabolism: from household to community metabolism**. Draft paper to submit to Land Use Policy.

Arizpe Nancy, Giampietro Mario, Ramos-Martin Jesus 2011. **Food security and fossil energy dependence: an international comparison of the use of fossil energy in agriculture (1991-2003)**. Critical Reviews in Plant Sciences, Vol.30: 45-63.

García-López Gustavo A. and Arizpe Nancy 2010. **Participatory processes soy conflicts in Paraguay and Argentina**. Ecological Economics Volume 70, Issue 2. Pages?

Villers Lourdes, Arizpe Nancy. Orellana Roger, Conde Cecilia, Hernandez. Josefina 2009. **Impactos del cambio climático en la floración y desarrollo del fruto del café en Veracruz, México.** Interciencia 2009, vol. 34 no. 5. Pages?

Spangenberg, Joachim H., Arizpe, Nancy, Rodríguez-Labajos, Beatriz, Binimelis, Rosa, Martinez-Alier, Joan, Maxim, Laura, Douguet, Jean-Marc (2010). **Socio-Economic Research within a Field Site Network Established by Ecologists – Pragmatic Approaches to Create Added Value**:48-49. **Atlas of Biodiversity Risk**. Edited by Settele, Josef, Penev, Lyubomir, Georgiev, Teodor, Grabaum, Ralf, Grobelnik, Vesna, Hammen, Volker, Klotz, Stefan, Kotarac, Mladen and Kühn, Ingolf. Pensoft Publ., Sofia/Moscow, 264 p.

Arizpe Nancy y Locatelli Fernando 2009. **La expansión de los agrotóxicos y los impactos en la salud humana.** Ecología Política Número 37. Pages?

Arizpe Nancy, Agüero Jose 2011. **Reconversión cañera y desarrollo económico y rural, ¿Para quién?** Ecología Política Número 41. Pages?

Draft papers

Arizpe Nancy and Ramos- Martín Jesus 2012. **Could mechanization be a solution for poverty in a Mayan community? Mennonite's Vs. Maya's agricultural production systems.** To be submitted within the Special Issue titled: Pathways of rural change: An integrated assessment of the socio-ecological metabolism of emerging ruralities. Journal of Agricultural Systems

1.5. Research stays abroad (indicate the length of the stay)

- **Research internship** April - September 2011 (six months)
    - **Name of organization:** The Commonwealth Scientific and Industrial Research Organisation CSIRO Ecosystem Science.
      Country: Brisbane, Australia.
    - **Grant:** AGAUR
- **Research internship** November 2010-January 2011 (three months)
    - **Name of organization:** Universidad Veracruzana
    - **Country:** Orizaba, México.
    - **Scholarship:** MEC Project
- **Research internship** April -August 2009 (five months)
    - **Name of organization** Institute of Social Ecology IFF, Klagenfurt University, Austria
    - **Country: Wien, Austria.**
    - **Scholarship:** Erasmus
- **Research internship** October 2008-March 2009 (six months)
    - **Name of organization** GEPAMA University of Buenos Aires UBA
    - **Country:** Buenos Aires, Argentina
    - **Scholarship:** European Union.