SUSTAINABILITY EVALUATION IN MUNICIPAL DISTRICTS BELONGING TO PARAÍBA DO SUL RIVER BASIN, BRAZIL.

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INTRODUCTION

In the last decades a growing has been observed as well as no controlled pressure on natural resources in most different areas of Brazilian territory. It is consequence of population increase and of territory disordered occupation, generating impacts on natural and socioeconomic environment.

Although, in literature there is not a consensus for the concept of what comes to be "Sustainable Development", in this work t we adopted the concept proposed by Brundtland Report (AJARA; 2003) and recommended by Agenda 21 (NATIONS, 2001), that defines it as the development that satisfies needs of present without committing capacity of future generations satisfy their own needs". The Sustainable Development would be an interaction of the environmental, social, economical and institutional dimensions and sustainability then the goal being reached in territory management.

In the context of "Sustainable Development", the natural resources management in a sustained way has need of specific information for: *i*) to operate the interaction between the environment and economical progress; *ii*) to measure potentials progresses in sustainability terms in each one of their dimensions; and *iii*) to inform the society the performance of this process. However, although information sources have proliferated in the last years, specific information requested for take decisions have been very scarce. In order to overcome these difficulties sustainability indicators and synthetic indexes are used (OECD,1994; HAMMOND et al., 1995).

In the literature some proposals are found for quantify and qualify the sustainable development in way to facilitate the monitoring and evaluation of environmental changes (CSD, 2001; IBGE, 2001; ESI, 2002; AJARA, 2003, PANTY et al., 2004). In this sense, the goal of this work consists in development a methodology for build a sustainability synthetic index that subsidizes a spatial analysis of "Sustainable Development" perspective. So, we propose a methodology that combines multivariate analysis, spatial statistics and Geoprocessing techniques. The study area selected was Paraíba do Sul River Basin. According to TUNDISI et al. (2003), a river basin area presents physical characteristics that turns it an appropriate unit for management and optimization the multiple uses of natural resources, as well as to turn sustainable development operational.

STUDY AREA

The Paraíba do Sul River Basin is understood between parallels 20°26'S and 23°00'S and meridians 41°00'W and 46°30'W, with an area of drainage of approximately 55.500Km^2 that extends through São Paulo (13.900km^2), Minas Gerais (20.700km^2) and Rio de Janeiro (20.900km^2) states. It is an unit of management and planning of the Committee for Integration of Paraíba do Sul River Basin - CEIVAP, formed by 180 municipal districts, as presented in the Figure 1.

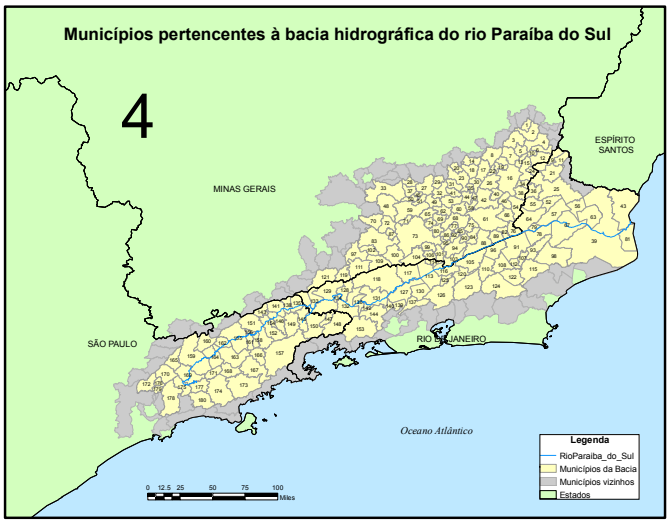

Figure 1 - Study area: Paraíba do Sul river basin.

This area presents an occupation with industrial and agricultural presence of great concentrations, where the population uses, in almost its totality, the waters of Paraíba do Sul river for several ends, to know: public provisioning, domestic and industrial dilution, energy generation, irrigation, fishes, among other (LABHID, 2001).

In the basin, the Paraíba do Sul River arrives to the sea in northwest and north of Rio de Janeiro state, with water quality prejudiced for domestic sewers releases, industrial emanation and an enormous amount of solids in suspension. Besides these problems, the Paraíba do Sul River presents in their margins waste existence, deforestations and consequent erosion, retreat of mineral resources for building without due environmental recovery. Also there are accidents with poisonous load transport, ciliary's forest devastation, predatory fishing, and no controlled and improper pesticides use. All these problems contribute to degradation of environmental quality in the basin, and in matter, of water resources (LAHID, 2003 and RODRIGUES et al. 2007).

METHODOLOGY

The methodology proposed for building sustainability synthetic index has as information granularity the municipal districts. In this work a municipal district is considered sustainable as: *i*) it possesses political and institutional resources capable to maintain or to improve the health of its environmental system; *ii*) to lessen the degradation and impact due the development; and *iii*) to reduce social inequality providing their inhabitants of basic conditions of life in a healthy and safe environment. So, the proposed methodology is composed by the following stages:

Stage 1. To select indicators (Table 1) based on environmental, social, economical and institutional dimensions;

