Land use change, agriculture and socio-economic implications

CLARIS LPB WP8
Introduction

CLARIS LPB Project: A Europe-South America Network for Climate Change Assessment and Impact Studies in La Plata Basin

The CLARIS LPB Project, funded by the European Community 7th Framework Programme, aims at predicting the regional climate change impacts on La Plata Basin (LPB) in South America, and at designing adaptation strategies for land-use, agriculture, rural development, hydropower production, river transportation, water resources and ecological systems in wetlands.

CLARIS LPB is integrated by 20 Partner Institutions from South America and Europe (research institutes from France, Argentina, Brazil, Germany, Italy, Spain, Sweden, Switzerland, United Kingdom and Uruguay) gathering more than 150 researchers, engineers and students and counts on the cooperation of various private institutions and NGOs.

The expected impacts of CLARIS LPB at the end of its four-year period (2008-2012) are:

• Strengthening of the cooperation between European and South American multidisciplinary research communities.

• Improvement of climate change impact prediction capacity for the region through the setting-up of an ensemble of multidisciplinary scenarios integrating in a coordinated way large-scale climate, regional climate, hydrological, land-use, and agriculture partners.

• Dissemination of adaptation strategies (specifically designed for land-use, agriculture production, rural development (small farmers), hydropower, flood risk, wetlands ecological systems, river navigation, and near-river urbanization) based on ensembles of probable climate change scenarios for the period 2010-2040.

This multidisciplinary network is divided in four inter-related and fully complementary Subprojects (which are also divided in different work packages):

• **Subproject1**: Management, dissemination and coordination activities.

• **Subproject2**: Past and future hydroclimate. Its objective is to improve our description and understanding of past and future climate variability in order to better represent possible future climate scenarios and quantify their possible uncertainties.

• **Subproject3**: Project interface. It aims at bridging the climate research with the socio-economic issues.

• **Subproject4**: Socio-economic scenarios and adaptation / prevention strategies. It builds adaptation strategies to climate change on different issues associated to land-use, agriculture, deforestation, hydropower production, floods and ecological systems in wetlands.
“Land use change, agriculture and socio-economic implications” is within Subproject 4 and its primary objective is to reveal deep and comprehensive insights into the complex net of impacts and interdependencies of climate change and anthropogenic adaptation measures for land use, agriculture and deforestation, by identifying causal chain relationships between climate change and induced anthropogenic reactions on land use, agriculture, bio energy and deforestation.

The focus is set on the agricultural sector, specifically on small and large farms. Main cropping systems of major socio-economic relevance are being analyzed and simulation studies for different climate scenarios will be projected under climate change driving forces. A further objective is to carry out an assessment to make explicit the strong relationship existing between land use systems, climate and water cycle, in order to define integrated adaptation strategies to climate change impacts.

The research should allow the elaboration of scenarios of potential future land use options identifying its impacts on social factors, such as migration, poverty, and economic implications such as GDP variation and unemployment rate. This might be achieved building an indicator framework that includes farmers’ participation in the development of an assessment tool to be integrated on a later stage into a warning and decision support system for decision makers.

In this brochure, each group from WP8 describes its system under study explaining the vulnerability of each system to climate; the usefulness of climate scenarios in the projection of future vulnerability and the design of possible adaptation strategies; and how stakeholders will be included in the research process.
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The need of a framework

The analysis of land use change and its impacts on Sustainable Development is complex and multi faceted. Land use change results from manifold interactions between society and environment. Society influences land use through political, economic and social processes. Interactions occur between different scales, impacts are spatially explicit and changes are evolving in time. A comprehensive framework is needed to structure the cause-effect relationships present in these situations.

The DPSIR conceptual framework for CLARIS LPB

The DPSIR conceptual framework was developed by the European Environmental Agency (EEA) in 1999 (Smeets and Weterings, 1999). According to the framework, there is a causal link between “driving forces D” (human activities) through “pressures P” (emissions, waste) to “states S” (physical, chemical, biological, socio-economic) and “impacts I” on the system leading eventually to political “responses R”. The causal chain from “driving forces” to “responses” need be broken down into steps by considering relationships and interactions (Frederiksen and Kristensen, 2008). DPSIR is a useful concept to assess in parallel socio-economic and environmental issues. It is therefore useful as an integrative framework, as different but related assessments may be combined.

In CLARIS LPB WP 8, we will use the framework to structure the complex web of causal relationships regarding anthropogenic climate change and land-use/land-cover changes.

