

## URBAN SUSTAINABILITY USING ORBITAL REMOTE SENSING DATA AND GEOPROCESSING TECHNIQUES

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### ABSTRACT

São José dos Campos is a municipality located in the region of Paraíba River Valley in São Paulo State. It is located between the cities of Rio de Janeiro and São Paulo, at one of the highest industrialized and urbanized areas of Brazil. In the decades 70/80, 80/90, São José dos Campos presented annual medium geometric rates of population growth of 6.84%, and 3.99% respectively. These rates are mainly due to high positive migratory flows within Brazil. Since 1980, 95% of this population is living in the urban area that has been submitted to an accelerated process of expansion. As in most of Brazilian cities this accelerated urban growth has been disorganized causing strong environmental impacts, together with a decrease in quality of life particularly in those residential districts of the lower social class. The main causes for poor housing conditions are: the extremely unfair distribution of income, land speculation which transforms land ownership into one of the most important instruments of income concentration, and Brazilian Government which currently reinforces privileges. In 1992 the Brazilian Institute for Space Research –INPE- made the land use macrozoning of the region of Paraíba Valley and North Cost of São Paulo State, using orbital remote sensing data and a methodology considering integrated planning. The final product of this project it was a land use map of the study area at the scale 1:250,000. According to regional guidelines, in 1994 the local government published the Municipal Master Plan which, among others results and proposals, presented a land use macrozoning of the São José dos Campos municipality at the scale 1:50,000. The objective of this work is to evaluate the present urban use at zones suitable for intensive urban use. Considering that these zones are scarce, and thus a limited municipal resource, the land use of the zone must be strictly controlled. For this evaluation the software SPRING-System for Geoinformation Processing – developed at INPE, was used. Using SPOT/PAN image from 1997, a visual interpretation was made to map the urban areas and to analyze characteristic patterns of intra-urban land use arrangements. This photo interpretation of the image was complemented by field surveys and by evaluation of color aerial photographs at the approximate scale of 1:8,000, obtained at the same year. The results were compared to a map of urban macrozones and allowed the identification and quantification of built areas in the urban periphery, that presents coarse grained texture, which represents extremely low population densities. These areas are located at sites suitable for intensive urbanization. These suburban areas are expensive alternatives for the urbanization because they require an extension of many urban facilities and services, and they represent a waste of natural resources, a fact incompatible with long term objectives involved in sustainable urbanization.

## 1 INTRODUCTION

São José dos Campos is a municipality of São Paulo State (Brazil), located in the region known as “Vale do Paraíba”, between the two Brazilian metropolises Rio de Janeiro and São Paulo. The axis between both metropolises is one of the most industrialized and urbanized areas of Brazil.

In the decades 70/80 and 80/90 São José dos Campos presented average annual geometric population growth rates respectively of 6,84% and 3,99%. Such growth rates were due mainly to positive migratory fluxes. Since 1980, over 95% of its population lives in town, which consequently has been submitted to an accelerated process of expansion.

As in most Brazilian cities, this accelerated urban growth was chaotic, causing strong negative environmental impacts, together with the loss of life quality, particularly in those residential areas where the segment of population from the poorest social classes live.

This paper is based on the concept that the urban planning process requires far reaching and long term decisions, if sustainable urban environments are expected. In this frame, “to act locally” must be subjected to “think globally and plan regionally”, according to Forman (1995).

Urban peripheries, located between urban and rural areas, are influenced interactively by both. In Brazilian cities the peripheries far away from downtown, have been the characteristic sites of residential quarters of the underprivileged. It is the area where those people live which have difficulties to the access of a satisfactory transportation system, to essential urban services, to equipment of common use, to work, and who live in miserable dwellings which, together with the destroyed nature, compose a non-qualified environment. Such areas generate an urban tissue with a discontinuous and very sparse configuration.

Being so, the objective of this work is to study the specific case of this occupation in São José dos Campos, considering the regional and municipal macro-zone plans of land use, aiming to a sustainable development.

## 2 LAND USE MACRO-ZONES – THE REGIONAL SCALE

In 1992 INPE (National Institute for Space Research) published the results of Project MAVALE (Macro-zones of the region “Vale do Paraíba” and northern littoral of São Paulo State), (Kurkdjian et al., 1992).

This region, with an area of about 18,000 km<sup>2</sup>, was analyzed using a regional planning methodology based on the use of orbital remote sensing products. These products were used to elaborate a set of diagnosis and thematic maps at the scale 1:250,000 of the physical environment and its changes in the region.

Based on fundamental thematic maps, integrated maps were elaborated containing information on the support capacity of land for urban expansion and engineering works and of the technical land classification for agricultural needs.

The comparison of these maps with multi-temporal land use/land cover maps of the region, including the urban expansion, allowed the identification of problems, whose solution was presented in the proposal of land use macro-zones.

The joint diagnosis of both the physical environment and the regional social-economical information provided the basic data to elaborate this proposal.

