The unequal spaces beyond the official limits:
The intra-urban dynamic of São Vicente Island in 1990s

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Abstract

This paper has two main goals. The first one is to show the main possibilities and limitations of the Brazilian Demographic Census for those who work with intra-urban analysis, dealing specially with information access at local, or intra-municipality level, and to promote a method of data analysis that minimizes these limitations. For this, a study case with the São Vicente Island, located on the coast of São Paulo, Brazil, was realized, using a procedure of data interpolation, known as kriging. Then, the second goal arises: to analyze the intra-urban dynamic of this island in the 1990s, a possible application for these procedures. This paper brings maps that show a visible segregation of households that overflows the official limits of the two municipalities studied.

Introduction

The microdata of the Brazilian Demographic Census of 2000, presented recently, brought some innovations and limitations when compared to the Census of 1991, for those researchers that study the intra-urban dynamic of certain area. The main innovations and limitations of this census are denoted in this paper, as well as suggestions of how to analyze the census tracts in a better way. To help in this work, a study case was realized with the São Vicente Island, located on the coast of São Paulo.

This island contains part of the municipalities of Santos and São Vicente (Figure 2), the first municipalities created on the State of São Paulo (São Vicente in 1532 and Santos in 1545). Santos is the core of the Baixada Santista Metropolitan Area (BSMA), which contains also another eight municipalities (Figure 1). The BSMA is the third Metropolitan Area of the State of São Paulo in terms of number of inhabitants, almost 1.5 million in 2000. Santos had almost 418 thousand in 2000, and 99.5% of them living in São Vicente Island. The insular part of Santos has almost 40 squared kilometers, shared by many hills, the residential place, and the Santos Harbor, the biggest of Latin America in terms of moved tons, 48 millions in 2001.

The Municipality of Santos is now consolidated. In 1980-1991, its population growth rate was 0.1% per year, while in 1991-2000 was reduced to 0.01% per year, almost null[1]. And São Vicente is the main destination place for those who left Santos. In 1990s, these two municipalities concentrated about 50% of the BSMA population, but this proportion is declining over the years.

With these facts, the intra-urban dynamic of this place has a growing importance.

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[1] Source: Jakob, 2003a.

Figure 1:

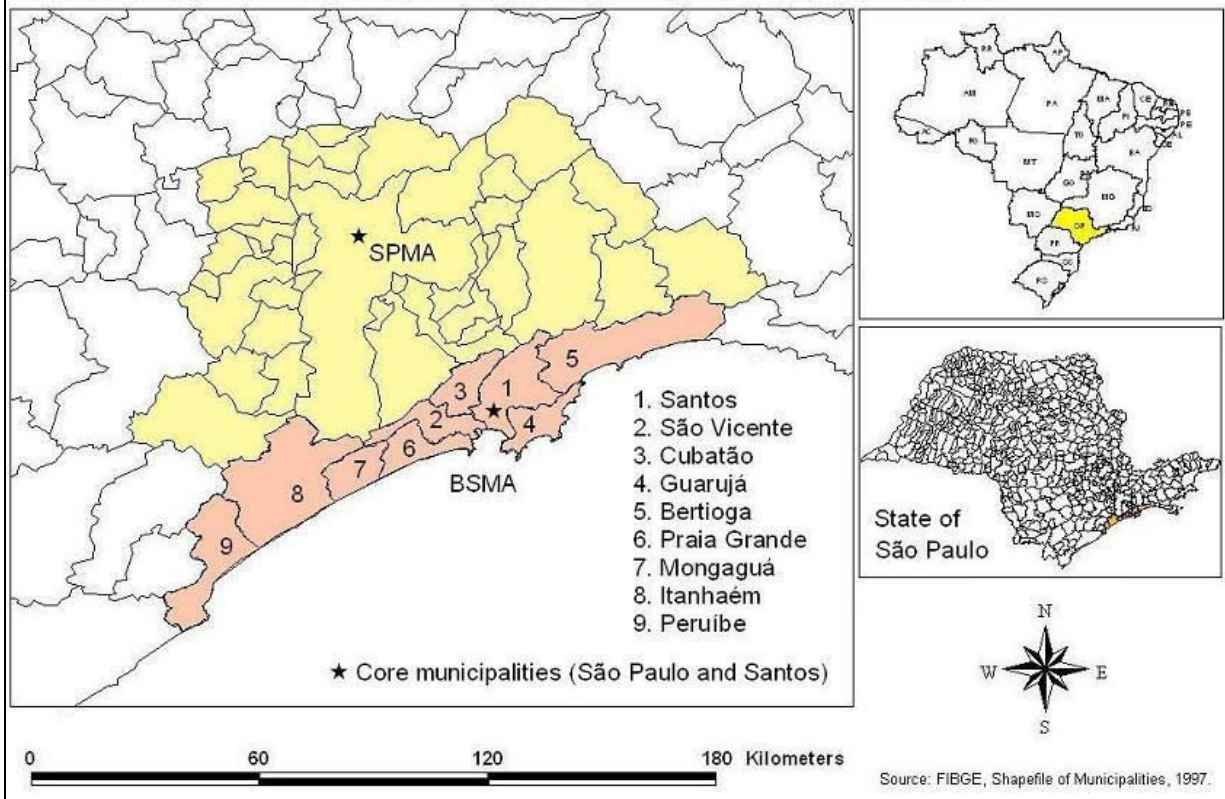São Paulo Metropolitan Area (SPMA) and Baixada Santista Metropolitan Area (BSMA), 1997

1. Santos
2. São Vicente
3. Cubatão
4. Guarujá
5. Bertioga
6. Praia Grande
7. Mongaguá
8. Itanhaém
9. Peruíbe

★ Core municipalities (São Paulo and Santos)

State of São Paulo

0   60   120   180 Kilometers

Source: FIBGE, Shapefile of Municipalities, 1997.

Figure 2:
Landsat Image of São Vicente Island and some municipalities

Source: INPE, Mosaico do Brasil (http://www.dpi.inpe.br/mosaico), accessed in Feb/2001. Landsat Image of 1999.

Jakob (2003a) denoted that the tendencies verified for the BSMA, of spatial "de-concentration" of population, "peripherization", and modification of the kinds of

occupation of the places, have an intra-municipality expression. In this way, this expression was analyzed for the São Vicente Island in this paper.

Methodological Aspects

The "intra-urban" term is used here in the same conception of Villaça, to whom:

"A estrutura do espaço regional é dominada pelo deslocamento das informações da energia, do capital constante e das mercadorias em geral. O espaço intra-urbano, ao contrário, é estruturado pelas condições de deslocamento do ser humano, seja enquanto portador da mercadoria força de trabalho - como no deslocamento casa/trabalho - seja enquanto consumidor - reprodução da força de trabalho, deslocamento casa-compras, casa-lazer, escola, etc." (Villaça, 1998: 20).

"The structure of the regional space is dominated by flows of energy information, constant capital and goods in general. The intra-urban space, in the other way, is structured by the conditions of the human being flows, like work force goods – transfers house/workplace – or consumer – reproduction of work force, transfers house-shopping, house-leisure, school, etc." (Villaça, op.cit.: 20).

So, the intra-urban space, or place, is not constrained to rigid boundaries, like administrative or official limits, and can be delimited by boundaries smaller or bigger than municipalities. It was used intra-municipality analysis in this paper in order to show that is possible to find very interesting results from local scale information, with census data only, using the census tracts as a small unit of analysis.

But the variable "census tracts" was removed from the microdata of the 2000 census, in order to preserve better the secrecy of information. The only one possibility to study census tracts now in Brazil is to obtain a database with aggregated data, no more in microdata format. However, this aggregated data now can come with the census tracts shapefile of 2000, for the first time the Brazilian Census Bureau (IBGE) makes the census tracts boundaries available. And through a comparison table, it is possible to recreate the census tracts boundaries for the censuses of 1991 and 1980, per example.

Once created the census tracts boundaries, is easy to create a shapefile of points, in order to make data interpolations. These interpolations, although generating maps with smoothed data, give more expression to the highest spatial concentrations of certain phenomenon, minimizing unexpressive differences of the contiguous data.

With the census tracts, the detail of the analysis grows, comparing to the analyses of "bairros"[2]. Then, it is necessary a better explain about data kriging.

The data interpolation by kriging

Geographic Information Systems are being used for many years as a method to visualize data, in order to obtain better conclusions. These "conventional" methods of data analysis generally use data like polygons, lines or points to represent geographic characteristics of the study area. The polygons usually represent with areas like municipalities, states or countries. Then, when the GIS software is used to analyze data, the whole polygon usually assumes the same value. This is not true. There are mean values between two polygons, that aren't seen with these kind of vector analyzes. Sometimes, there are huge differences, and then, the map becomes like a patchwork of colors.

A better method of data analysis is the data interpolation. The mean values are preserved, and the final result is a surface of smooth data, which minimizes the differences between the polygons, and gives more expression to the highest spatial concentrations. Kriging generally is known as the best linear method of data interpolation, with the minor errors and unbiased. It uses the tabular data and its geographic position in order to calculate the interpolations. As a result, a surface map is created from the original points map. The Tobler's First Law of Geography is used, that says that nearest unit analysis are more similar than that more distant ones. So, using mathematical functions, it gives more significant weights to nearer positions of the known point, and the weight becomes less significant when the distance from the point grows, originating new interpolated points based on these linear combination of the data.

Geostatistics includes a wide variety of techniques, like the Inverse Distance Weight (IDW), nearest neighbor analysis and linear and non-linear kriging. It is commonly used to identify and map spatial patterns across a landscape, and can be used to find spatial autocorrelation between data points. For this, the most common function used is the (semi)variogram. The variogram is a mathematical description of the relationship between the variance of pairs of observations (data points) and the distance

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[2] In Brazil, big municipalities are divided by districts, and each district can be divided by bairros. But small municipalities, in general, are divided just by bairros, without districts. So, the bairro is an administrative boundary smaller than the district, both inside of the municipality.

separating these observations (h). Spatial autocorrelation can then be used to make better estimates for unsampled data points (inference = kriging).

Kriging is based on the idea that you can make inferences regarding a random function $Z(x)$, given data points $Z(x_1)$, $Z(x_2)$, …, $Z(x_n)$. The function $Z(x) = m(x) + \gamma(h) + \varepsilon$ has a constant mean, a spatial correlation, and a residual error. The spatial correlation is given by the variogram:

$\gamma(h) = \frac{1}{2} \text{var} [Z(x) – Z(x+h)] = \frac{1}{2} E [\{Z(x) – Z(x+h)\}^2]$; in practice:

$\gamma(h) = \frac{1}{2} N(h) \Sigma_i[Z(x_i) – Z(x_i+h)]^2$, where $N(h)$ is the total number of pairs of observations separated by a distance h, and the fitted curve minimizes the variance of the errors.

The Figure 3 shows the variogram components, and its main models. The nugget effect (or nugget variance) can be zero or a non-zero value for γ when h = 0. It shows how much short distances are similar or not. A high value indicates expressive variations at short distances. It is produced by various sources of unexplained error (e.g. measurement error), or by significant differences at near positions. The sill is the maximum value of γ of the fitted curve. For large values of h the variogram levels out, indicating that there no longer is any correlation between data points. The sill should be equal to the variance of the data set. It is important to define de sill in order to analyze the range, the value of h where the sill occurs (or 95% of the value of the sill), the maximum point where there are spatial correlation of the data. And this spatial autocorrelation of some variable is given in known distance units, like meters or miles, and can be a proxy of spatial segregation. With this, is possible to find a value of spatial segregation of certain variable. In general, 30 or more pairs per point are needed to generate a reasonable sample variogram.

Other factors to be studied are the anisotropy and the drift. The anisotropy happens when there is a spatial autocorrelation more concentrated in certain direction, and the drift happens when some attributes (like the mean of the values) modifies themselves in a systematic way. There are specific functions to deal with these factors.

Kriging produces the best linear unbiased estimate of an attribute at an unmeasured site. There are many kinds of kriging. The ordinary kriging is used when there is no drift in the data, although it can incorporate also anisotropy analysis; universal kriging accounts for drift; punctual kriging produces values for non-sampled points; block kriging produces values for areas instead points; and co-kriging uses two or

more variables that are correlated between themselves in the estimation of values for one of them. In this paper, the ordinary kriging was used.

Figure 3:
Variogram Models and Components
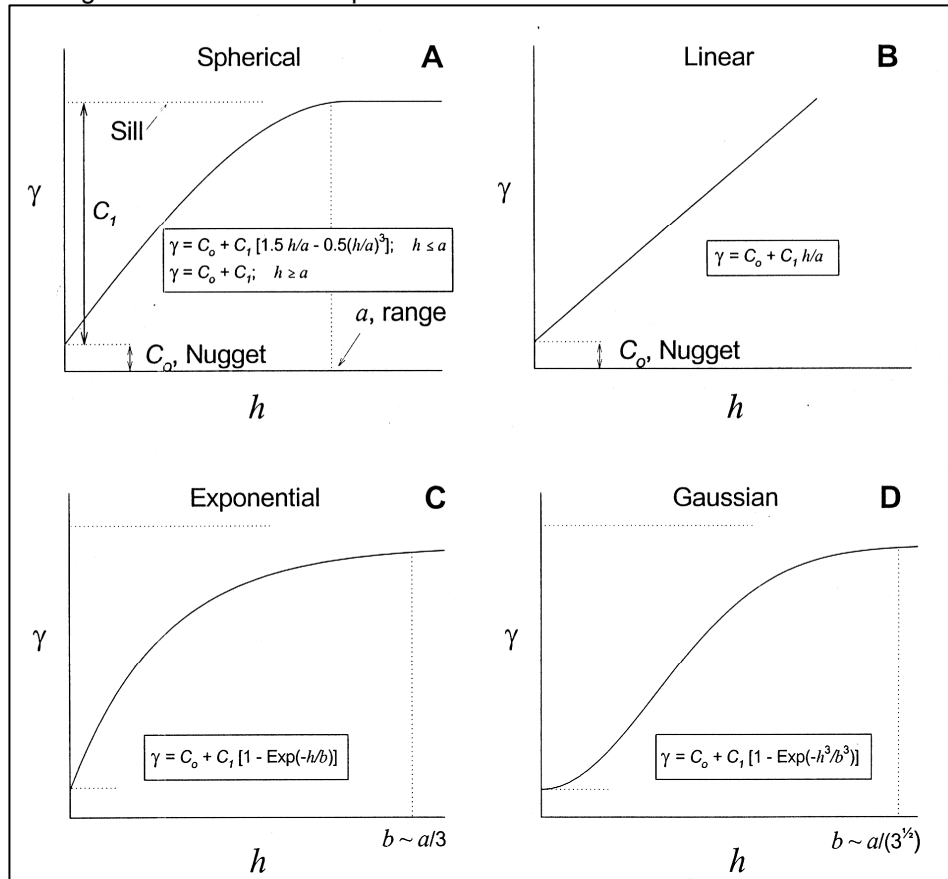
Source: Jakob (2003a)

Ordinary kriging is a data interpolation method that "*is often associated with the acronym B.L.U.E. for 'best linear unbiased estimator'. Ordinary kriging is 'linear' because its estimates are weighted linear combinations of the available data; it is 'unbiased' since it tries to have the mean residual error equal to '0'; it is 'best' because it aims at minimizing the variance of the errors*" (Isaaks and Srivastava, 1989: 278).

Finally, it can be observed that kriging, although bring very good results (especially for 100 or more points or observations), demands more specialization, dedication and training for the involved people, in order to obtain better, more expressive and, above all, reliable and accurate results[3].

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[3] More details about kriging can be obtained in Matheron, 1963; Journel and Huijbregts, 1973; Jakob, 2004, 2003a and 2003b, among others.

The intra-urban dynamic of São Vicente Island

After the creation of interpolated maps, is possible to analyze the mobility of social groups, people and households, and find its spatial concentration which, in this paper, happens inside of the São Vicente Island.

Linking the population mobility and the expansion of São Paulo Metropolitan Area (SPMA), Cunha (1994) denoted that 90% of the migration inside SPMA was formed by nuclear families, and pointed the main characteristics that would originate the familiar migration, like the familiar life cycle, its socio-economic condition, its size, and its socio-occupational level. Smolka (1994, 1992a, 1992b, 1992c) found a similar result, studying the intra-urban structure of Rio de Janeiro, which pointed as the main responsible factors for the intra-urban mobility the demographical ones (related to the familiar life cycle), the socio-economical ones (related to the labor market insertion), and the environmental and cultural factors, related to the neighborhood adaptability or not, and to the introduction of "new ways of life", like the closed condominiums.

In order to analyze data at census tracts level, we have the limitation imposed by the Brazilian Census Bureau, allowing only data related to age, years of study and income of the head of household, as well as household variables, like its type, localization, condition of occupation, number of inhabitants, kinds of water supply, sanitary installation, and trash destination. Since is impossible to make data tabulations at census tracts level in 2000, because the microdata are unavailable, these variables shall be analyzed in an independent way in 2000. For this, interpolated maps of each one of these variables were created for the island in 1991 and 2000, in order to find and denote the movement of them spatial concentrations in 1990s.

Jakob (2003a) pointed some tendencies of population spatial de-concentration, peripherization, and modification of ways of place occupation inside BSMA. As denoted before, one aim of this paper will be to show that these tendencies have an intra-municipality expression at the core-municipalities of the area.

Another goal of this paper, related to the spatial segregation of social groups, would be to verify if the characteristics of the places are being modified along time, due to the appearing of new ways of occupation acting in these places, which could be happening due to urban renovation processes, with valorization of the area and the resultant expulsion of poorer families, or due to the familiar life cycle. With this, families

at initial stages of life cycle could be looking for new occupation places, meanwhile those at fragmentation stages would stay on those older and consolidated locals. So, these ways of occupation could implicate on ageing or rejuvenating of certain locals, depending on the type of occupation evolved on this process.

Once denoted these goals, the analysis of census tracts were divided on population and household characteristics.

The population characteristics of census tracts

This topic analyzes some characteristics of the census tracts inhabitants of the São Vicente Island, like the mean age, mean number of years of study of the head of household, and his/ her mean monthly income, in minimum salaries, in census tracts.

The Figure 4 shows the mean age of the household heads in the census tract. As you can see, the elderly are located on a coastal strip of the island, especially in the bairros of Gonzaga and Boqueirão in Santos, a noble area with a high land price. The legend also shows that the age reaches more than 60 years as a mean age. The less colored strip in direction north-south in Santos in 2000 is represented by the hills, clearly seen in Figure 2.

Santos is one of the preferred places of the retired people because of its life quality, the beaches, weather, programs for old people, and the proximity with the municipality of São Paulo (near 65 kilometers), where most of them worked. Some people also live in Santos and work in São Paulo, the commuters.

The maps of mean age of the inhabitants are quite similar and so it was omitted. The only difference was in the legend, varying from 19.7 to 48.8 years-old. Then, we can distinguish the areas of youth and old people.

The mean years of study of the literate household heads are presented in Figure 5, that has about the same pattern of Figure 4, unless for some areas located on the extreme points of the coastal strip of São Vicente Island. The east part is closed to the ferry boat terminal that departs to Guarujá, a municipality that was installed as a vacation colony for rich people from São Paulo and was one of the first municipalities of the State of São Paulo with urban planning. Guarujá still attracts medium and high class tourists, even now. The west part of the seafront is formed by Ilha Porchat (Porchat Island), a high class condominium for wealthy people, a noble area from São Vicente.

Figure 4:

Mean Age of the Household Heads in Census Tracts
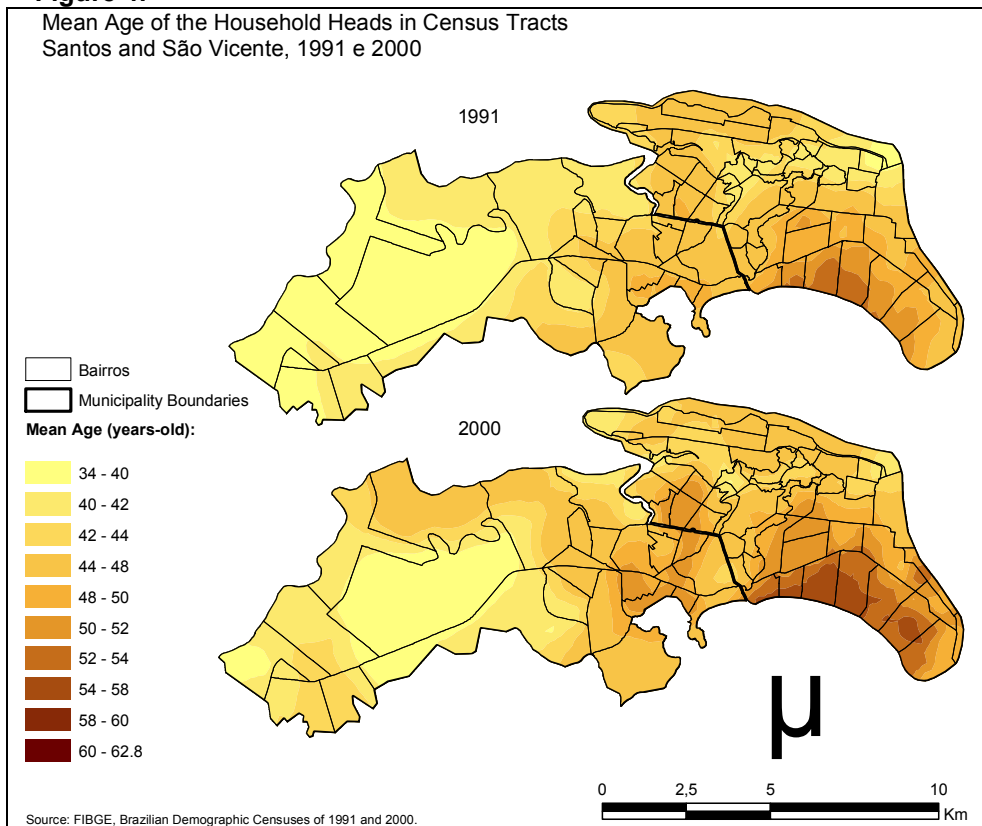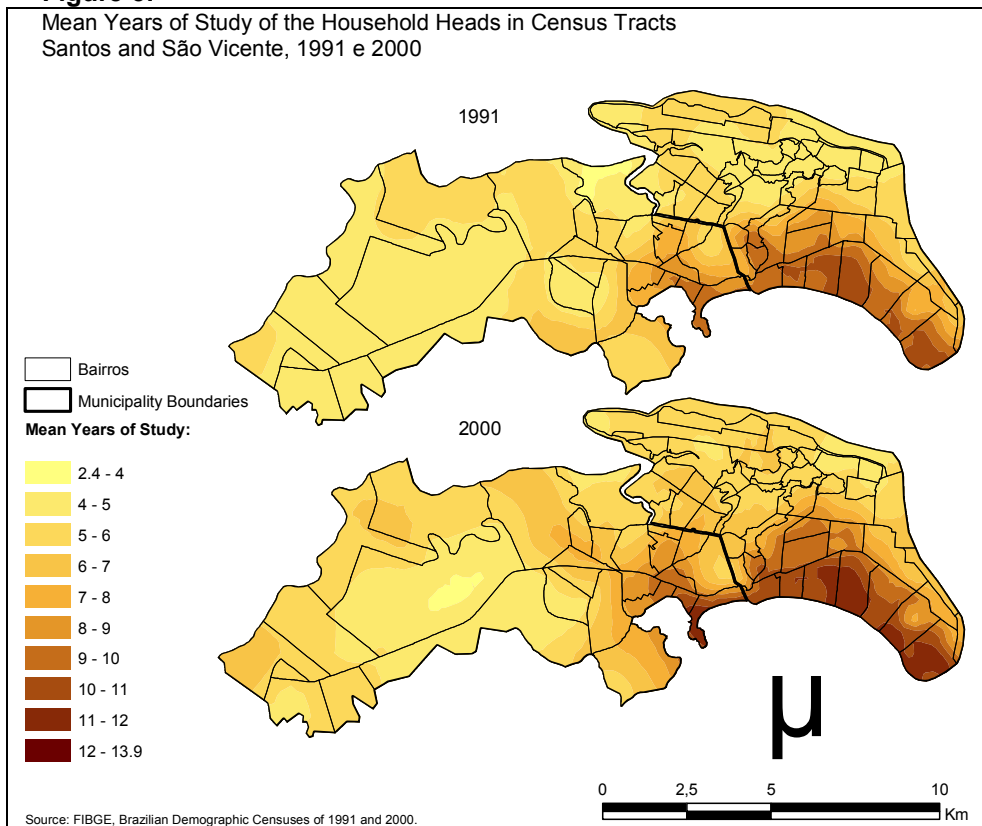Santos and São Vicente, 1991 e 2000

1991

Bairros

Municipality Boundaries

Mean Age (years-old):

- 34 - 40
- 40 - 42
- 42 - 44
- 44 - 48
- 48 - 50
- 50 - 52
- 52 - 54
- 54 - 58
- 58 - 60
- 60 - 62.8

2000

μ

0   2,5   5   10
Km

Source: FIBGE, Brazilian Demographic Censuses of 1991 and 2000.

Figure 5:

Mean Years of Study of the Household Heads in Census Tracts
Santos and São Vicente, 1991 e 2000

1991

Bairros

Municipality Boundaries

Mean Years of Study:

- 2.4 - 4
- 4 - 5
- 5 - 6
- 6 - 7
- 7 - 8
- 8 - 9
- 9 - 10
- 10 - 11
- 11 - 12
- 12 - 13.9

2000

μ

0   2,5   5   10
Km

Source: FIBGE, Brazilian Demographic Censuses of 1991 and 2000.

The mean monthly income of the household heads that earned (and declared) some salary in the census data are denoted in Figure 6. The legend brings the mean income in minimum wages[4].

Figure 6:

Monthly Mean Income of the Household Heads in Census Tracts
Santos and São Vicente, 1991 e 2000

Source: FIBGE, Brazilian Demographic Censuses of 1991 and 2000.
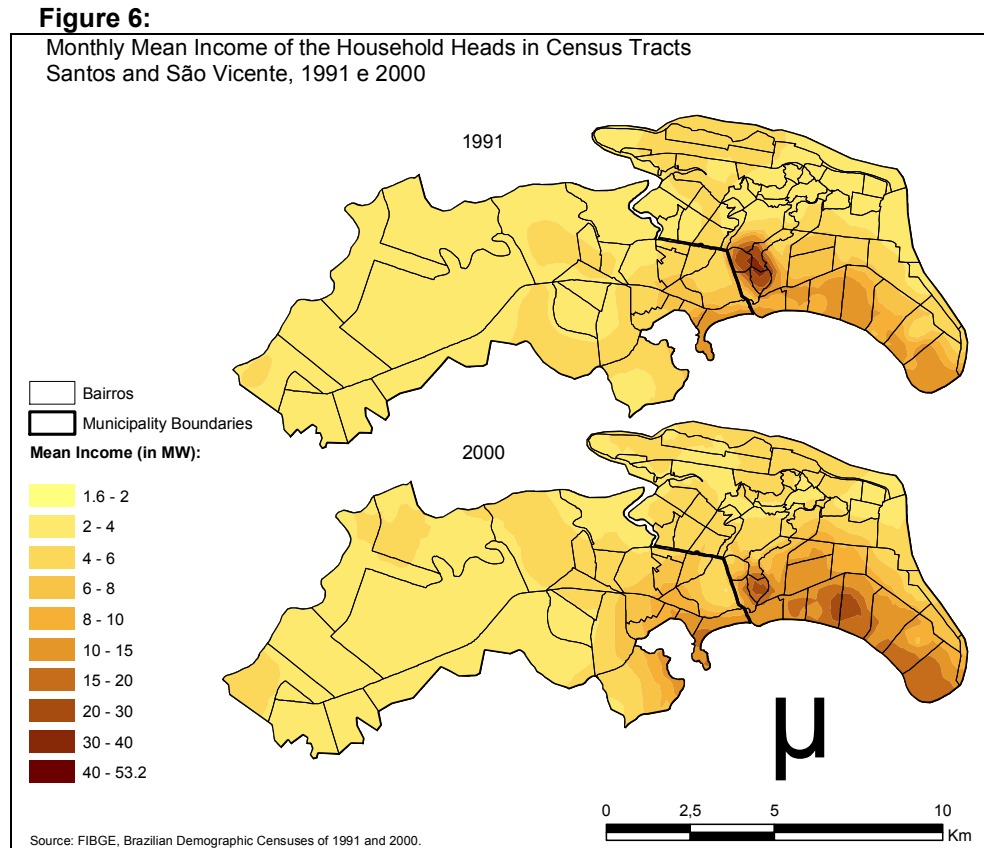
Although this figure denotes about the same pattern represented in figures 4 and 5, we can see a spatial concentration of high income in the south part of the hills of Santos, especially in 1991. This can be explained by the presence of a closed condominium, with high quality residences, and the concentration seems to decline in 2000 because this census tract was divided for the 2000 census. Another concentration can be seen in the bairros of Gonzaga and Boqueirão, especially in 2000. As noted before, these areas are noble ones in Santos.

These three figures clearly show the presence of a spatial segregation of the households in São Vicente Island. Since the mean values could distort the original numbers, different maps were produced, with parts of the range of the variables. So, the higher spatial concentrations showed in the map of the mean age of the household

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[4] The monthly minimum wage was about US$ 90 in 2000 in Brazil.

heads was about the same of the proportion of household heads with more than 70 years-old, that varied from 0 to 39.4% of the household heads in the census tract. And the heads from 10 to 29 years-old varied from 0 to 43.5%, corresponding to the lighter area of Figure 4.

The years of study also were represented by different maps, and the higher spatial concentrations of Figure 5 were almost the same as the heads of household with 12 or more years of study, and the less colored areas represented the illiterate people (considering only people with 5 or more years-old). The census tracts concentrated until 44.4% of illiterate heads, and until 82.9% of heads with college degree or higher. Both census tracts were seen in Santos in 1991.

Analyzing now the income, maps were created for the proportion of heads of household without any monthly income, and that ones earning 10 or more minimum wages. As we can see in Figure 6, the areas with more concentration of heads with higher income represent the areas with high proportion of heads earning 10 or more minimum wages. That spatial concentration area showed in Figure 6 in 1991 in Santos (with a condominium in the hill of Santa Teresinha) concentrated 95% of the heads earning more than 10 minimum wages every month, declining to 88.3% of them in 2000, been beat by a tract in the Gonzaga/Boqueirão area, with 89.6% of the household heads earning this class of income[5].

And the less colored areas represent less income, but a census tract in the periphery of São Vicente (in the southwest part) called attention. It concentrated 56.8% of the heads without monthly income, of a total of 345 households in this tract, with 99% of houses, 96% own, and 96% with inadequate collection system.
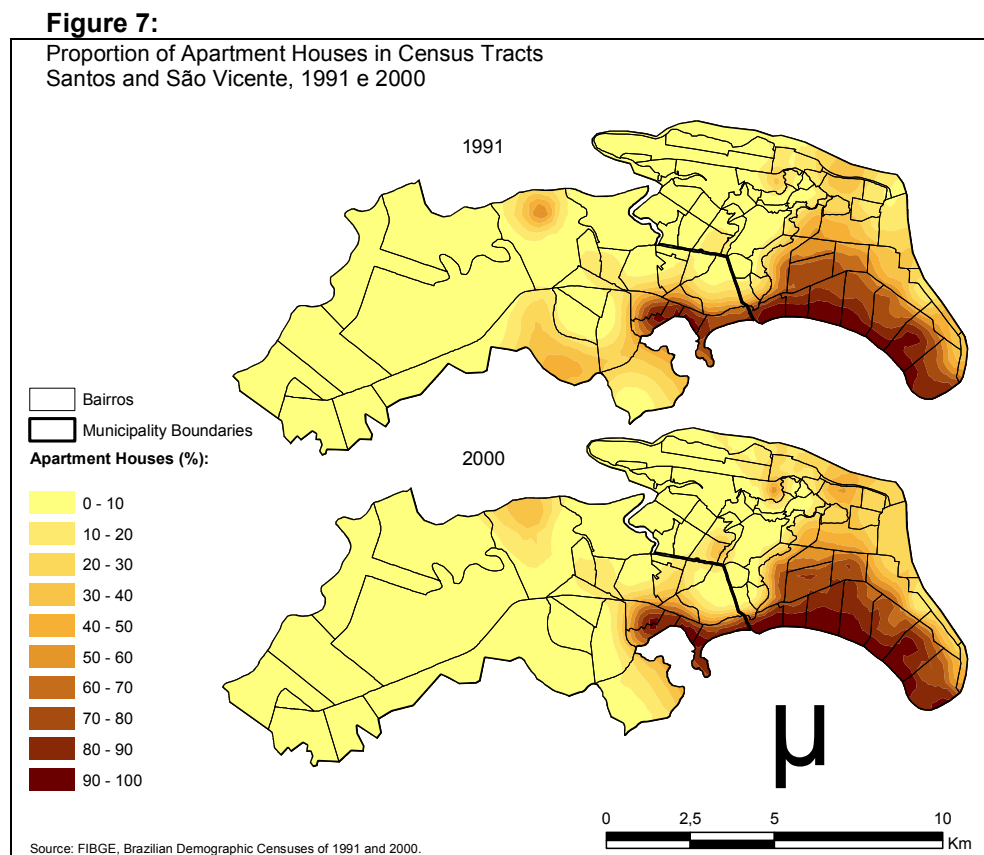
With this landscape, is very important to analyze the residential attributes of the households. And this is the main goals of the next item.

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[5] The ideal would be to remove the effects of the inflation of the period, but with the aggregated data of 2000 census, all data treatment is very limited. So, the income data is not completely comparable.
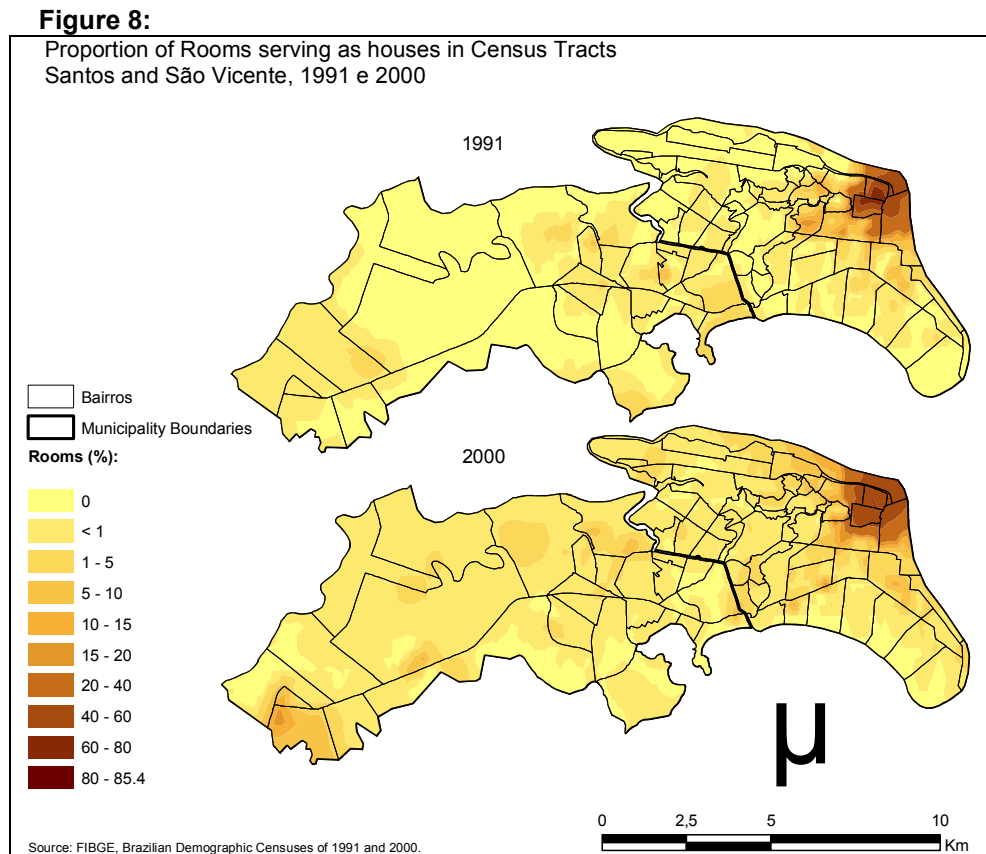
The residential characteristics of the census tracts

The goal of this item is to verify the evolution of the residential conditions of the population at the census tracts level in São Vicente Island, and try to show that the worst conditions were located at the hills and the periphery of the municipality, clearly confirming vectors which leave or overflow the boundaries of the municipality.

The figures 7 and 8 are the result of the interpolation of the variable "type of household". They clearly show the existence of a differential spatial concentration in terms of this variable. While the concentration of apartment houses was more expressive at the seafront, besides the presence of some isolated places (Figure 7), the spatial concentration of households like rooms (room houses) was more significant in Paquetá, Vila Nova and Centro, the most antique area of Santos (Figure 8). The higher concentration of houses was verified at the hills, at west part of the island, and near the harbor zone, places which correspond to the less colored area of these maps.

Figure 7:

Proportion of Apartment Houses in Census Tracts
Santos and São Vicente, 1991 e 2000

1991

2000

Bairros
Municipality Boundaries

Apartment Houses (%):

0 - 10
10 - 20
20 - 30
30 - 40
40 - 50
50 - 60
60 - 70
70 - 80
80 - 90
90 - 100

0   2,5   5   10
Km

Source: FIBGE, Brazilian Demographic Censuses of 1991 and 2000.

It can be verified, from these maps, that this different spatial concentrations of types of household didn't modifies themselves in a significant way along the 1990s, and also the presence of certain limits between the popular, the noble and the antique areas. And the complimentary maps of the figures 7 and 8 are the proportion of houses in census tracts, the less colored areas of these figures.

Figure 8:

Proportion of Rooms serving as houses in Census Tracts
Santos and São Vicente, 1991 e 2000

Source: FIBGE, Brazilian Demographic Censuses of 1991 and 2000.

With respect to the sanitary installation, which can help to detect more recent occupation areas (expansion areas), it can be seen, from Figure 9, that the participation of households without official collection system or septic tank was more concentrated in Chico de Paula, in 2000, as well as in a place between the Casqueiro river and Vila Industrial, at the limits of Santos and Cubatão. So, these areas could be considered as expansion areas, located on the periphery of the municipality of Santos. In São Vicente, the most recent areas, or the periphery, are located on the central part of the municipality, as well as the west portion, northwest in 1991 and southwest in 2000.

Analyzing now the water supply, the Figure 10 shows that there was an improvement in 1990s in order to raise the number of households linked to the official

water system. In Santos, there were just a few concentrations near the slopes of the hills and near the antique area in 2000, and in São Vicente the agglomerations were present in areas of expansion between some rivers, and it causes some technical difficulties to implement the official water system.

Figure 9:

Proportion of Households without Official Collection System or Septic Tank in Census Tracts Santos and São Vicente, 1991 e 2000

Source: FIBGE, Brazilian Demographic Censuses of 1991 and 2000.
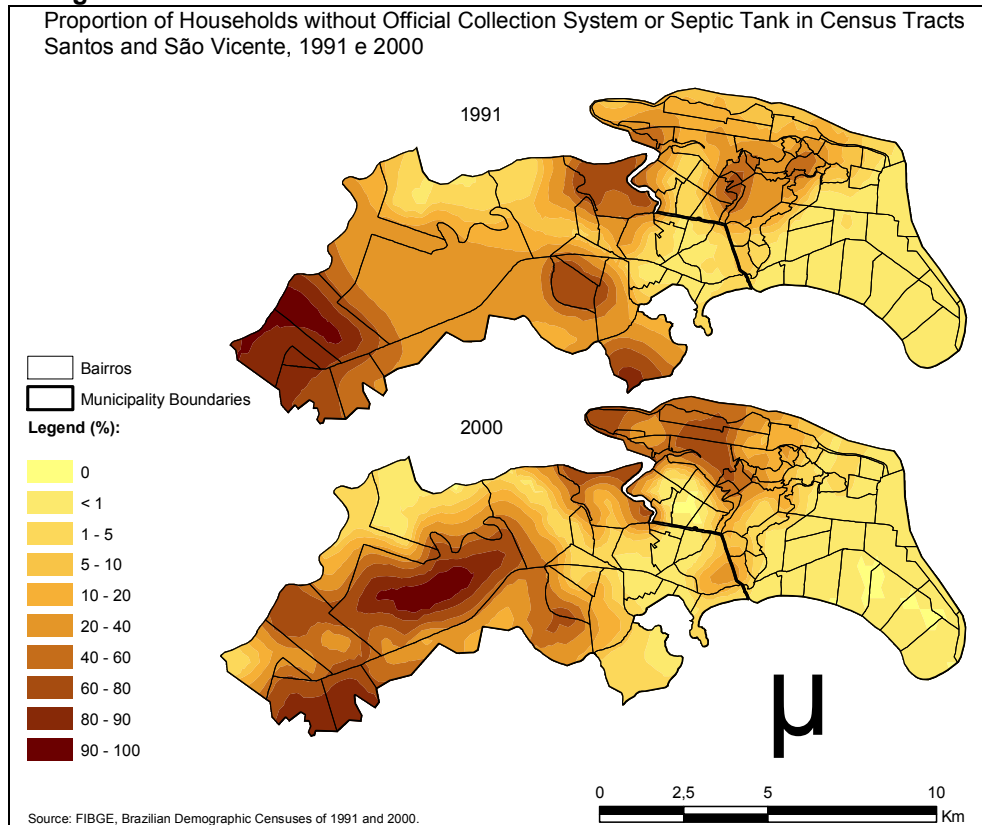
Finally, dealing with garbage destination, Figure 11 shows that the improvements are also visible in the 1990s. In 2000, just a few areas in the hills of São Vicente and near the limits with Cubatão concentrated some residences without trash collected. This case also brings some technical difficulties, because the trucks can not "climb" the hills.

In a former work, dealing especially with the insular part of Santos, it was noted too a growing concentration of single-person households near the seafront and in the antique areas of Santos. In the seafront by the presence of the elderly, retired, living alone (with children married already and living in another place), and in the antique areas living in rooms serving as houses[6].

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[6] Jakob (2004)

Figure 10:

Proportion of Households without General Distribution System of Water in Census Tracts
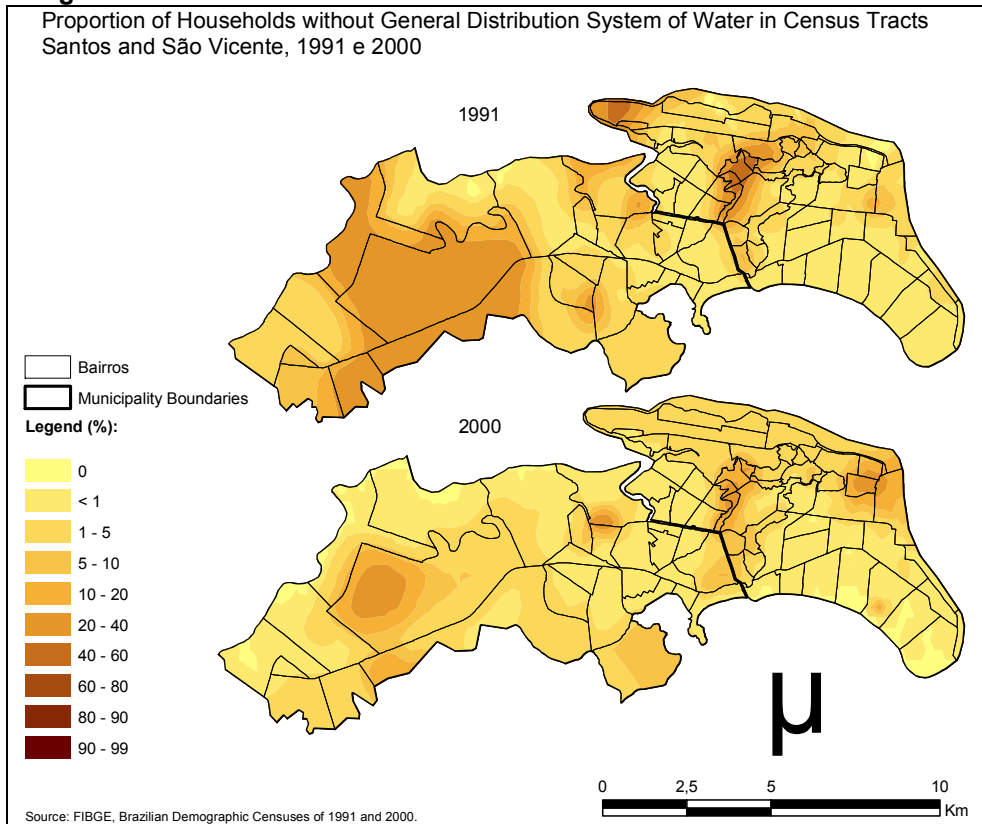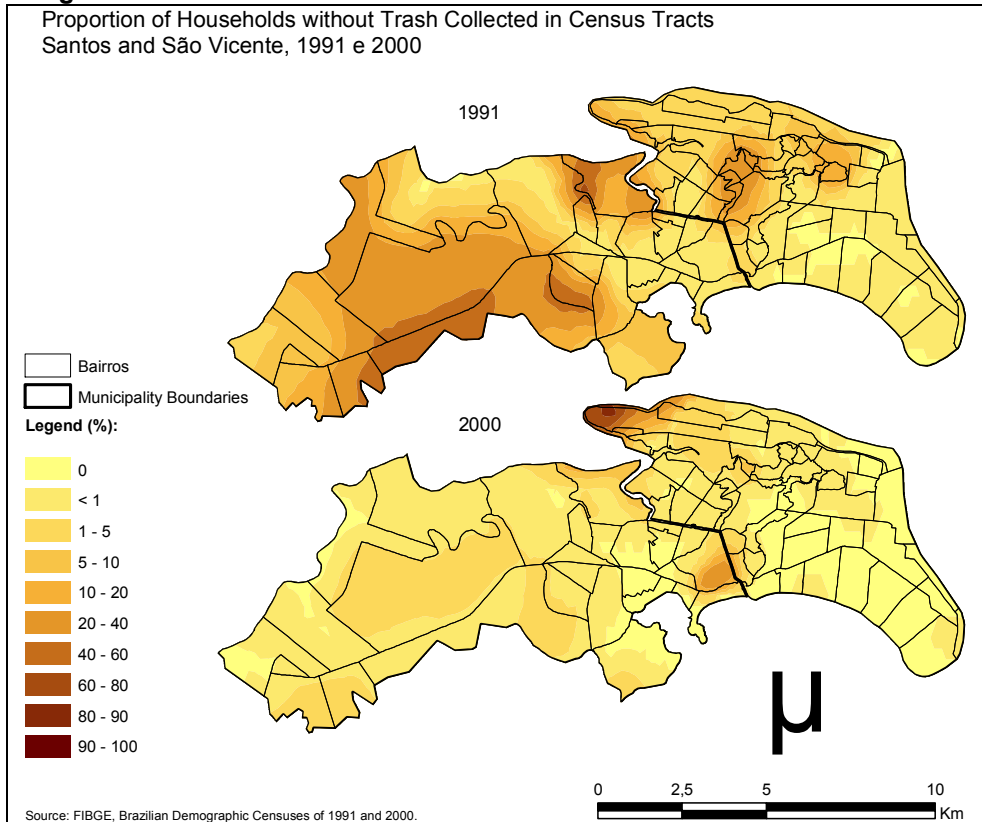Santos and São Vicente, 1991 e 2000

1991

Bairros
Municipality Boundaries

Legend (%):

- 0
- < 1
- 1 - 5
- 5 - 10
- 10 - 20
- 20 - 40
- 40 - 60
- 60 - 80
- 80 - 90
- 90 - 99

2000

μ

0   2,5   5   10
Km

Source: FIBGE, Brazilian Demographic Censuses of 1991 and 2000.

Figure 11:

Proportion of Households without Trash Collected in Census Tracts
Santos and São Vicente, 1991 e 2000

1991

Bairros
Municipality Boundaries

Legend (%):

- 0
- < 1
- 1 - 5
- 5 - 10
- 10 - 20
- 20 - 40
- 40 - 60
- 60 - 80
- 80 - 90
- 90 - 100

2000

μ

0   2,5   5   10
Km

Source: FIBGE, Brazilian Demographic Censuses of 1991 and 2000.

Conclusions

The presented maps showed clearly the tendency of socio-spatial segregation of population. The areas located until two kilometers from the seafront, in general the noble ones, occupied by wealthy and older household heads, and with more proportion of apartment houses, in general owns.

The census tracts located at west of the hill zone, until a distance of three or four kilometers of it, and also that located until one kilometer of the harbor zone, the coastal strip at north, northeast and east of Santos, were the most popular areas, with more participation of own houses, more inhabitants, high levels of illiteracy, youngest household heads (with less than 50 years), poorer ones, and with lower levels of public services, although with expressive improvements in 2000.

The tracts situated near Centro (the old center of Santos), at northeast, an area with older occupation, denoted the higher concentrations of rooms, rented and single-person households, although had concentrated in 1991 bigger families, significant levels of illiteracy, household heads with ages until 40 or 50 years, without income or monthly incomes until one minimum wage.

So, these three areas were observed in the municipality of Santos, as well as in the island as a whole, a noble one and two more popular, with limits well defined. Between them, a space occupied by the mean class, inhabited by household heads with monthly incomes between 5 and 10 minimum wages, ages between 40 and 69 years (consolidated families, and families in the stage of fragmentation), nuclear families and, in general, own apartment houses.

It was observed also, in this paper, the relation core-periphery, with the periphery been defined as a more popular area and the spatial segregation, in terms of spatial concentration of social groups. So, the core-municipality consolidates itself as a more developed municipality, with more complex urban functions than its neighbors, and the socio-spatial processes which occurred in it are gradually moved to its nearest neighbors, and so on, explaining the urban expansion of the metropolitan area.

The families that are not capable to pay the price for to live in the noble areas of Santos, by fragmentation (children becoming married) or waste of income, are moving themselves to the insular part of São Vicente, and the ones that are there usually have the same problem, starting the urban expansion of the region.

This analysis shows how the processes are complex and have its expressions well located, which are more explained by mean of a municipality analysis. So, in order to understand better the processes involved in a regional analysis, usually an intra-urban analysis is necessary, because it can detect the causes of these broader processes, as well as to help on the simplification of their complexity.

This paper denoted also that important intra-urban analysis can be done without the presentation of any table, only by means of maps of interpolated variables. As important as the analysis of the intra-urban dynamic was the presentation of this new methodology of analysis, based on the spatial concentration of certain population and household attributes. The kriging technique shows itself well adequate to the proposed goals, since in the 1991-2000 period of time, with a range of only nine years, important movements of spatial concentrations were seen in the created maps, especially that ones about residential attributes.

Given the space limitation of a scientific article, it was preferred not to broach more specific details about the creation of these maps, the presentation of the variograms which were used to create the interpolations, the treatment of the census data, detection of anisotropies, calculation of model parameters, etc. But these steps can be more studied by means of a more detailed search on the literature. It was preferred, in this paper, to emphasize more the analysis which can be done by mean of these spatial statistics techniques, through a study case.

Finally, I hope that this paper can be used as inspiration in order that other researchers use their study area data with the same goals, what could originate new applications for these presented techniques, and also turn possible the change of information about this matter.

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