Driving forces

Driving forces are defined by Holman et al. (2008) as “causes of environmental change which are exogenous to the region”. This may be anthropogenic induced climate change, national and international policies or socio-economic changes. Driving forces are the forces which cause observed landscape change (Bürgi et al., 2004).

Briefly, driving forces are the factors which cause changes in a system. They may be social, economical or ecological and may have positive or negative influences. For CLARIS LPB, it was not difficult to agree on “anthropogenic produced climate change” as one driver. The issue “climate change” can be defined by three major indicators: drought, temperature and rainfall. But climate change seemed not to be the only driver. It was decided, that major economic and demographic drivers (price relation, population growth) will be also observed and discussed in the research.

Pressures

Pressures are on the one hand the means through which drivers are expressed (temperature, precipitation ...) and on the other hand the system the pressure “attacks”. In that case, they are human activities and natural processes which result from the driving forces (in our case broadly speaking land use change as such). It was agreed that WP 8 will carry out research with emphasis on different rural production systems as family farmers, cooperatives, dairy milk producers etc. (including land use sectors as forest, transport, etc.).

State

State is the situation of the environment under current conditions. The combination of environmental and socio economic conditions define the state of the WP 8 rural systems under study. The state component was filled with the indicators the different sub-groups work with: Agro biodiversity, yield, fire risk, farm typology, crop species, and soil degradation. The state element allows for the rich and holistic approach that will be implemented in WP 8.

Impact

Impacts are the modifications of the state. It is useful to divide the impacts into direct impacts and indirect impacts. Impacts may be declining yields and declining food availability, changes in water quality, increase in fertilizer use, and as indirect (or secondary) impacts poverty, health problems, etc.

Response

Response refers to efforts to address the changes in “state” and “impacts” (formal policies, informal coping mechanisms etc.). It was agreed that in WP 8 responses at political level, family farm level and cooperative level will be objective of analysis. Policies and management options as well as attitudes and strategies will be taken into account.
WP Land Use

The DPSIR framework for WP8 - Figure 1.

Drivers
- Climate change (drought, temperature, rainfall)
- Price relations, population growths

Pressure
- Temperature, precipitation, ...

State
- Agrobiodiversity, soil degradation, yield, fire risk, land tenure, farm typologies, sensitivity, perception, crop species, technologies, rent vulnerability, risk

Impacts
- Land use change, Sustainability (econ, environ, social), income, food security, land tenure

Response
- Policies
- Strategies
- at political level, family farm level and cooperative level

The role of scenarios in the DPSIR framework - Figure 2.

“Imput from climate modelling”

DRIVERS

PRESSURE

STATE

RESPONSE

“Imput from crop modelling”

References
Vulnerability of Agricultural Systems to Climate in the Argentine Pampa

Which is the vulnerability of agricultural systems in Argentina?

The initial stage of research aims to develop a profile of the production systems of three typical districts of the Pampa area (Argentina): Balcarce, Junín (Province of Buenos Aires) and San Justo (Province of Santa Fe). This profile will characterize the productive, social and economic dimensions of the systems and will describe the link of each system with the territory. A typology of systems will be developed in order to examine the relationship system-territory for each type. Our research hypothesis is that the vulnerabilities and adaptation strategies will differ substantially from one system type to another. Furthermore, the system profiles will allow assessing the impact of climate change on each system. Vulnerabilities and possible adaptation strategies will be discussed and agreed upon with the actors involved discussing in participatory workshops. In order to sustain the vulnerability studies with modelling studies, a crop model (DSSAT) calibrated for the different regions and crops (soybean, corn, wheat and sunflower) will be used to evaluate the impact of climate change onto the crop yields, to suggest adaptation strategies and conclude on the increase/decrease of the crop system vulnerability in Argentina first and in other countries of La Plata Basin later. This analysis will take into account the uncertainty in the climate scenarios and in the crop yield impacts following the experience of a previous FP6 CLARIS pilot project in the Humid Pampa (see Fig. 3).

While the research on the system typology is at its initial stages, the interviewing with farmers and qualified informants reveals some preliminary vulnerability factors that affect the production systems under study. These factors include:

- The concentration of the production (even if not so much in land tenure until now) and the reduction of the number of small production units. These processes increase the vulnerability of the whole local agrarian system because production is mainly depending on actors from other areas moving to these districts motivated by financial reasons. These actors can easily withdraw from the local scene at their convenience.