The final map of macro-zones indicates the appropriate zones for forestry, natural pasture; planted pasture; special cultures (e.g. rubber tree *Hevea brasiliensis*); orchards for sub-tropical climate; orchards for temperate climate; temporary and permanent cultures with different levels of management; areas for environmental protection; besides potential areas for urbanization, of interest for this study.

At regional level (scale 1:250,000) those sections indicated as favorable for urban expansion are constituted essentially by fluvial and lake sediments of Taubaté Basin, dominated by non-consolidated fine-grain silt-clay rocks, with minor insertions of sedimentary conglomerates and breccias. It is subdivided in two units. The first presents hill slopes of 3 to 10% showing relief features of rolling hills and soils predominantly of latosol type, texture medium/clay and depth medium to profound, as well as podzol soils of medium to low depth, texture of average clay which normally occurs on areas of gentle rolling relief.

Those sections, considered auspicious for urban expansion, correspond to small sectors of the region which are almost all already urbanized, and as such they constitute a limited space for future growth. Within these sectors, the

urban centers of Jacareí, São José dos Campos, Caçapava, Taubaté, Tremembé, Pindamonhangaba, Aparecida, Guaratinguetá, Lorena, Cachoeira Paulista and Cruzeiro, are located. These towns are the largest ones from the region, and are part of one of the most important urban-industrial axis from Brazil. Within this axis, the municipality of São José dos Campos plays a very important role, with 485.780 inhabitants (1996), 95,12% of which live in the urban area.

### 3 LAND USE MACRO-ZONES – THE SCALE OF MUNICIPALITY

Based on the regional project (MAVALE) the Prefecture of São José dos Campos municipality (1994), in the frame of its' Master Plan, elaborated a proposal for mapping Municipal Macro-zones, at scale 1:50,000, in order to direct the spatial development of the society within its' territory. The following zones were defined:

- rural macro-zone = inadequate for urban development. It is indicated for both agricultural/cattle raising and agro-industrial activities.
- Macro-zone APA IV = indicated for agricultural activities and inadequate for urban development, only for leisure activities with minimum impermeability index.
- Urban macro-zone = adequate for urban functions.
- Macro-zone for urban expansion I = indicated for urban development and also for agricultural, cattle raising and forest use.
- Macro-zone for urban expansion II = adequate for tourism and leisure, with low occupation density such as cottages and clubs.

The municipality of São José dos Campos encompasses an area 1,118 km<sup>2</sup>, of which 232 km<sup>2</sup> are indicated technically for intensive urban use (urban macro-zone and macro-zone for urban expansion I). From this value, 120 km<sup>2</sup> are built-up areas with consolidated occupation.

Being so, it is clear that in the long run, the remaining areas are a limited resource and that its' occupation should be carefully and responsibly planned and controlled.

### 4 THE URBAN PERIPHERY

To study the urban occupation of these areas indicated for urban use, the software SPRING (System for Geoinformation Processing) developed by INPE, was used. The interpretation on the screen of the SPOT-PAN image (K/J 716/397 from September 2<sup>nd</sup> 1997), was complemented with the interpretation of color aerial photos at scale 1:10,000 of the aerial survey performed in October 1997.

Initially, using techniques for analysis and interpretation of remote sensing data, the urbanized areas with consolidated use and areas of urban periphery were identified by the arrangements of intra-urban land use. The areas of urban periphery mentioned, present a rough texture at the SPOT/PAN image, defined by a combination of segments of discontinuous and irregular clear gray tones, as well as points and patches in different clear gray tones, contrasting with dark gray tones in the overall frame. These areas are discontinuous to the urban tissue, very sparse, showing tenuous connections with it.

Such a pattern corresponds to allotments whose net of streets are of reduced dimension, without integration to the existing net, occupied by small and rudimentary constructions in areas still occupied by natural vegetation with low elevation, typical for rural zones. Such areas are inhabited by a low-income population, which was confirmed during a field survey.

Within a society that shows an extremely unfair income distribution, where urban lots are elements that strongly contribute for the income concentration and where the State reinforces privileges, the poorer are expelled to the periphery, because they are not the segment of society which demand is solvent, specially due to the high prices of urbanized lots in central sectors, associated to the high indices of unemployment and underemployment.

Using SPRING, besides this information plan (IP) containing areas of urban periphery, another IP was made, containing the limits of areas indicated for urban use and another one containing the local drainage net.

The sectors of urban periphery located in areas technically indicated for urban use, come up to 13 km<sup>2</sup>, i.e. this is

quite a portion of the total amount of areas available.

