STUDYING A MEDIUM SIZE CITY GROWTH IN BRAZIL AND ITS CONSEQUENCES USING GEOTECHNOLOGIES

Sandra M.F. DA COSTA; Osman PINHEIRO JUNIOR
University of Vale do Paraíba
Institute of Research and Developing
Sandra@univap.br

Working Group VII/2

KEY WORDS: geotechnologies, urban growth, environmental limitations

ABSTRACT

The city of São José dos Campos is the most important city located at the Region of Paraíba River Valley, considering the process of industrialisation. It was, and it continues being, marked by an intense industrialisation, which started to command the growth of the municipal district after the decade of 50. The city grew without the local government could control the process definitively. In this sense, this research detected and evaluated the changes happened in the urban space of the city of São José dos Campos and analysed the environmental occupation, as a consequence of the process of urban growth without a town planning, using remote sensing data and techniques and a geographical information system (*geotechnologies*). This research will analyse the period of larger urban transformation, in respect to the industrialisation and recent economical changes: 1953 to 1997. A 3D model of the urban perimeter and a slope map have been produced to investigate how the city has occupied the site, which was assessed using digital topography data. The urban area was mapped using aerial photography obtained in 1953, 1962, 1973, and 1985, and SPOT Pan image, obtained in September 1997, all of them in scale of 1:25,000. The idea was to verify the city performance considering the relation between growth and site (environmental limitations) using the *geotechnologies* performance.

1 INTRODUCTION

According to Santos (1997), the geographical space can be considered as a group of accomplishments through functions and shapes that come as testimony of a history written by processes of the past and of the present. This space, or space-landscape, is the testimony of an instance of a mean of production in its concrete manifestations, the testimony of an instance of the world. In this context, Souza (1999) and Carlos (1992) affirm that the urban space is the space expression of the mode of production and the urban landscape, as a manifestation of the urban space, reproduces in one moment several moments of the history.

Those concepts permit to conclude that is very important to study and to analyse the urban form and its growth to understand the urban space, or the city, as subsidies to the urban planning. Frequently, these sort of studies show that the cities growth is a dynamic process, constantly encroaching upon areas that are not suiTable for urban land uses, guiding the growth of urban sprawl that are often unplanned (Nagarathinam et al., 1988).

Considering this, *geotechnologies* (the jointed use of remote sensing and GIS technologies) have been used as an important tools to help urban planners apprehend spatial dynamics and urban morphology. It can provide planners with visually impacting material and a method of monitoring the urban area, which is important in the formulation and monitoring of urban planning strategies and municipal policies. Its use has already been successfully applied to urban studies: Li and Forster (1998), da Costa and Cintra (1999), Meinel at al. (1998), Pathan et al. (1998).

In this sense, this research detected and evaluated the changes happened in the urban space of a medium size Brazilian city, São José dos Campos, and analyzed its environmental occupation, as a consequence of the process of urban growth with a poor structured town planning, using remote sensing data and geographical information systems (*geotechnologies*). This research analysed the period of larger urban transformation for Brazil and for this city, in respect to the industrialisation and recent economical changes: 1950 to 1997.

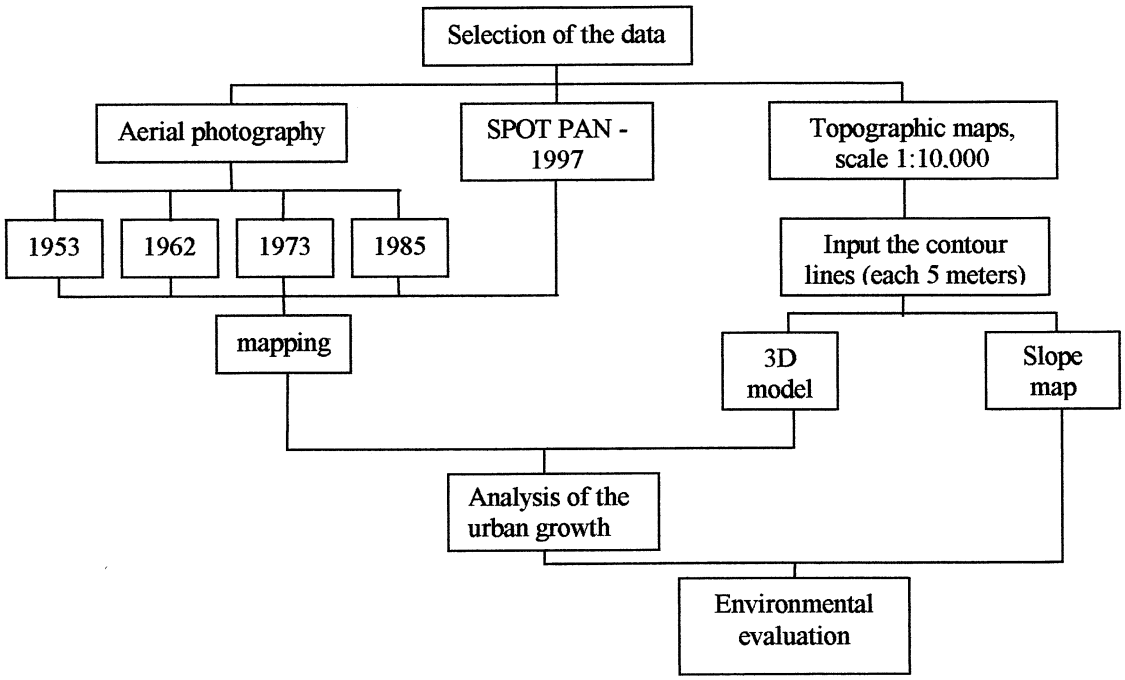

Figure 2 - Methodology flow chart

3.1 Producing the urban area maps

According to the flow chart, some data were collected to produce a map of urban area in distinct periods to identify changes in the urban space. Those maps were elaborated using aerial photography, scale 1:25,000, taken in 1953, 1962, 1973, and 1985, and a SPOT panchromatic image, obtained in 1997, scale 1:25,000. From these data was extracted the urban limits that were digitized to Arc-Info GIS and manipulated (overlaid) to calculate the urban growth rate and to define the principal growth axes among each period of study.

3.2 Elaborating the 3D model and slope map

The urban perimeter of São José dos Campos city is covered by 21 topographic maps in the scale 1:10,000. All these maps were digitized considering the contour lines, obtained each 5 meters. After that, a slope map was produced with five classes of slope, in degrees, using Arc-Info commands: *createtin* (produces a tin from an arc-vector data), *tinarc* (produces a slope map in degrees or percentage), and *polygrid* (produces a map in grid-raster format to made possible to overlay different data).

The elevation data also made possible to elaborated a 3D model, which permitted to visualize the urban site topography and help the analysis of the occupation.

3.3 Analyzing the urban growth and its relationship with the environment

The next step was to establish the relationship among the urban area maps produced to each year and the slope map. This was made using the GIS Arc-Info that permitted to establish crossing (overlay) rules. In this way, it was possible to understand the behavior of the city considering the environmental limitation, in respect to the slope.

Another important possible result was the analysis of the urban growth axes according to the topography. It was made using the SPRING, a Brazilian GIS produced by INPE (National Institute for Space Research), in which was elaborated the 3D model.

A field work was made to check the results obtained.

4 RESULTS AND DISCUSSION

4.1 Urban Growth

The urban growth map produced using the aerial photographies and the SPOT PAN image can be visualized in Figure 3. According to that, the city studied had occupied completely the main plateau up to 1962. Actually, at that moment the city did not have a law of zoning that could control or even guide its growth and, through some public decisions, the city was been adapted to its industrial development dynamism.

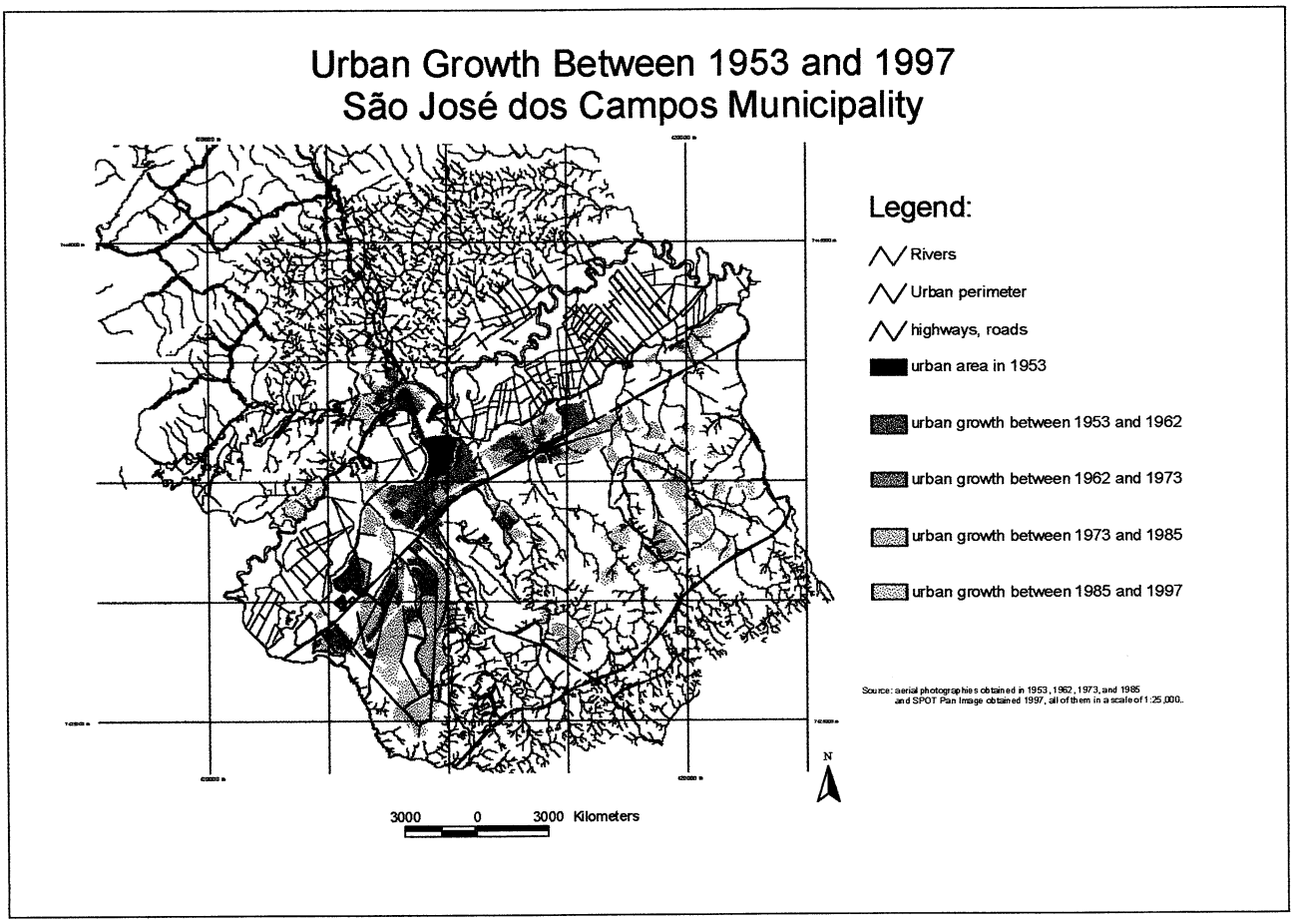

Figure 3. Map representing the urban growth between 1953 and 1997

The first law of zoning was elaborated in 1971 (law no. 1606/71) and its effect was not noted in 1973. As stated by that law, the urban land use was organized and some directions of urban expansion were established.

Between 1962 and 1973 the city presented a new axe of growth, to the direction of South and Southeast zones, been guided by the readiness of free space with infrastructure. During the period between 1973 and 1985, the urban growth rate was more significant to the South zone. This was pulled by the law of zoning proposed in 1980, that specified that area as unifamily residential zone.

The urban growth rate during this period was not the largest one but the most significant in terms of absolute numbers (Table 1). At that time, the municipal district had an industrialization increase that produced effects to the urban area like urban population and economical growth.

Between 1985 and 1997, it is possible to notice a decrease in the process (Table 1) caused by economical problems (80's crisis) and for a larger vertical urban growth than horizontal one. The principal axes of urban growth during this period (Figure 3) toke place in the southwest zone of the city, where many illegal settlements appeared. The law of zoning, approved in 1990, defined that area as "macro - zone of urban expansion", which associated to the low price of real estate, motivated the growth to that direction. The last law of zoning, published in 1997, tried to correct those faults.

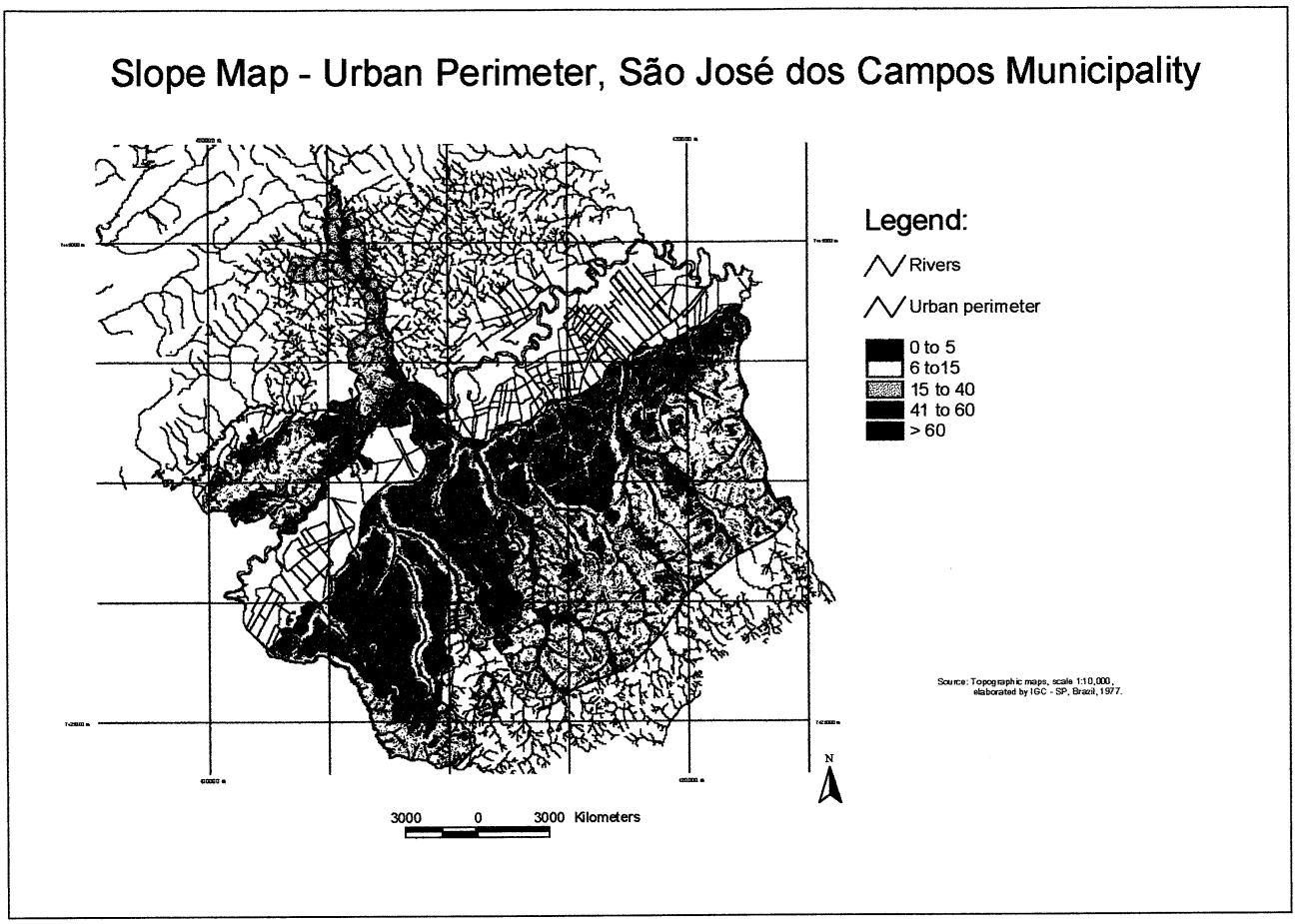

Figure 5. Slope map

Year	0° up to 5°	6° up to 15°	16° up to 40°	41° up to 60°	> 60°
1953	83.6	15.5	0.90	0	0
1962	86.0	13.2	0.80	0	0
1973	86.6	12.7	0.70	0	0
1985	80.13	18.13	1.72	0.01	0.01
1997	73.6	24.1	2.30	0	0

Table 2 - Relation Between Urban Area and Slope (% of occupation)

5 CONCLUSION

The evaluation of the environment, produced in this paper, did not use many physical parameters like geology, geomorphology, drainage, vegetation, and so on but it is just a part of a research that is beginning and expect to analyze all these information in a combined approach. By now, it was possible to understand the urban growth behavior and briefly considering its relation with the slope.

In this context, it made clear that the urban perimeter was defined according to the topography, that did not put the occupation conflicting to that. So, this paper shows that more than 93% of the area has an adequate site, in topography point of view, and that the urban area has growth to the best sites.

The research, when concluded, will try to evaluate the relation between urban occupation and environment, considering all important parameters, and analyze the social - economic parameters in this context, using, as much as possible, *geotechnologies*, which has been demonstrated as an important tools to decision makers.

Year	Urban Growth (km^2)	Urban Area Growth Rate	Urban Population Growth Rate**
1953 up to 1962	4.8	250.0	113.8
1962 up to 1973	7.6	77.5	132.9
1973 up to 1985	21.1	120.7	109.0
1985 up to 1997	17.1	44.4	67.1

Table 1. Urban Population and Urban Area Growth Rate Between 1950 and 1997

4.2 The urban growth and the environment

The topography of the urban site is predominantly formed by plateaus (Figure 4). These plateaus were produced by the deposition of sediments of the Paraíba river, the main one in this area, along thousands of years. The southern and northern zones have the most undulated terrain and the central area, where was the first place occupied, has the best topography: very flat, with low slope (Figure 5).

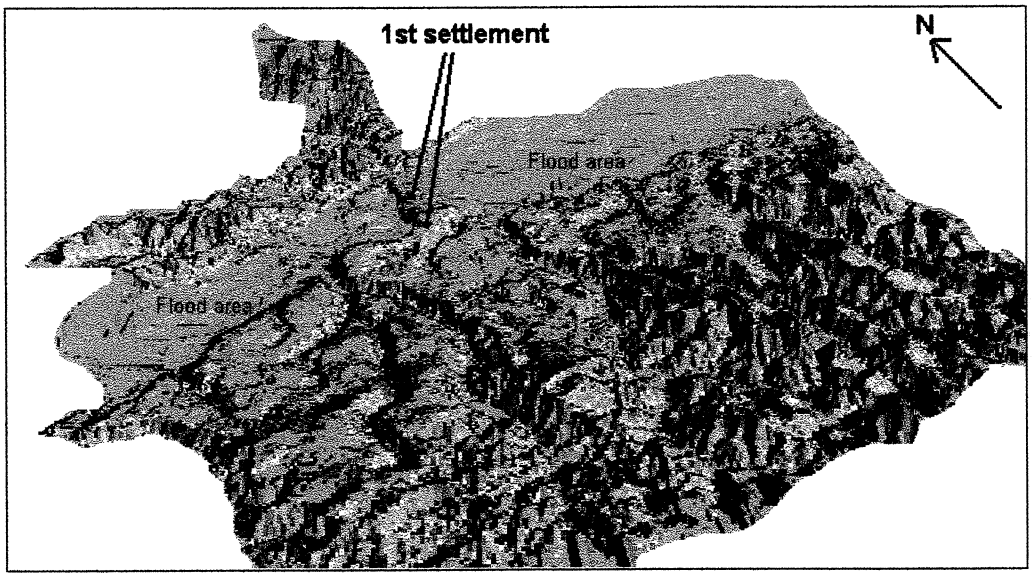

Figure 4 - 3D model of the urban perimeter

It is easy to see, in Figure 5, that most of the urban perimeter does not have problems associated to the slope. Actually, 58.7% of the area is located in the class 0 up to 5°, and 34.8% in the class 6 up to 15%, meaning that it is predominantly flat.

The map of urban growth was overlaid to the slope map to provide information about the relationship between growth and environment, in this case represented by the slope (Table 2).

According to the Table 2, it is possible to visualize that the city occupied the best site up to 1985. It means that more than 80% of the urban area, in each year, was located at the class 0 up to 5° It still happened even in 1997, when most of the urban area was located in the class 0 up to 5° (97.7%). The highest value of slope are located at the southeast and at the north of the urban perimeter, which were not effectively occupied.

** The period considered to calculate the urban population rate is not the same considered to calculate the urban area growth rate: 1950 up to 1960, 1960 up to 1970, 1970 up to 1980, and 1980 up to 1996 (census data).

ACKNOWLEDGEMENTS

The authors are thankful to FAPESP (São Paulo State Foundation for Research Support) for giving financial support to this research.

REFERENCES

Carlos, A. F. A. 1992. A cidade. Contexto, São Paulo, 98 p.

Da Costa, S.M.F; Cintra, J.P.1999. Environmental analysis of the metropolitan areas in Brazil. ISPRS Journal of Photogrammetry and Remote Sensing, 54(1999), pp. 41-19.

Ferreira dos Santos, C.N. 1988. A cidade como um jogo de cartas. Projeto Editores, São Paulo, 192 p.

Li, L.; Forster, B.C. 1998. Features and themes overview of features extraction and spectral classification and the impact of high spatial resolution satellite image data. In: ISPRS Commission VII Symposium, Vol. XXXII, Part 7, Budapest, Hungary, pp. 245-249.

Meinel, G.; Lippold, R.; Netzband, M. 1998. The potential use of new high resolution satellite data for urban and regional planning. In: ISPRS Commission VII Symposium, Vol. XXXII, Part 7, Budapest, Hungary, pp. 250-257.

Nagarathinam, V.; Jayagobi, K.; Maruthachalam, M.; Panchanathan, S.; Palanivelu, R. 1988. Urban monitoring using SPOT imagery - a case study. In: International Archives of Photogrammetry and Remote Sensing, Kyoto, Japan, Vol. XXVII, Part B9, pp. vii-322-vii328.

Pathan, S.K.; Bhanderi, R.J.; Arya, A. S.; Navalgund, R.R.; Bhavsar, N.M.; Desai, P.P.; Gajjar, K.J.; Aggarwal, B.S.; Bhowmik, M.M. 1998. A perspective plan for Ahmedabad Urban development authority area - 2011: remote sensing and GIS based approach. In: ISPRS Commission VII Symposium, Vol. XXXII, Part 7, Budapest, Hungary, pp. 258-265.

Santos, M. 1997. Espaço e Método. Nobel, São Paulo, 88 p.

Souza, M. A. de. 1999. A metrópole global? Refletindo sobre São Paulo. In: Souza, M.A. de et al. (orgs). Metrópole e globalização. CEDESP, São Paulo, 254 p.