Spatial Regional Framework to Sensor TTC: La Plata Basin, MERCOSUR.

Ana Paula Turetta, Gabriel Martins Sales Fonte, Luis Iván Ortiz Valencia, Heitor Luis da Costa Coutinho, Santiago Baeza, Mariano Oyarzaba, Karen Tscherning.

Abstract

Sustainability of land use in European regions (SENSOR) is a project that has as technical objective: to build, validate and implement sustainability impact assessment tools, including databases and spatial reference frameworks for the analysis of land and human resources in the context of agricultural, regional and environmental policies.

SENSOR TTC is an extension of SENSOR EU and aims to adapt the European approach to extra European conditions in Targeted Third Countries (TTC).

The framework is an adaptation of the ecosystem function approach in that it assesses the direct impact of LUC on the three pillars of sustainability. The challenge to define the spatial framework for MERCOSUR is to harmonize the regionalization among Brazil, Argentina and Uruguay, because the countries have different administration regions, with different levels on sustainability indicators data and policies. ArcGIS 9.3 shows to be a very useful tool for this application.

Introduction

The Mercosur (South Common Market) was implemented in 1991, and includes Brazil, Argentina and Uruguay, partners in the Sensor TTC project (*Sustainability Impact Assessment: Tools for Environmental Social and Economic Effects of Multifunctional Land Use in European Regions*). Despite being close to completing 20 years of its creation this agreement is still very strongly connected to economic issues. Social and environmental issues addressed by this group of countries are rare, resulting in a lack of institutions dealing with common policies for the block, and limited data available that considers the Mercosur as an integrated region. Therefore, the first approximation for the creation of cluster regions in the La Plata River Basin, the project case study region in the Mercosur, considered as spatial units the countries´ administrative areas that contain a reasonable amount of indicator data. These included the Argentinian Departments, Uruguayan Censitary Units, and Brazilian micro-regions.

This initial approach for a Mercosur Spatial Regional Reference Framework (SRRF) is being used for the implementation of the SIAT prototype. SIAT – Sustainability Impact Assessment Tools – that is the main end product of SENSOR. The aim of SIAT is to enable policymakers to design their own policy scenarios and immediately assess the impact of these scenarios on sustainability. The prototype developed by South America Group was based on the policy case "sugarcane expansion in Mato Grosso do Sul – Brazil".

The second effort aimed at creating cluster regions from areas with similar socio-economic and environmental features, more like the procedure adopted by the European Sensor team. This resulted in an improved SRRF that will be used for the implementation of the second SIAT prototype, related to the policy case "expansion of afforestation in the La Plata River Basin". It

still needs improvement, but the results are very promising and show that the Sensor methodology is useful for creating cluster regions in the Mercosur area.