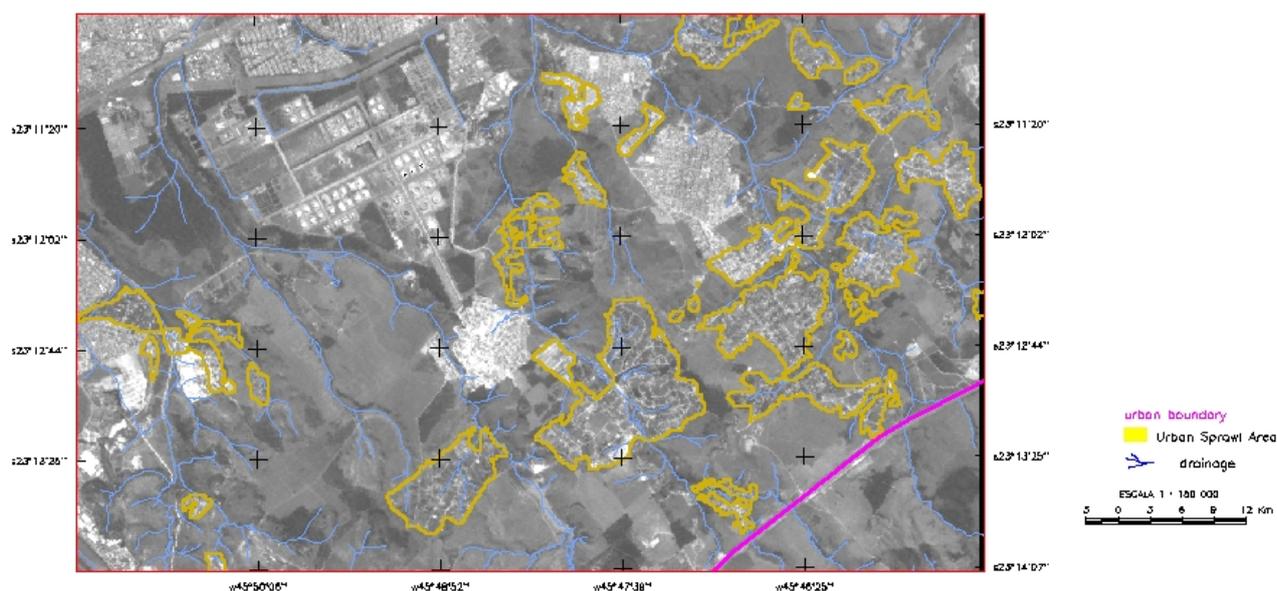


Figure 1 – Urban periphery of São José dos Campos and the SPOT Pan image

The integrated analysis of the three IPs generated, shows that the urban periphery occupies areas made up of gentle rolling to rolling relief, mainly represented by medium to large slopes with watersheds in concave/convex form, which are those areas with the highest potential for the process of urban growth in the municipality of São José dos Campos. One can perceive that the sparse and disordered occupation of the periphery is also due to the relief features of this region, i.e. to large watersheds of plain/convex and convex/concave forms, which are entirely favorable to the urbanization process, and allow a certain liberty for occupation. The valleys, which are defined by the drainage system, still look intact because they are natural obstacles to this process, due to the availability of more adequate areas.

In practical terms, the expansion of the urban tissue in the municipality, according to the Law for Urban-Land Use (1997) is made through the approval of the allotment of soil for urban purposes in those areas located in urban zones and of urban expansion of the municipality.

In this case, the allotments or subdivisions are made by the owner of the allotment, who shall execute the works and services of urban infra-structure. In these allotments, besides the public areas reserved for public circulation, there are also areas reserved for institutional locations (equipment for use by the community) and green areas.

Normally the person who executes the allotment, makes a partnership with the land owner to execute the undertaking. The speculation with the price of the urbanized land occurs because of the big demand which is not satisfied, that turns such land to one of the strongest elements of income concentrations in the country as well as a stimulus to the “clandestine” allotments, which are made without obedience to the pertinent law.

Being so, the final result of parceling the terrain for urban demands, is the subdivision of larger sectors in lots reserved for construction, whose minimum size is of a half-lot (5 x 25m).

In this context, the private interest of the entrepreneur is related to the profit obtained with urban land, and not to the

construction itself, because the profit obtained by the allotment is much higher than at the second activity. Frequently it is performed through self-construction. The result of this process is a physically and socially non-integrated urban tissue, with poorly executed houses which, according to Benevolo (1991) “are becoming most of human settlements”.

They also consist of expensive urbanization alternatives concerning area, facilities and urban services and they represent a waste of natural resources.

In the case of São José dos Campos it became evident through the regional and municipality plans, that there is a shortage of this resource and that there is a need to plan its use, considering the compatibility with the long term objectives involved in sustainable urbanization.

One of the requirements, besides considering environmental issues such as the protection of water resources, the terrain with sandy soils, the dense vegetation cover, seems to be the elaboration and implementation of public policies related to popular housing, which involve going back to the practice of project control, starting from the urban scale to the construction scale. In this case one could work taking into account the vertical component, increasing densities. The fundamental issue is to satisfy the wishes and needs of the population involved. In order to do that, it would be necessary to review the role of urban management, establishing new instruments, including among them the expropriation for social reasons, anticipating the expansion of the urban perimeter, which transforms rural in urban areas through simple changes of Law.

The information obtained by orbital remote sensing data (HRV/SPOT images on panchromatic mode), due to its repetition and spatial resolution, was helpful to monitor these areas of peripheral occupation. Similarly, the integration of this information plan with others related to the physical environment which characterize the urban location, using the geoprocessing system, was an adequate procedure to evaluate and provide information for planning decisions.

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