Table 1 – Dimension and indicators selected

Dimension	Subdimension	Indicator	Code
Environmental	Atmosphere	Effective flock	ATMO1
		N° of automobiles for private use	ATMO2
	Sanitation	Access to garbage collection service	SANE1
		Access to sanitary exhaustion service	SANE2
		Access to water supply systems	SANE3
		Final destination of garbage	SANE4
		N° of homes with sanitary installation	SANE5
		Sewer treatment	SANE7
	Land	Deforestation	TERRA1
		Products picked area	TERRA2
		Products planted area	TERRA3
Social	Population	Nº of infantile deaths	POPU1
		Nº of alive children	POPU2
		Nº of deaths	POPU3
		Population rural / urban	POPU4
		Resident population	POPU5
		No natural of residence municipal district	POPU6
	Habitation	Habitational density	HABI1
		Number of homes	HABI2
		Nº of homes with electric power	HABI3
		Home type	HABI4
	Citizenship	Totaled Capable voters	CIDA1
		Percentage of Attendance	CIDA2
		Percentage of Abstention	CIDA3
		Percentage of valid votes for mayor	CIDAP4
	Income	Per capita home income	RENDA1
	Health	Immunization applied doses	SAUDE1
		Number of hospitals	SAUDE2
		Number of beds for hospital	SAUDE3
	Education	Years of study	EDUCA1
		Literacy	EDUCA2
Economic		Monthly medium consumption of electric power used for the rural area	
		Monthly medium consumption of electric power used for the industry	
		Municipal gross domestic product	QECO3
		Per capita gross domestic product	QECO4
Institucional	Institutional capacity	Master plan existence	CAIN1
		Existence of soil use and occupation law	CAIN2
		Weigh electoral	CAIN3
	Information	Nº of homes with television	INFO1
		Nº of homes with phone line	INFO2
		Nº of homes with radio	INFO3
		Nº of homes with microcomputer	INFO4

Stage 2. To systematize data in a Geographical Information System (GIS);

Stage 3. To perform an exploratory and spatial analysis of indicators in way to evaluate the statistical and spatial behavior in agreement with social, environmental, economical and institutional dimensions;
Stage 4. To perform the treatment of missing values and outliers for each indicator;
Stage 5. To normalize the indicators through the formula below to create a comparable scale:

$$valuer = \frac{ValueMax - value}{ValueMax - ValueMin}$$

Stage 6. To analyze correlation among indicators with aiming of eliminating redundant variables;
Stage 7. To perform principal components analysis with aiming of building synthetic indicators for each dimension and to analyze its spatial representativeness using the Moran index;
Stage 8. To build the sustainability synthetic index (ISS) using the average of the simple indicators that represent the environmental (IAM), social (ISO), economical (IEC) and institutional (IIN) dimensions:

$$ISS = \frac{IAM + ISO + IEC + IIN}{4}$$

Stage 9. To analyze spatial representativeness of the sustainability synthetic index (ISS);
Stage 10. To performance cluster analysis for evaluation the similarities among municipal districts; and
Stage 11. To interpret the reached results.

RESULTS

The cluster analysis used hierarchical method and obtained four groups. To validate the obtained result, it was compared with sustainability synthetic indexes. The research reveals a strong differentiation interns, resulting from different patterns of development in the area. The groups are (Figure 2):

- Group 1: There are municipal districts with the smallest indicators, being considered all dimensions;
- Group 2: There are transition municipal districts, mainly in the social and urban/rural infrastructure dimension;
- Group 3: There are municipal districts whose development is more balanced, with moderate indexes in all dimensions; and
- Group 4: They are the municipal districts with largest sustainability synthetic indexes, due they be municipal districts with larger development social, economical, institutional and environmental.

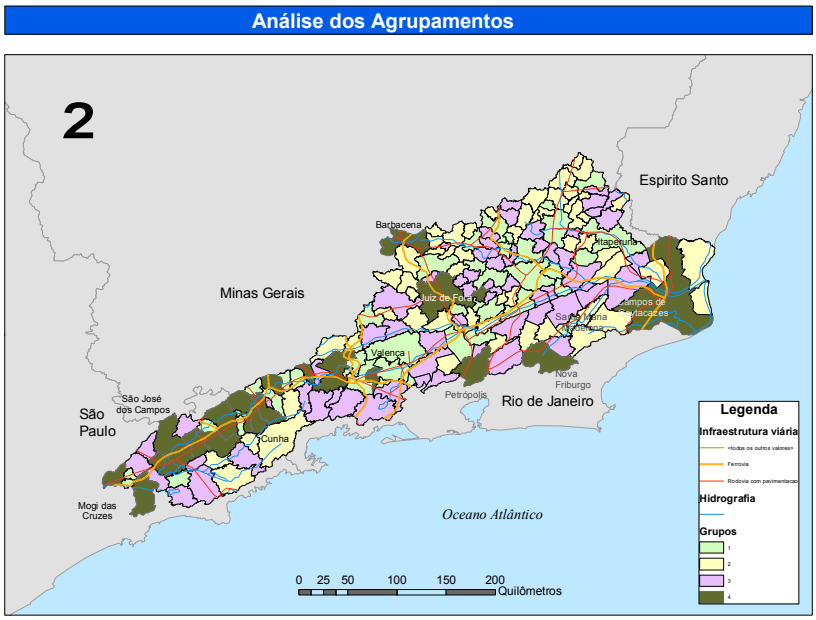

Figure 2 - Cluster Analysis

CONCLUSION

The elaboration of sustainability synthetic index provides an opportunity to understand reality of Paraíba do Sul River Basin, in the sustainable development context. There area four characteristic areas: São Jose dos Campos, the area around Volta Redonda, the area around Juiz de Fora and the area around Campos dos Goytacazes.

The results presented by sustainability synthetic indexes for each municipal district supply important elements for reflection on development process of study area. Using those elements we could analyze the public politics to local context.

The integration of multivariate analysis and Geoprocessing techniques were effective in the visualization process, facilitating understanding of municipal sustainability synthetic indexes.

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