- The production of high margin crops (i.e., soybean or potatoes) in low productivity land. High crop prices push crop farming activities into low quality soils replacing livestock production. This process increases the vulnerability of the systems given that crops in marginal areas have much larger yield variability. Also, crop farming in livestock-quality soils may lead to land degradation.

- The scarce use of insurance instruments (i.e., crop yield insurance or futures markets) leads to hard impacts from weather and economic variations in farms’ sales and income.

- Policy measures meant to the agricultural sector often increase the uncertainty about the commercial and macro-economic conditions. Such uncertainty discourages production and reduces the production level (i.e., planted area) and investment.
What is expected from climate change scenarios?
Climate change scenarios will allow an approximation to the level of key variables impacting the social and economic performance of the systems. For instance, these scenarios will be the link among weather, agronomic and socio-economic models that will be used to understand the productive and economic performance of the systems in today’s climate. The performance and vulnerabilities of the systems in the current scenario will allow social actors to discuss about which adaptation strategies seems suitable for them under the future climate to ensure the growth of the production systems and the development of the local societies (prospective methodology).

Another valuable contribution of the scenarios is its appropriateness for integrated assessment. Climate change and its impact on societies is a complex matter that has to be tackled by an interdisciplinary research team. The integrated assessment methodology allows the integration of specific scenarios into a more general one that describes impacts and strategies for diverse systems, societies and regions. An important point is that the impact of climate change will be different for different systems and societies. In this regard the research based on different areas of Argentina (San Justo, Junín and Balcarce) will allow evaluating this differential impact and drawing meaningful comparison among the three sites.

Which adaptation strategies can be designed; with whom; for whom?
The design and evaluation of adaptation strategies will be done with the participation of the stakeholders involved in order to include their feedbacks and suggestions. Also, workshops with climate change experts will be carried out to analyze future weather patterns and the vulnerabilities of each system. The objective of this work is to provide guidelines to local farmers, local governments, research institutions, NGOs and private companies to adapt to the future environment, taking into account not only climate changes but also socio-economic changes.

Stakeholders that will cooperate in the project
The stakeholders participating in each of the three districts in the project include: the Secretary of Production of the District Government, local farmers’ Associations (Sociedad Rural, Federación Agraria, grupo CREA), Local Research/Extension Institutions such as FCA and INTA-Balcarce, and relevant private companies such as local insurance companies of agriculture cooperative and futures exchanges (Mercado a Término de Buenos Aires and Rosario Futures Exchange).

References
Agricultural systems and land use in the La Plata Basin

Which is the vulnerability of the agricultural systems in the study area?

Agricultural land use in the La Plata Basin (LPB) is highly dynamic and of particular importance not only for the region itself but also for the world economy and food security. Land use in rural areas of LPB is dominated by cattle grazing (under planted and native pastures) and export monocultures including soybean, maize, cotton, sugarcane (for alcohol and sugar), eucalyptus and pines (for timber and cellulose industry), rice, wheat, coffee, and orange. During the last years, the region was subjected to a significant process of land use change, as a result of several policies implemented since the decade of 1960.

Climate patterns have a strong influence on agricultural land use, and climate variation is expected to increase in the near future. Different parts of the Basin will be affected with different intensity by this variation, resulting in varying degrees of vulnerability of the Basin’s agricultural systems. Therefore, a new process of land use change might be expected, modifying the current geography of agricultural production in LPB. As an example, while the climatic risk for agricultural crops will increase in some areas of the Brazilian part of LPB, mainly due an increase in droughts frequency and intensity, reduction of frost risk will favour tropical crops. Effects of climate change on water resources will further strengthen negative impacts on agricultural land use.

What is expected from climate change scenarios?

Different climate change scenarios, like those presented in the IPCC Fourth Assessment Report (AR4), entail different projections of future changes in temperature, and will result in different impacts on agricultural systems in LPB. The geography of agricultural production within LPB can be strongly impacted in the near future due the effects of temperature increases on crops. The IPCC scenarios combined with an Agricultural Zoning of Climatic Risks, forecast significant impacts on some Brazilian regions within LPB, like the reduction of available area for crop cultivation.

Setting up climate change scenarios is not free of uncertainty, which calls for research on specific scenarios of future agricultural land use. Cropping systems of major socio-economic relevance will be analyzed through simulation studies for different climate scenarios. In addition, social impacts of land use reallocation, like
migration, poverty, as well as economic implications, such as GDP variation and unemployment rate, must be taken into consideration.