Methodology and Results

The Sensor TTC project adopted a spatial focus on the total area of MERCOSUR that corresponds to the La Plata river Basin as the area of study. The countries that are participating in this project are: Brazil, Argentina and Uruguay (Figure 1).
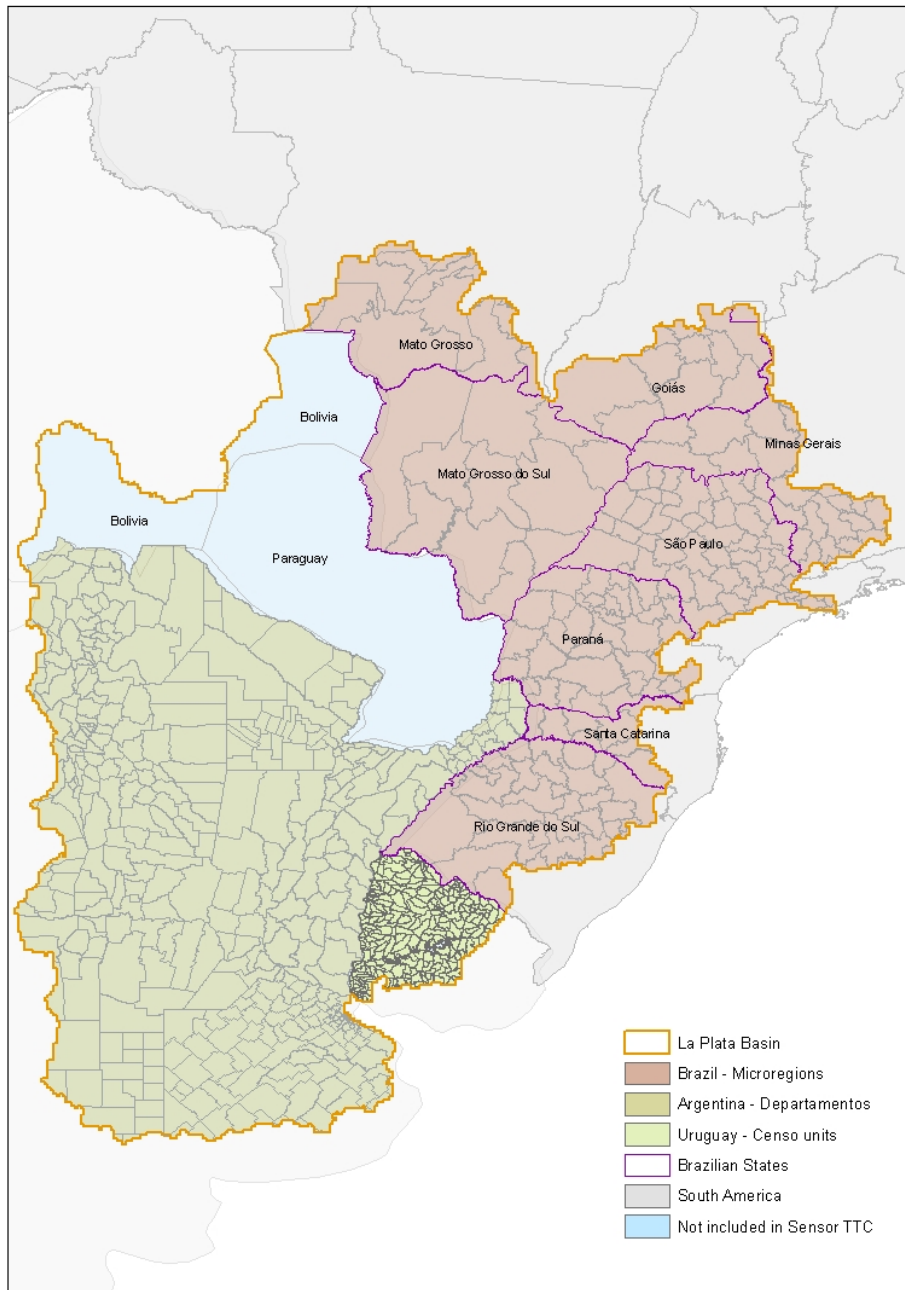

Figure 1: La Plata Basin.

The La Plata Basin has approximately 3.1 million km^2 and represents a very dynamic area that expresses very well the current reality in terms of changes in land use in developing countries. Both in Europe and South America the pressure on natural resources is increasing, nevertheless, the continents differ in their intervention priorities and the intensities of the processes, including decision-making and policy formulation and implementation. Part of these differences are due to diverse institutional capability to produce and share data to enable a regional spatial framework that can be the basis for territorial ordinance planning and land use policy making.

The SRRF formulation process for the La Plata Basin can be divided into two phases: the first was based on the administrative regions existing in the area and the second on the global database available for the area.

Phase 1:

It was decided that the spatial units for MERCOSUR would be the combination of the Brazilian micro-regions, Argentinean departments and Uruguay's census units (Figure 1). This option considered the most detailed information level for each country. In Brazil it was decided to use the micro-regions since it is possible to obtain quality information for this administrative level and also because they result from a clustering process. The micro-regions, which are groups of municipalities, the lowest administrative level in Brazil, have been used by IBGE (Brazil Institution of Geographic and Statistics) since the 1970´s. The criterion to create a micro-region is based on the unity of natural, social and economic characteristics (IBGE, 1970). In the 1990´s the micro-region concept was enhanced and began to consider some of the peculiarities regarding the organization of space (IBGE, 1997), including the relationship between micro-regions in numerous aspects of production structure, agriculture, industry, extractive minerals, and fishing. The concept stresses that micro-regions are not individual, self-sufficient areas but are interdependent.

For the characterization of the administrative units the same variables as used in the characterization of cluster regions in Europe were used. Table 1 shows these variables and their availability in the different countries.

Table 1: Data available for areas characterization in MERCOSUR based on SENSOR EU criteria.

Variables EU	Brazil	Argentina	Uruguay
Environmental zones	-	-	-
Temperature	X	X	X
Precipitation	X	X	X
Soils	X	X	X
Land Cover	X	X	X
Forest cover	X	X	X
Population Density	X	X	-
GDP	X	X	X
Unemployment rate	X	X	X
Livestock	X	X	X
Land use	X	X	-
Agricultural limitations	X	X	-
Functional Urban Areas	X	X	-
Amount of beds per local inhabitants	-	-	-
Road Density	X*	X	-

The information with the greatest level of detail for the countries involved. Despite this, it was not satisfactory for the definition of a SRRF for the La Prata basin, which led the group to look for new alternatives for the definition of the work. This fact can be attributed to three principal factors:

Heterogeneity among countries: the countries are very different in many aspects. For example: Uruguay measures 176,000 km^2 while the area of Brazil is 8,500,000 km^2. This fact defines a series of different organization levels in the countries;

- Based on administrative boundaries: as the administrative boundaries reflect the differences among the organization level of the countries, it is not a good approach for the objective of this work;

- Number of regions: in total there are 1,218 administrative units in Brazil, Argentina and Uruguay.

- One question that has to be emphasized is that the methodological concept used in this phase differs completely from that adopted in Europe, since the characterization of administrative regions do not allow a new regionalization proposal to be generated based on the natural and socio-economic similarities within the La Plata Basin.

A further reason for the development of Phase 2 SRRF is that the initial approach did not enable a test of the transferability of the European SRRF framework, based on the clustering of regions considering social, economic, and environmental characteristics. Please note that phase 1 SRRF will be used in the first SIAT prototype, under development, targeted towards the policy case of sugarcane expansion in the State of Mato Grosso do Sul. Ex-ante impact evaluation at the State level in Brazil will have best results if carried out using micro-regions as the basic spatial planning unit.

Phase 2

Phase 2 of the project proposes the creation of similar regions in the La Plata basin based on the collection of information available in global databases and made available by international

reference institutions (FAO, USGS, etc...). The list of data used, as well as the sources, can be seen in Table 2.

Table 2: List and references of dataset used in Phase 2.

MERCOSUR	Number of variables	Data source
Soils	1	FAO Geonetwork Portal
Ecological Zones	2	FAO Geonetwork Portal
Elevation	1	FAO Geonetwork Portal
Climate	1	FAO Climpag
Temperature	1	World Clim
Land Use	1	FAO Geonetwork Portal
Roads (Infrastructure)	1	The Pennsylvania State University
Population Density	1	United Nations Environment Programme

The ArcGis 9.3 software (ESRI, Inc., Redlands, CA) was used as the spatial focus for the micro-regional information plans for Brazil and the 'departments' for Argentina and Uruguay.

After this process, the TwoStep cluster method[1] statistical analysis was run in SPSS version 15 which groups similar areas according to the variables used.

The Two-Step cluster method is an exploratory tool designed to reveal natural groupings (or clusters) within a dataset which can handle very large data sets. It is implemented in the statistical software SPSS. It requires only two steps: first, pre-clustering the cases into many small sub-clusters, and then clustering the sub-clusters resulting from pre-cluster step into the final number of clusters. The pre-cluster step uses a sequential clustering approach. It scans the data records one by one and decides if the current record should be merged with the previously formed clusters or if it starts a new cluster based on the distance criterion. The procedure is implemented by constructing a modified cluster feature (CF) tree.

The algorithm employed by this procedure has several desirable features:

- Handling of categorical and continuous variables. By assuming variables to be independent, a joint multinomial-normal distribution can be placed on categorical and continuous variables.

- Automatic selection of the number of clusters. By comparing the values of a model-choice criterion across different clustering solutions, the procedure can automatically determine the optimal number of clusters.

- Scalability. By constructing a cluster features (CF) tree that summarizes the records, the Two-Step algorithm allows large data files to be analyzed.

Two types of distance measures are considered: the Euclidean distance and the likelihood distance. The former is available when no categorical variables are specified. The latter is especially useful when categorical variables are used. The likelihood function is computed using the normal density for continuous variables and the multinomial probability mass function is used for categorical variables. All variables are treated as independent.

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[1] Greater details can be found at: www.rrz.uni-hamburg.de/RRZ/Software/SPSS/Algorith.120/twostepcluster.pdf

Importance measures are plotted using a Pearson chi-square statistic as the importance of a categorical variable and a t-statistic as the importance of a continuous variable. Significance reports one minus the p value for the test of equality of means for a continuous variable and the expected frequency with the overall dataset for a categorical variable. For this study 5 categorical variables – soil, environmental zones (2 variables), land use and climate - and 4 continuous variables – roads, population density, elevation and temperature – were considered.

597 units were considered, corresponding to all the micro-regions of Brazil and the departments of Argentina and Uruguay, which are part of the La Plata Basin. Of these units, 551, or 92.3%, were considered valid for the system analysis.

20 MLPC (Mercosur-La Plata cluster) were identified (Figure 2). The mean size of the MLPC was 139,471 km^2. The smallest MLPC was the 13th with 9,661 km^2 and the biggest was the 14th with 435,562 km^2.
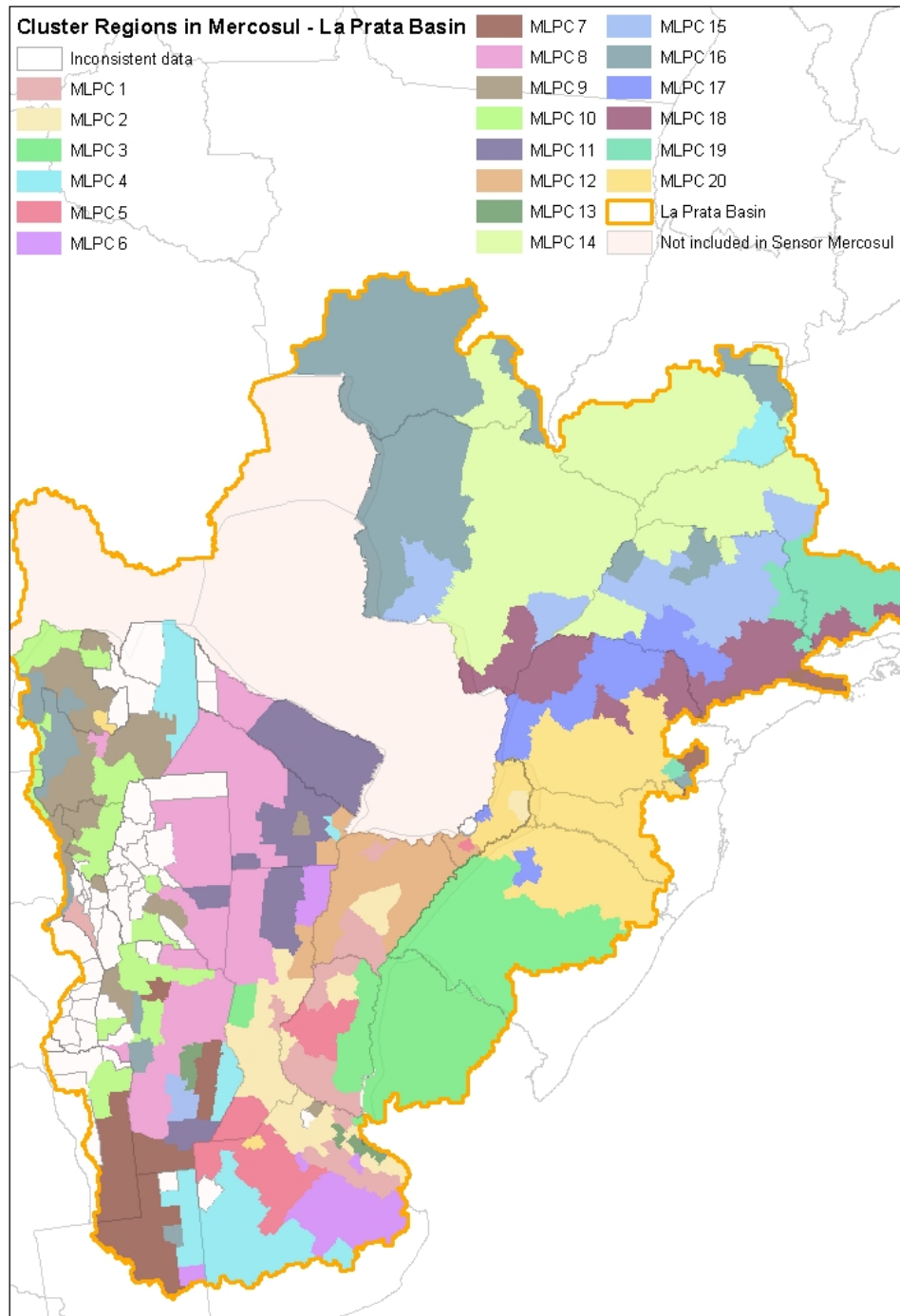
Figure 2: Mercosur-La Plata cluster (MLPC) of Mercosur.

Conclusions

The methodological approach was helpful to work with a large amount of data. GIS and modelling techniques allowed the integration of data and information to better characterize the differences among areas at La Prata basin.

The world datasets were important to generate a first approximation of a MERCOSUR – La Plata basin regionalization proposal where it was possible to identify general domains in the area. However, it is important to refine and improve the dataset, selecting the most relevant variables and adding socio-economics data. The methodology was shown to be useful and robust to work with very large datasets.

Nevertheless, it is worth emphasizing, for the purposes of the SIAT MERCOSUR prototype, that the division into micro-regions in Mato Grosso do Sul State (Phase 1) will be maintained, defined as a project study area.

The Phase 2 SRRF can be further enhanced by the entry of data from Bolivia and Paraguay, leading to the consolidation of a full La Plata River basin SRRF. The SIAT Mercosur second prototype will be based on the Phase 2 SRRF, since the case study of forestry expansion is relevant to at least 3 countries of the basin: Brazil, Argentina, and Uruguay. Simulations of sustainability impact analysis of potential Mercosur land use policies will greatly benefit from the proposed SRRF.

References

IBGE (Instituto Brasileiro de Geografia e Estastistica), 1970. Divisao do Brasil em Microregiões Homogeneas. Rio de Janeiro, Brazil.

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