**Which adaptation strategies can be designed; with whom; for whom?**

The design of adaptation strategies must be based on the assessment of the vulnerability of the main agricultural areas to climate change in LPB. Furthermore, adaptation should focus on anticipatory and preventative measures, instead on reaction to the consequences of climate change. In this sense, it is necessary to think in terms of pro-active adaptation to respond to the vulnerabilities of agricultural systems to climate change. So far we have seen mostly general adaptation strategies, like the integration of crops and pastures, and the design of agro-forestry systems. These strategies aim at improving soil and water management and conservation, decreasing the vulnerability to climatic variability. Plant breeding to develop drought resistant of crops, has also been suggested. Other non structural adaptation strategies, like insurance against extreme climatic events and the set up of warning systems must be considered as well.

Local knowledge will be important for the design of adaptation strategies, but policy design must be led by the State. Therefore it is necessary to involve stakeholders at different levels, local and national, farmers, cooperatives, scientists and other decision and policy makers.

**Stakeholders that will cooperate in the project**

In LPB we can find a large variety of agricultural systems, not only in terms of cultivated crops, but also in terms of farm size and structure, and land tenure. Therefore, in order to take into account this variability, the NUMAVAM-UFSC team will work with different stakeholders, at local and national levels. At local level, an important group of stakeholders are family farmers, the reason why a case study will be carried out with family farmers of Anchieta, a municipality located in Santa Catarina State, Brazil, close to the Argentinean border. Another important group are agricultural cooperatives. Here, the NUMAVAM-UFSC team chose to work with COTRIJAL, an important cooperative located in Não-Me-Toque, Rio Grande do Sul State, whose associates are very representative of the main agricultural systems found in the Brazilian part of LPB. At national level, the chosen stakeholder is the Permanent Commission on Climate Change of the Brazilian Congress.
The Impacts of Climate, Anthropogenic Factors and Land Use Change on Fire, Fire Risk and Vegetation Functioning in La Plata Basin

Which is the vulnerability of the agro-ecological systems in the study area?

The study covers the whole La Plata Basin landscape, although focusing in the regions with higher fire occurrence: the north boundary going towards the southwest (Paraguay, southeast Brazil and northeast Argentina).

![Figure 1](image_url) Spatial patterns of fire occurrence in the La Plata Basin landscape from 2002 to 2008 from five different remote sensing datasets. January 2002 to December 2008 (AQUA and TERRA).

This region is one of the most fire-prone worldwide, due to recurrent drought periods and high temperatures, the presence of continuous biomass fuelbeds and the human colonization strategy ongoing on the north-western side of the basin. Two kinds of fires affect those areas:

1. The agricultural fires used for crop waste combustion, particularly sugar cane and wheat.
2. The wild fires in natural systems. Forest fires occur during the driest years (El Niño for example) at the end of the dry season. Due to the complexity of the interrelations among these pressures, those areas are highly vulnerable to alterations in the climate and land use.

In general, the fires in natural vegetation can reset natural ecosystems to their early successional stages, favour plant functional types adapted to recurrent disturbances and change the land cover patterns. Such modifications may have significant impacts in the biodiversity, ecosystems functioning and services, in the reflectance and albedo, in the emission of aerosols and in the hydrological and carbon cycles. The consequences can be alteration on regional biosphere/atmosphere interactions, adverse health effects of smoke haze, increment of runoff and soil erosion, increment of sediments in the rivers, loss of animal and vegetal species, among others.

The observations to date point that the ignitions seems to exhibit a high dependency to the climatic conditions, since 75% of fires concentrate in the dry season (from August to October) and are often associated with extreme heat waves and drought events caused by El Niño. Temperature and soil water availability interact with ecosystem functioning and human activity to determine fire occurrence. The agricultural fires can spread out easily to natural vegetation patches in the dry season due to wind and low air humidity. It is worth to highlight that the La Plata Basin landscape is highly fragmented. As a consequence, grassland/shrubland fires are highly recurrent with low interannual variability, while severe forest fires, with most biomass consumption, happens only during prolonged droughts mostly driven by El Niño events or extreme episodes.
What is expected from climate change scenarios?
Fire is directly controlled by climate, as a balance between fuel amount, its spatial distribution, and water status. For forests, interannual variability in burnt areas and drought highly correlate, so we can suspect that an increasing drought will enhance fire by drying out the litter and canopy. Climate impact on fire in savannas is more uncertain, as vegetation is already dry annually, we can suspect that an increasing drought will decrease available fuel biomass and spatial continuity so that fire spread and intensity will be lighter. However, we highly suspect that fire consequences on long term changes will switch forested ecosystems into shrubby fire-prone ecosystems. This consequence of climate changes on fire regime could be more important than seasonal impact on the present vegetation functioning, and is hardly deriving from present analysis of fire regimes and its interannual variability.

Which adaptation strategies can be designed; with whom; for whom?
Adaptation strategies related to fire will benefit from experiences in other similar biomes where multiple fire prevention strategies have been designed, as in Australia and Africa. Strategies to limit fires can be implemented with farmer associations and governmental institutions to increase fire fighting expenditures, modifying forest management practices to create fire breaks, cleaning understorey shrubs by promoting grazing and sylvo-pastoral systems and managing landscapes by promoting less fragmented landscape structures of forest, crops, and grasslands.

Stakeholders that will cooperate in the project
We are planning to work with three stakeholders in Brazil: The CEMIG (Compania de Energia de Minas Gerais), the IEF (Instituto Estadual de Florestas, Minas Gerais) and the ALAGO (Associação dos municípios do Lago de Furnas). We have already contacted these institutions and they are motivated in a joint effort for fire data acquisition and in setting up a fire prevention program in the northern part of the LPB.
Which is the vulnerability of the pastures system in Uruguay to climate?
The major climatic vulnerability of the cattle pasture production is associated with droughts. The more frequent and intense dry periods due to increased climate variability combined with the intensification of the production and the shift to more shallow soils due to the agriculture expansion has rendered the pasture system more vulnerable. This vulnerability is clearly manifested during severe droughts with large economic loss and social disruptions (job losses in all the production chain, endebtment, bankruptcy and dislocation of producers, especially small ones), especially in the dairy and cattle growers sectors.

Large areas of the La Plata Basin pampas suffered a record breaking drought during austral spring 2008 and summer 2009. The socioeconomic impact was devastating in many regions. Many sectors were severely affected, but particularly vulnerable ones are the cattle growers and dairy farms that depend on pastures for grazing. As the drought deepens, the available options for these farmers quickly vanish. Droughts jeopardize not only the annual income, as is the case in the entire agriculture sector, but also the main capital since the survival of the herd can be at risk.

Which were the impacts of past events?
The region is still in the process of recovering from the most severe drought in the record with devastating impacts throughout the agriculture sector. In Uruguay, the Ministry of Agriculture estimated the economic losses in 450 million dollars for the entire agriculture sector. The Rural Association of Uruguay doubled the estimation when considering the weight loss in the national cattle stock, and also report a total of 12,800 jobs lost due to the impact of the drought. During the 1988/89 drought, one of the more extended and generalized droughts in recent decades, the national cattle stock shrank by more than 15%.

What is expected from climate change scenarios?
Serious consideration of climate change issues in the decision making processes is only recently emerging. Beyond the international pressure on that respect, this is largely explained by the recent climatic extreme events, most importantly the 2008/09
drought. Droughts have always been the most feared climate adversity and have by far the largest economic impact, although the social impact and visibility of severe weather events and floods is also large.

Given this context, what is most commonly asked of climate change scenarios is their impact on climate risks associated with dry periods. In other words, it is expected that the scenarios would give an estimate of the frequency and intensity of droughts, especially multi-annual droughts which have historically generated the most devastating impacts.

Which adaptation strategies can be designed; with whom; for whom?

There are several ideas taking hold in the public sector to better prepare for the next drought. Currently, these strategies are being framed under the conceptual understanding that it is a manifestation of climate change. Large irrigation systems, drought emergency funds, insurance and other financial mechanisms are being explored by the public sector. One key and common element to all of these tools is a sound evaluation of the climate risk associated with droughts.

Stakeholders that will cooperate in the project

Uruguay is under the process of establishing a “National System in response to Climate Variability and Change”, which was officially created by initiative of the President in 2009. It produced a “National Plan in response to Climate Variability and Change” with the participation of all relevant branches of government, academia and civil society. It’s presumably the place where the main policies referring to climate change will be drafted and therefore presents a great opportunity for collaboration.

Other stakeholders with whom we are already working are:
