

MOBILITY, URBAN SPRAWL AND ENVIRONMENTAL RISKS IN BRAZILIAN URBAN AGGLOMERATIONS: CHALLENGES FOR THE URBAN SUSTAINABILITY IN A DEVELOPING COUNTRY¹

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Introduction

According to United Nations projections, urban population in the world will reach more than 50% in 2007 and the most important change will occur in developing countries. Contemporary social theory has given much consideration to certain radical changes at the foundations of modernity; this globalization process may be destructive as well as the solution for perplexing paradoxes of modernity. The environmental dilemma is a major demonstration of this process in the 21st century because it carries in its demands the ambiguities of the production-consumption relation. Thus, environmental debate stresses the evidence of the 'side-effects' of industrial processes and products. The concomitant occurrence of these processes endangers basic conditions of survival, changes ways of life and puts into question the belief of the superior rationality of experts.

In this sense, global environmental risks express the challenges of such changes through estimates of global warming and of its impacts on population. This situation may be better observed in the complexity of urban contexts around the world, including most of the urban agglomerations of developing countries. In Brazil, migration to urban areas occurred rapidly in the nineteen seventies and by late 20th century had begun to present signs of an important transformation. The metropolitan areas that had grown in earlier decades now lose centrality. New urban agglomerations began to be the destination of urban-urban migration. In this second "urban transition", urban sprawl is one of the signs of a new production-consumption relationship in space.

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Brazilian sprawl differs from that of the United States because there is an overlay of social processes that led to these urban forms. In the first urban transition, rural-urban migration was most important and the relationship between urbanization and production was mostly obvious. Today, urban-urban migration reveals new social forces which are leading to new urban forms: consumption of space follows the global urban tendency, in which regions and not cities are the most important scale of everyday life.

The recent tendencies of the world urbanization process in a context of globalized markets point to a situation in which regions (as opposed to specific localities) emerge as economic and political arenas with greater autonomy of action at national and global levels. City-regions constitute nodes which express a new social, economic and political order which, far from dissolution of regional importance resulting from the globalization process, become increasingly central to modern life. Urbanization, then, widens its scope beyond the image of the chaotic city which grows like an amoeba. The image is replaced by one of a polynucleated city, fragmented, with low densities, over wide-ranging territorial extensions, but at the same time more and more integrated.

Studies concerned with this uncontrolled expansion of land use mention innumerable social, economic and environmental impacts. Among the principal factors considered in terms of urban sprawl and the consumption of natural resources is the intensive use of individual automobile transportation. While this characteristic may be seen as both cause and consequence, the bottom line is that the greater the distances between different spheres of daily life, such as work, residence, study or shopping, the greater the demand for automobile transportation.

This is part of the growth in demand for fossil fuels as the principal energy matrix of the modern world, a process with many different consequences. In the case of sprawl, the growing use of automobile transportation is also associated with an increase in air pollution. In this context, this paper discusses the recent changes that have occurred in Brazilian urban agglomerations, arguing that population mobility (migration and commuting) play an important role in determining demographic changes, in particular sprawl-like urbanization processes. Most urban sprawl studies analyze the relationships between urbanization and environmental change, but there is a need for efforts to treat these questions in developing countries. This paper will focus on the relations between population mobility and urban form in Brazilian urban agglomerations using demographic data provided by the national Census Bureau (IBGE) to assess the most sprawling areas and the relationships on urban quality of life.

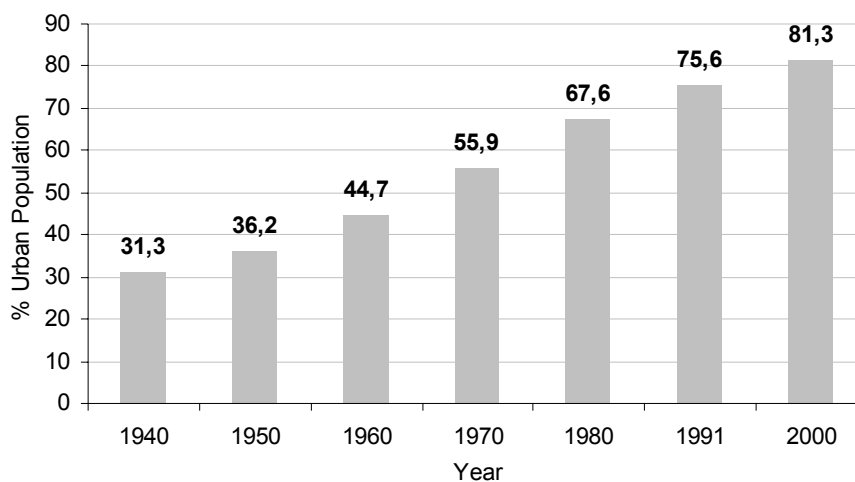
Commuting data has not been commonly used in Brazilian urban studies, probably because it has not seemed to be a relevant phenomenon until recent years. These data began to be used intensively only in the last ten years as commuting increased throughout Brazil. This increase is

associated with the expansion of urbanized areas in a new urban morphology associated to the sprawl model. Despite the slowing of urban population growth in recent years, the physical size of urban areas is now increasing in many agglomerations of the country.

A sprawl index was created to identify this process in each urban agglomeration. The index is formed with a set of several sprawl factors identified in the international literature as important measures of sprawl-like situations, seeking to adapt it to the Brazilian context. Geographic Information Systems (GIS) were also used to create spatial indices, like urban density and a spatial fragmentation index. Today's city has an increasingly complex structure, above all considering the ramification of urban networks, the interaction of economic flows, the intensification of population mobility and changes in consumption patterns. An agglomeration may therefore take on different forms as it disperses in space and these different forms may have distinct social and environmental impacts.

The Brazilian urban context: commuting and sprawl

In a period of sixty years, Brazil's urban population has increased from 30% to 80% of total population, the urban transition having been made in the mid-sixties. The urban transition, as in other countries of Latin America, occurred in a unique context: **after** developed countries, but **before** most developing countries.



Source: IBGE, Demographic Census 1940 – 2000.

Despite continuous urbanization, social and economic drivers of this process changed in the last years of the 20th Century. During the first years of the urban transition, long-distance migration prevailed, especially the Northeast-Southeast flow. Today, urban-urban migration has assumed the major role in spatial mobility. Commuting is increasing in metropolitan areas and has become part of private strategies to reduce social, economic and environmental risk.

Giddens (1991) argues that personal life and the social ties that it involves are deeply interwoven with more far-reaching abstract systems. In late modernity, social rationality is more and more disconnected and fragmented for the individual. And this fragmentation is becoming visible in the morphology of urban areas. Not only as a reflection of economic globalization, but because of new ways of life spreading around the world, including into developing countries.

Brazilian urban studies have concentrated on such themes as the center-periphery dichotomy, industrial neighborhoods, population densification and rural-urban immigration. City planners, sociologists, anthropologists and geographers concentrated on studies of the occupation of intra-urban spaces, seeking to understand the social changes which structured the city. The city – conceived as a center-periphery, wealth-poverty dichotomy – reproduces the marginalization process of the working classes.

The discussions about the relationship between rural and urban persisted for many years as the center of discussion. The overarching concern, however, was in relation to growing population concentration in large cities. Inspired in a sociological and geographical tradition that dicotomized the analysis of the social into those two categories, Brazilian studies have emphasized issues such as the relations between urbanization and industrialization; the city as an expression of modernization; real estate speculation; and the establishment of social services. And by opposition, the rural was archaic, linked to agriculture, to the simple life, to smaller populations and without access to services.

By the 1980s and 1990s, the rural-urban dichotomy no longer sustained urban analyses, especially considering the new environmental discourse which introduced new issues for urban studies. Natural resource use and the quality of life changed the meaning of urban for everyone, whether or not they lived in urban areas. The relationship among environmental discourse, quality of life, the urban and the rural came to be seen as interrelated phenomena.

In Brazil, Metropolitan Areas (MAs) were legally constituted in 1973/74 with the objective of promoting integrated planning and common services of metropolitan interest, under the aegis of the federal government. Nine MAs were created: Belém, Belo Horizonte, Curitiba, Fortaleza, Porto Alegre, Recife, Salvador, São Paulo and Rio de Janeiro. After the Federal Constitution of 1988, the number increased to 26. That significant increase of areas classified like MAs was not necessarily a reflection of metropolitanization processes, but rather reflects a change in the **political** process of creating metropolitan areas. The 1988 Constitution (Chapter III, Article 26, Paragraph 3), authorized States to define the number of MAs and the criteria for constituting them. This measure accompanied the process of decentralization of urban administration to the municipal level, and was an incentive to the creation of new MAs. But what might these criteria be?

Table 1 – Brazilian Metropolitan Areas, year of institutionalization, number of municipalities and central municipality

State	Metropolitan Areas	Year	Number of municipalities	Central municipality
AL	RM de Maceió	11/19/98	11	Maceió
BA	RM de Salvador ¹	06/08/73	10	Salvador
CE	RM de Fortaleza ¹	06/08/73	13	Fortaleza
DF	Região Integrada de Desenvolvimento do Distrito Federal e Entorno (RIDE) ²	02/19/98	21	Brasília
ES	RM de Vitória	02/21/95	6	Vitória
GO	RM de Goiânia	12/30/99	11	Goiânia
MA	Grande São Luís	01/12/98	4	São Luís
MG	RM de Belo Horizonte ^{1 e 3}	06/08/73	34	Belo Horizonte
	RM do Vale do Aço ³	12/30/98	4	Ipatinga ⁵
PA	RM de Belém ¹	06/08/73	5	Belém
PR	RM de Curitiba ¹	06/08/73	25	Curitiba
	RM de Londrina	06/17/98	6	Londrina
	RM de Maringá	07/17/98	8	Maringá
PE	RM de Recife ¹	06/08/73	14	Recife
RJ	RM do Rio de Janeiro ¹	07/01/74	20	Rio de Janeiro
RN	RM de Natal	01/16/97	6	Natal
RS	RM de Porto Alegre ¹	06/08/73	31	Porto Alegre
	RM de Florianópolis ⁴	01/06/98	22	Florianópolis
	RM do Vale do Itajaí ⁴	01/06/98	16	Blumenau
SC	RM do Norte/Nordeste Catarinense ⁴	01/06/98	20	Joinville
	RM da Foz do Rio Itajaí ⁴	01/06/98	9	Itajaí
	RM Carbonífera ⁴	01/09/02	10	Criciúma
	RM de Tubarão ⁴	01/09/02	18	Tubarão
SP	RM de São Paulo ¹	06/08/73	39	São Paulo
	RM da Baixada Santista	07/30/96	9	Santos
	RM de Campinas	06/19/00	19	Campinas
Total	26	-	413	-

Source: EMPLASA, 2000 and IBGE

1 Metropolitan Areas officialized in Brazil in 1973 e 1974.

2 Integrated Region of Economic Development (RIDE) is composed by municipalities from the States of Minas Gerais and Goiás and the Federal District

3 Does not include the Metropolitan Collar of Belo Horizonte and Vale do Aço

4 Includes the Metropolitan Core and the Expansion Area

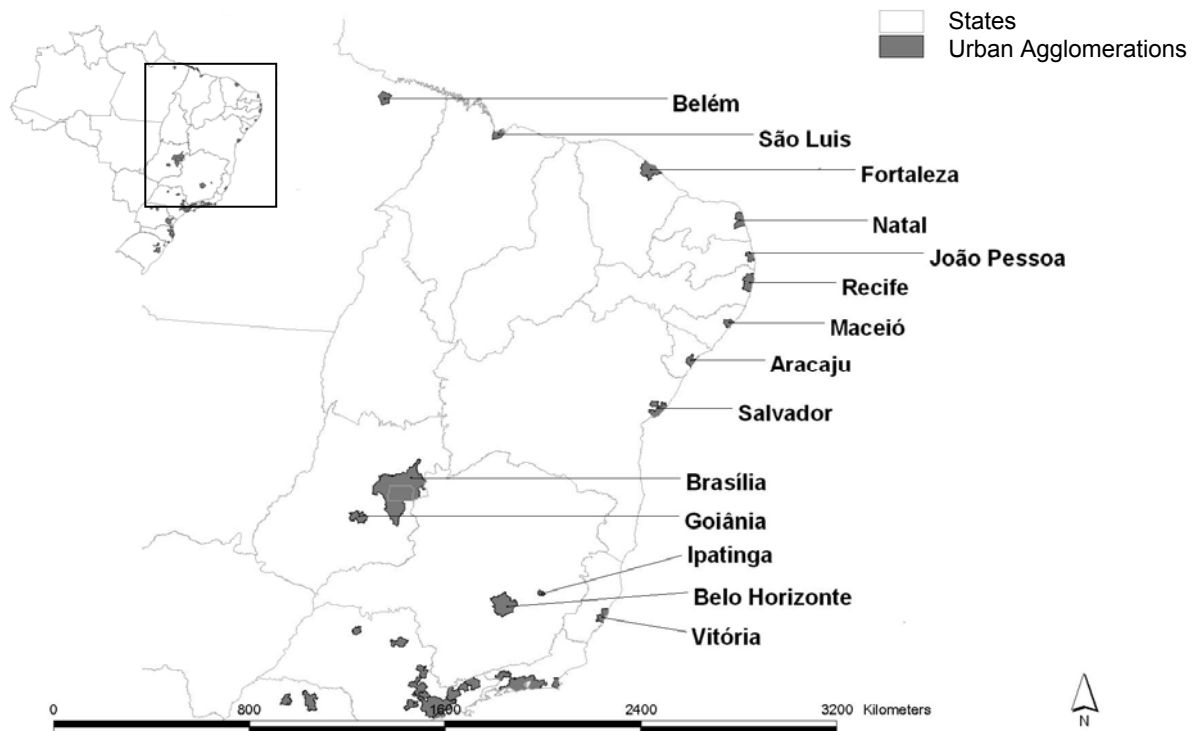
5 The creation law of Metropolitan Area of Vale do Aço does not mention the central core of the region, but Ipatinga is the main municipality of the region

The new dynamics of urban networks in Brazil leads us to question the limits of the metropolis. Terms like city-region, global cities, diffuse city, dispersed urbanization, urban sprawl, peri-urbanization, metapolis or megalopolis are signs of a new spatial-functional organization of the complex system of social, economic and cultural interrelations involved in the globalization process. And it is in these urban contexts that the signs of globalization are felt more clearly; on one hand, a growing need for new interpretations of the urban phenomenon, and on the other, the extreme difficulty in apprehending increasingly complex processes.

One study which updated the concept of urban agglomeration in Brazil, independent of legal definitions, was "Characterization and tendencies of the urban network of Brazil" (IPEA / IBGE / UNICAMP, 2000). This study classified the Brazilian urban network in terms of homogeneous and analytical criteria applicable to the whole country, using uniform data sources. The criteria used for the identification of urban agglomerations in this research were:

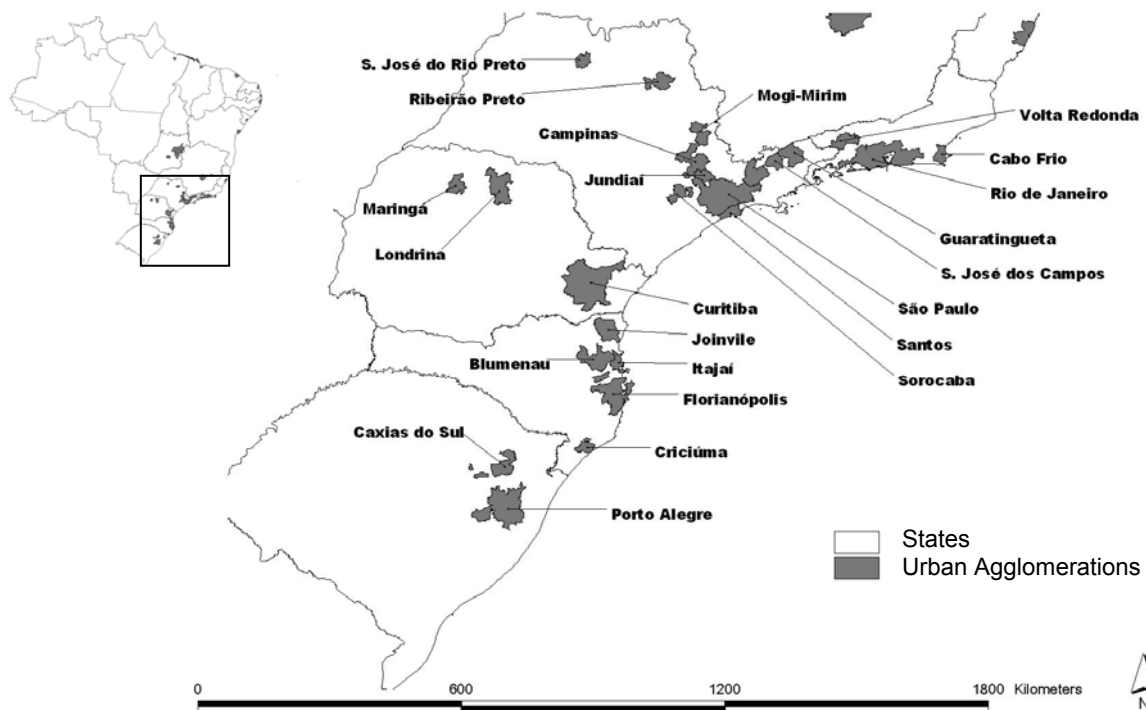
- Continuous urban spaces (conurbation). Continuity of the built-up area between the central core and at least one other municipality or the expansion of the built-up area from one municipality to the territory of another;
- Population size. For urban agglomerations resulting from the expansion of the central core, municipalities with a 1991 population of 200,000 or more inhabitants were included. When more than one urban core was involved: 150,000 inhabitants for the set of municipalities;
- Density – 60 inhabitants per km²
- 65% of the economically active population in urban activities;
- Growth – 1980/91 growth rate;
- Discontinuous urban spaces (perceptible flows of economic integration);
- Other indicators of regional importance;
- Population growth rate of peripheral municipalities.

This methodology produced 49 urban agglomerations, classified into 12 "Metropolitan Areas" (Global, National and Regional), 12 "Regional Urban Centers" and 25 "Sub-regional Centers." According to Baeninger (2004), these results revealed that recent urbanization involved an intense process of interiorization of urban agglomerations, indicating the appearance of new areas of population attraction.



Source: IBGE, Municipal Digital Shapes, 2000

Figure 1 – Location of Urban Agglomerations in the North, Northeast and Central-West Regions and in the States of Minas Gerais and Espírito Santo



Source: IBGE, Municipal Digital Shapes, 2000

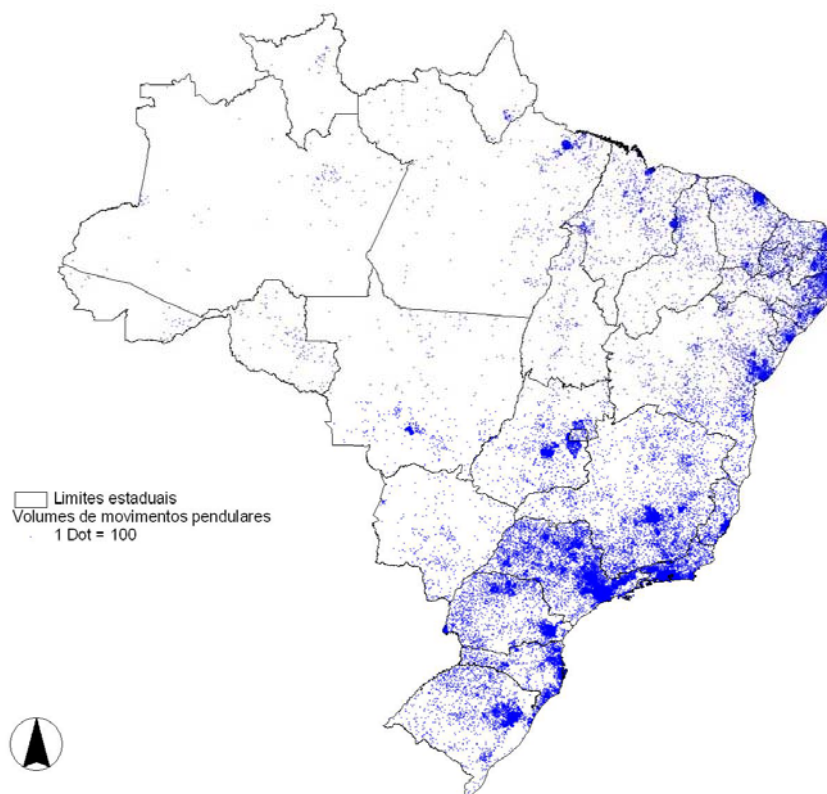
Figure 2 – Location of Urban Agglomerations in the South Region and in the States of São Paulo and Rio de Janeiro.

Approximately 56.4% of total population in 1991, up from 50.8% in 1980, lived in these agglomerations. In relation to total **urban** population, however, their share declined from 75.1% in 1980 to 69.4% in 2000. According to UN estimates, Brazil will have 90% of its population living in urban areas by 2050. While total urban population continues to increase, more of this growth is attributable to small and medium-size municipalities, which now absorb an important part of this growth.

Brazil's urban network is increasingly complex and diversified. Traditional migration destinations are now growing more slowly. The growth rates of the global cities of São Paulo and Rio de Janeiro were below the average for urban agglomerations and even for total urban population between 1980 and 1991; their share of total urban population declined from 42.8% in 1980 to 37% in 2000.

These data require a better understanding of growth processes in this new spatial configuration. Once we recognize decentralization and de-concentration of the urban network, it is important to understand, in a comparative way, whether these processes are equally intense in all parts of the country, and especially whether spatial mobility has different impacts on urban form in different regions.

Given this new configuration of the urban network, we then sought to determine the spatial distribution processes within the 49 agglomerations mentioned earlier. Our hypothesis is that these movements have now become an indispensable criterion for updating metropolitan and regional limits, and that new intra-urban movements linked to dispersed and fragmented urbanization are especially important. These questions are raised at a moment of new growth tendencies of Brazilian cities. Recent migration is less similar to earlier rural-urban and long-distance migration, having shifted to a predominance of short-distance movements. Among the important types of this short-distance movement is the commuting pattern within metropolitan areas, a type of urbanization more similar to sprawl-intense metropolises in other parts of the world. Commuting is an important condition for the consolidation of urban agglomerations.



Source: IBGE, Demographic Census 2000

Figure 3 – Commuters by municipality of residence (2000)

According to Hogan (1993), commuting plays an important role in sustainable development. While these movements may sometimes redirect the burden of environmental deterioration, favoring some groups and penalizing others, the possibility of carrying out diverse activities (residence, work, study, consumption) in different places serves to conciliate conflicting needs in individual households. On the one hand, there may be a tradeoff between new environmental stresses created by commuting and the attenuation of competing demands of household members. On the other hand, more complex mobility patterns may diminish the vulnerability of households to unemployment, to inadequate educational or health services and to the isolation from family support which was often a result of earlier migration patterns.

An examination of commuting data for the 49 urban agglomerations shows the relative concentration of this process. According to the 2000 Demographic Census, 7.4 million people worked or studied in municipalities other than that of residence, representing 4.4% of total population. The 49 urban agglomerations considered here account for more than 70% of those movements, 6.4% of the population of these areas.

São Paulo and Rio de Janeiro concentrate 38% of all commuters. When we analyze those volumes in terms of proportion of total population, however, these cities give way to smaller places. In São Paulo and Rio de Janeiro commuters correspond to 6.6% and 7.4% of their total population, respectively, while in agglomerations such as Vitória (ES), Florianópolis (SC) and Jundiaí (SP),

commuters represent more than 10% of total population. It is clear, then, that while commuting may be concentrated in some regions, it is not a phenomenon exclusive of traditional metropolises like São Paulo and Rio de Janeiro.

Table 2 – Commuters by urban agglomeration and type of movement (Intra: movements within the same UA; Inter: between UAs; and Extra: to places outside an UA)

Urban Agglomeration	Intra UA		Inter UA		Extra UA		Total	
	N	%	N	%	N	%	N	%
São Paulo	1.012.422	91,4	33.713	3,0	61.779	5,6	1.107.914	100,0
Rio de Janeiro	723.353	92,1	11.397	1,5	50.396	6,4	785.146	100,0
Salvador	59.213	81,1	2.987	4,1	10.855	14,9	73.055	100,0
Belo Horizonte	345.180	92,3	5.582	1,5	23.219	6,2	373.982	100,0
Fortaleza	70.397	86,8	1.656	2,0	9.065	11,2	81.119	100,0
Brasília	121.728	93,1	2.201	1,7	6.880	5,3	130.809	100,0
Curitiba	178.581	92,0	4.793	2,5	10.801	5,6	194.175	100,0
Recife	262.550	92,1	4.316	1,5	18.201	6,4	285.067	100,0
Porto Alegre	314.031	94,0	3.567	1,1	16.423	4,9	334.021	100,0
Belém	106.297	88,4	1.327	1,1	12.607	10,5	120.231	100,0
Goiânia	91.046	84,1	5.722	5,3	11.431	10,6	108.199	100,0
Campinas	128.802	78,6	22.690	13,8	12.394	7,6	163.886	100,0
São Luis	30.078	86,7	977	2,8	3.654	10,5	34.710	100,0
Maceió	8.460	58,6	955	6,6	5.015	34,8	14.430	100,0
Natal	40.454	86,0	1.388	3,0	5.213	11,1	47.055	100,0
Teresina	15.236	77,3	1.204	6,1	3.267	16,6	19.707	100,0
João Pessoa	27.655	79,1	2.135	6,1	5.185	14,8	34.975	100,0
São José dos Campos	33.523	67,2	11.385	22,8	4.949	9,9	49.857	100,0
Ribeirão Preto	15.936	64,0	2.979	12,0	5.993	24,1	24.908	100,0
Cuiabá	22.281	82,6	251	0,9	4.459	16,5	26.991	100,0
Sorocaba	29.826	63,3	11.610	24,6	5.699	12,1	47.135	100,0
Aracaju	42.555	84,5	1.315	2,6	6.503	12,9	50.373	100,0
Londrina	24.856	75,8	3.364	10,3	4.559	13,9	32.779	100,0
Santos	101.484	80,1	19.338	15,3	5.873	4,6	126.695	100,0
Joinville	14.428	65,6	3.896	17,7	3.672	16,7	21.995	100,0
São José do Rio Preto	5.386	50,2	1.948	18,2	3.393	31,6	10.726	100,0
Caxias do Sul	7.055	60,6	3.105	26,7	1.485	12,8	11.645	100,0
Pelotas	1.441	29,8	1.194	24,7	2.202	45,5	4.837	100,0
Jundiá	32.812	62,2	17.371	32,9	2.537	4,8	52.720	100,0
Florianópolis	74.817	90,7	4.205	5,1	3.497	4,2	82.519	100,0
Maringá	23.982	81,1	2.323	7,9	3.258	11,0	29.563	100,0
Vitória	142.544	90,2	3.165	2,0	12.324	7,8	158.033	100,0
Ilhéus	1.690	34,5	984	20,1	2.223	45,4	4.897	100,0
Volta Redonda	21.980	61,0	5.846	16,2	8.204	22,8	36.030	100,0
Blumenau	14.979	79,7	2.715	14,5	1.095	5,8	18.789	100,0
Limeira	4.555	26,7	6.975	40,9	5.529	32,4	17.059	100,0
Cascavel	508	10,6	1.487	31,2	2.774	58,2	4.769	100,0
Caruaru	569	24,3	541	23,2	1.227	52,5	2.337	100,0
Ipatinga	11.314	60,0	3.119	16,5	4.418	23,4	18.851	100,0
Petrolina	4.455	58,3	750	9,8	2.433	31,9	7.637	100,0
Juazeiro do Norte	3.452	50,4	1.309	19,1	2.088	30,5	6.850	100,0
Araraquara	1.089	14,2	3.051	39,7	3.538	46,1	7.678	100,0
Araçatuba	1.750	28,9	1.386	22,9	2.916	48,2	6.052	100,0
Criciúma	10.249	62,3	1.784	10,8	4.418	26,9	16.452	100,0
Itajaí	16.291	72,8	4.001	17,9	2.093	9,3	22.384	100,0
Cabo Frio	11.800	62,0	4.593	24,2	2.625	13,8	19.017	100,0
Mogi-Mirim	5.925	45,8	4.446	34,4	2.568	19,8	12.939	100,0
Guaratingueta	7.527	51,8	4.566	31,4	2.440	16,8	14.534	100,0
Itabira	1.160	22,2	2.384	45,5	1.692	32,3	5.236	100,0
TOTAL	4.227.705	87,0	243.997	5,0	389.069	8,0	4.860.770	100,0

Source: FIBGE, Demographic Census 2000

As a result of the increase of commuting in Brazil, urban areas look more and more like classic sprawl. While the term "urban sprawl" emerged around 1960 as a pejorative designation to express the uncontrolled expansion of North American urban areas, above all in reference to the suburban pattern of urbanization (Kiefer, 2003), it refers basically to a pattern of low density. Although the definition of the term is still controversial, there is a considerable body of research which shows the importance of the phenomenon in other areas of the world, mostly on the basis of case studies.

Los Angeles is one of the most cited cases. Between 1970 and 1990, the population of the Los Angeles area grew by 45%, while the physical area occupied by this population grew by 300% (MEADOWS, 1999); in other words, there was a significant reduction in urban density. Outlying areas grew at the expense of the consolidated urban center.

In general, the consensus on the sprawl debate is this gap between population growth and the physical expansion of the city, which explains the tendency toward low urban densities in most metropolitan areas of the world. In this sense, several studies show the same urban distortion of Los Angeles occurring in several areas of the United States and in other areas of the world. Even in European cities, traditionally associated with a compact urban form (RICHARDSON and CHANG-HEE, 2004), there are signs that sprawl is increasing.

Urban sprawl research leans heavily on case studies. They demonstrate the historical processes of urban occupation and how urban limits changed over time. However, from an historical point of view, urban growth associated to physical expansion is not a new concern; to a certain extent, growth has always meant territorial expansion. What is new today is the fact that new urban forms have appeared over the second half of the 20th century. According to Richardson and Chang-hee (2004:1), there seems to be a convergence in urban settlement patterns in the United States and Western Europe.

This transition can be observed in lifestyles which are disseminated through large urban centers, propelled by the globalization of consumption patterns, which produce increasing homogeneity in different areas of the world. Dependence on individual transportation plays an important role in the compression of space and time in post-modern cities. As part of this process, both medium and long-distance commuting is becoming much more evident.

But what is sprawl in the context of developing countries? It is clear that the drivers of sprawl cannot be the same in different social contexts, although we cannot deny the homogenization of consumption patterns in the world's cities. In Brazil, mega-cities like São Paulo and Rio de Janeiro reveal a certain ambiguity in this regard, and new social behaviors are not so directly reflected in these cities' consolidated urban form. In the case of new metropolitan areas like Brasilia or Campinas, the morphological consequences of new behaviors can be more easily observed. It is

important to keep in mind, then, that Brazilian urbanization is not explained only by the experience of São Paulo or Rio de Janeiro, in spite of their population concentration. Urbanization is increasingly characterized by a complex network of urban areas in the country as a whole.

Measuring sprawl: a methodological approach

The challenge of studying the dimensions of urban sprawl may be summarized as the task of measuring the urban expansion which extrapolates the limits of a conurbation. The urban sprawl literature seeks to identify empirically observable factors in metropolitan areas, in order to compare a country's overall situation. In the present study, then, urban sprawl is understood as a process and not as a phenomenon in itself, since the empirical phenomenon can only be apprehended in comparative terms.

To elucidate this relationship, in an effort to generalize, we can hypothesize different forms of urban settlement and assess their impact on urban life. Figure 4 shows how a population's distribution in the intra-urban space can assume different expressions in spite of the same average density.

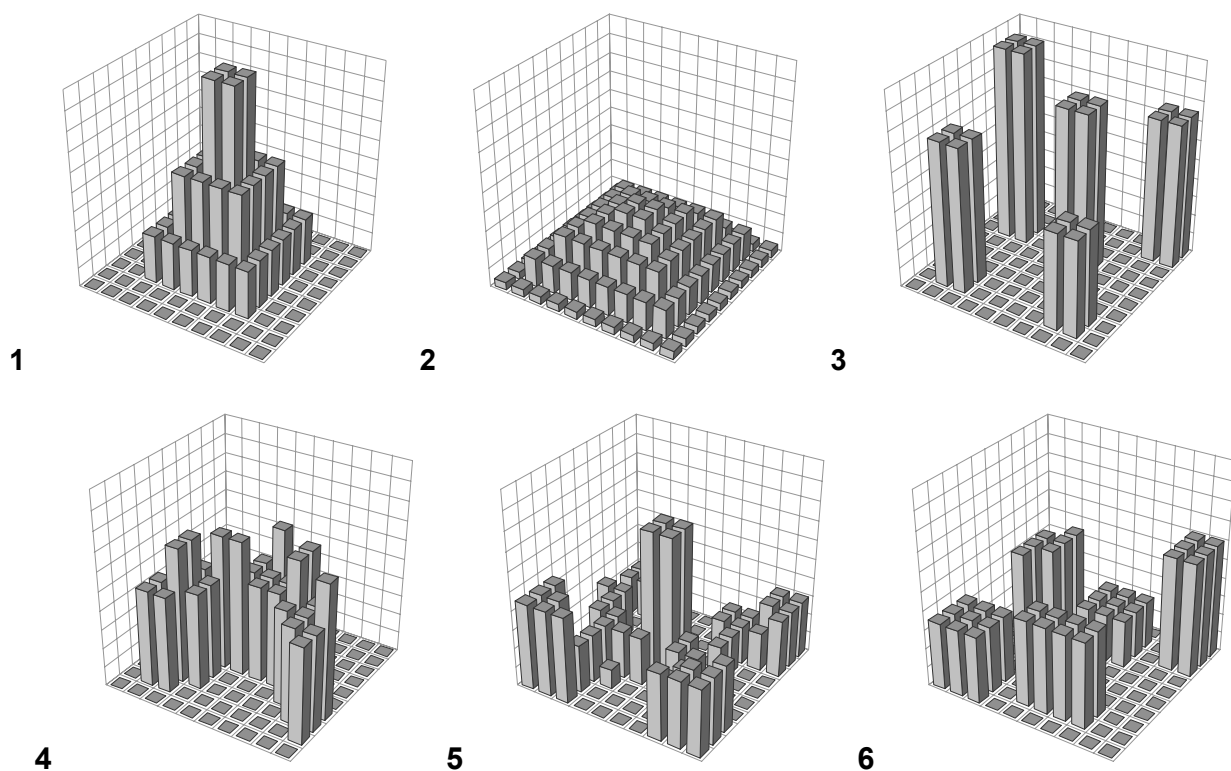


Figure 4 – Schematic models of different urban shapes

Models 1 and 2 represent typical monocentric cities, but with different spatial distributions, the first being more compact. Model 3 is clearly more fragmented and, as is also the case of Model 2, can be classified as more dispersed than Model 1. While Models 4, 5 and 6 seem to be more

similar, Model 4 possesses more pronounced continuity than Models 5 and 6. If those models represent urban areas or urban agglomerations, what could be said in this respect? Do people who live in two different areas, for example, in Models 1 and 5, have similar daily activities? The hypothesis is that urban space – socially built and reflecting different interests and social actions – has differentiated consequences in urban life, according to their formal characteristics. In terms of environmental conditions, the impacts of urban expansion seem to be more evident. Intuitively, Model 3 (more dispersed) will have smaller continuous urban areas, fragmented green areas and greater demand for automotive transport, among other environmentally relevant factors.

Of course is not possible to summarize the complexity of urbanization with such simplified schematic models, using a classification based on single-factor categories, but it is unquestionable that Brazilian urban agglomerations assume very different formal dimensions. In terms of the perception of the person who travels from one city to another, it is common to hear comparisons between origin and destination city to the effect that distances between one activity and another are long, that spatial organization is different, or that traffic jams and access to services are worse.

The objective of this section, then, is to identify, from the sprawl literature, the principal indicators for classifying an urban area in terms of urban dispersion. These dimensions are then applied to 37 selected urban agglomerations to obtain a ranking of urban sprawl and to map sprawling situations in the country. Finally, the section also seeks to verify the existence, or not, of an "outlying pattern" in contemporary Brazilian urbanization and whether this "pattern" can be apprehended in spatial terms in a comparative way, in a diversity of economic, social, political and demographic contexts.

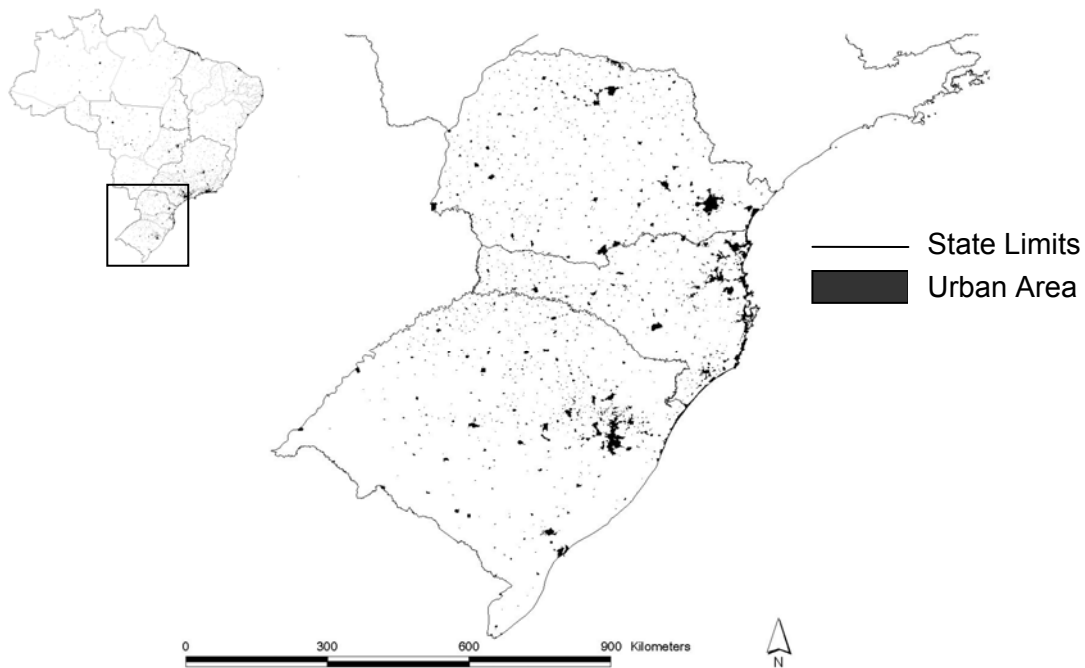
Density

The works of Galster et al. (2001), Batty, Xie and Sun (1999), Chin (2002), Torrens and Alberti (2000), Cutsinger et al. (2005), Burns and Carreras (2004), Angel Sheppard and Civco (2005), among others, used satellite images to evaluate urban expansion in several parts of the world. Angel, Sheppard and Civco (2005) present a worldwide study considering a group of approximately 4 thousand cities with population greater than 100 thousand inhabitants. In this study, the densities of developing country cities tend to be greater than in the developed countries; however, in both groups the tendency over time has been toward lower density.

The Global Rural-Urban Mapping Project (GRUMP) developed at the Center for International Earth Science Information Network (CIESIN), Columbia University, used satellite images and nighttime lights emitted by urban agglomerations to estimate urbanized areas. And in Brazil, Kampel (200x) has carried out similar work in the Amazonian state of Pará.

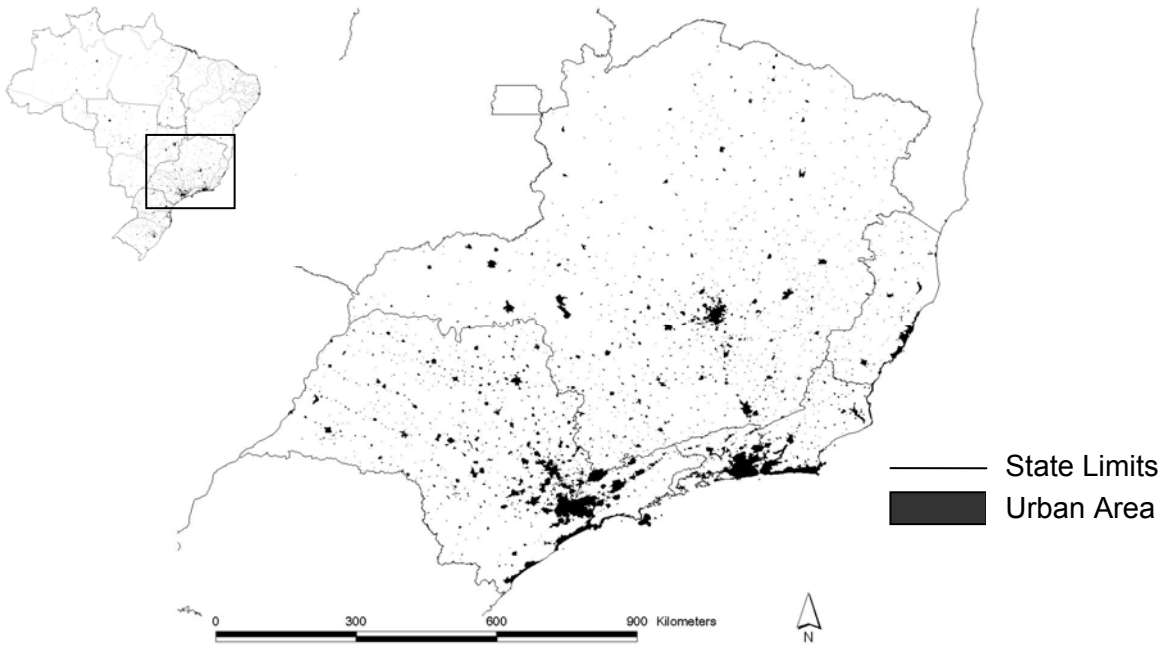
But the systematic use of these instruments still has operational limitations. Among them is the high cost of acquiring the images and the subsequent processing and analysis, above all when more detailed space cuttings are needed, as in the case of urban agglomerations which are not part of institutionalized metropolitan areas in Brazil.

For these reasons, official IBGE data on urban and rural census tracts were used; these are public access data, available in digital format. Garcia and Matos (2005) also used these data and discussed their under-utilization in Brazilian urban studies. These data are organized in a Geographical Information System and classify census tracts into urban/rural categories, detailing each situation according to function. For example, it distinguishes areas with rural villages from those areas of agricultural use only.



Source: IBGE, Municipal Digital Shapes, 2000

Figure 5 – Urban Areas, South Region



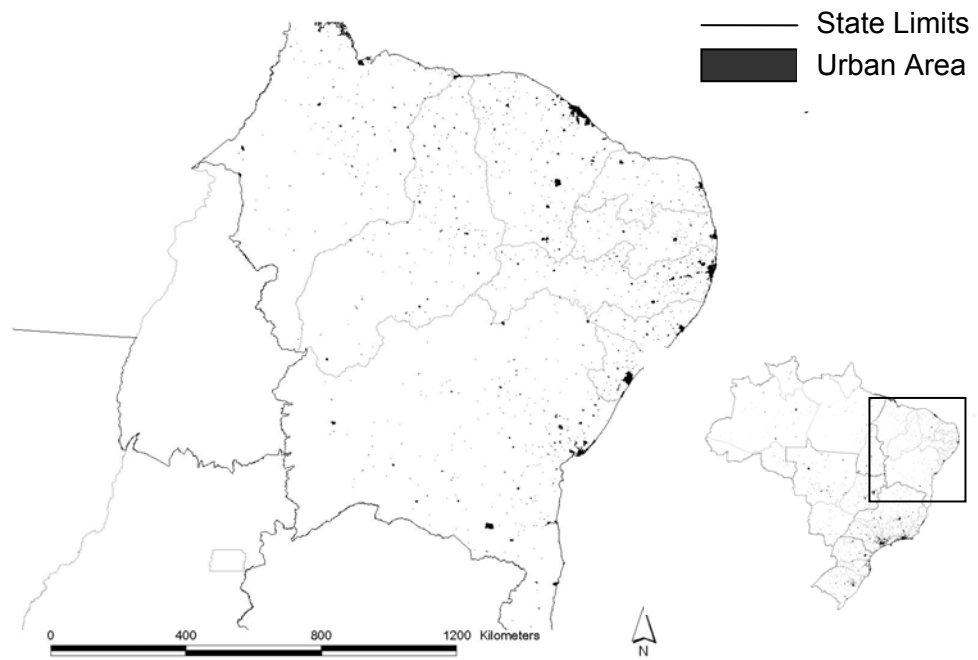
Source: IBGE, Municipal Digital Shapes, 2000

Figure 6 – Urban Areas, Southeast Region



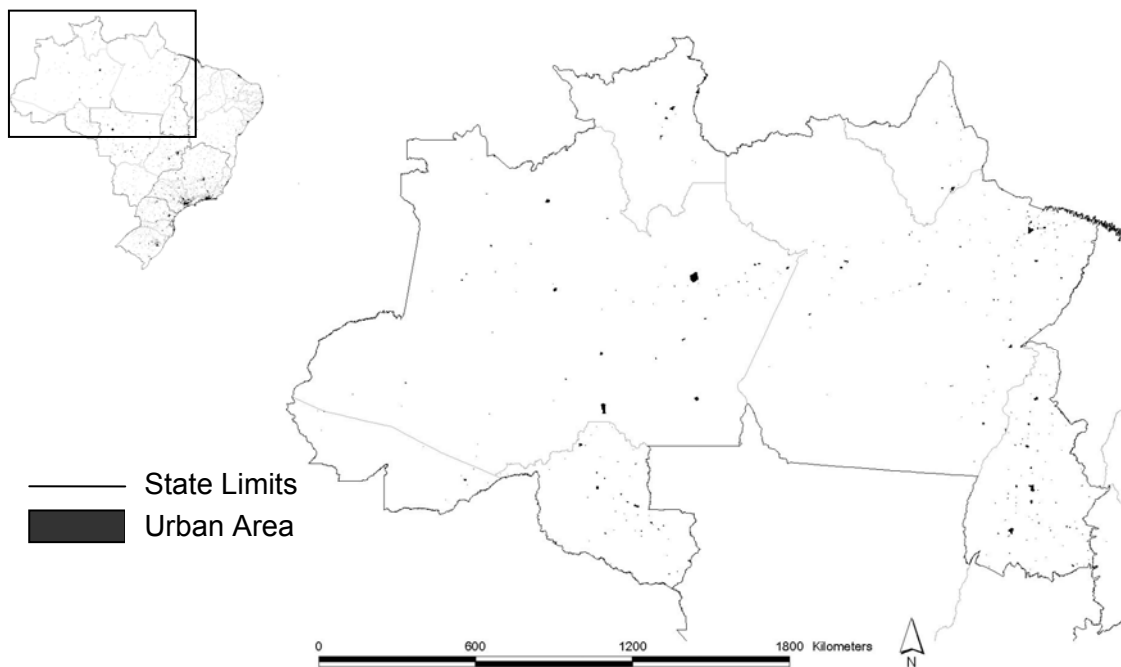
Source: IBGE, Municipal Digital Shapes, 2000

Figure 7 – Urban Areas, Center-West Region



Source: IBGE, Municipal Digital Shapes, 2000

Figure 8 – Urban Areas, Northeast Region



Source: IBGE, Municipal Digital Shapes, 2000

Figure 9 – Urban Areas, North Region

The total urban area in Brazil, according to this criterion, is approximately 95 thousand km², which represents 1.12% of Brazilian territory, holding 140 million people – 81.8% of total population in 2000. National population density is approximately 20 inhabitants per km². When only the urban area is considered, density is 1,453 thousand inhabitants per km². The selected 37 urban agglomerations represent about 1/3 of the total urban area (30.5 thousand km²) and concentrate 71.6 million people. Population density in these agglomerations is 2,353 inhabitants per km². The region with the highest urban density has 8.3 thousand inhabitants per km² and the lowest density is 600 inhabitants per km². Very different situations exist, then, in terms of urban density. São Paulo, for example, in spite of holding second place in terms of territorial size (4.2% of the total urban area), has one of the highest urban densities (4.3 thousand inhabitants per km²).

Table 3 – Population, Households, Urban Area, Demographic Density, Household Density and Average Number of Inhabitants per household by Urban Agglomeration, 2000.

Urban Agglomeration	Population	Households	Urban Area (Km ²)	Demographic Density (hab./Km ²)	Household Density (dwellings/km ²)	Average No. of inhabitants per household
São Paulo	17.596.957	5.000.541	4.033,50	4.362,7	1.239,8	3,5
Rio de Janeiro	10.870.155	3.295.702	5.128,16	2.119,7	642,7	3,3
Salvador	2.959.434	791.007	696,14	4.251,2	1.136,3	3,7
Belo Horizonte	4.210.662	1.151.418	1.666,49	2.526,7	690,9	3,7
Fortaleza	2.821.761	692.926	1.278,83	2.206,5	541,8	4,1
Brasília	2.623.303	701.028	2.083,55	1.259,1	336,5	3,7
Curitiba	2.502.129	728.859	1.184,91	2.111,7	615,1	3,4
Recife	3.238.736	849.458	973,43	3.327,1	872,6	3,8
Porto Alegre	3.436.431	1.065.320	1.566,11	2.194,2	680,2	3,2
Belém	1.965.794	412.634	404,53	4.859,5	1.020,0	4,8
Goiânia	1.560.625	447.284	724,37	2.154,5	617,5	3,5
Campinas	2.119.322	610.616	1.167,06	1.815,9	523,2	3,5
São Luis	945.280	221.409	332,56	2.842,4	665,8	4,3
Maceió	865.717	220.414	244,90	3.535,0	900,0	3,9
Natal	961.638	241.998	248,07	3.876,5	975,5	4,0
João Pessoa	828.712	212.388	315,22	2.629,0	673,8	3,9
São José dos Campos	1.172.423	319.772	869,79	1.347,9	367,6	3,7
Ribeirão Preto	603.452	173.083	309,48	1.949,9	559,3	3,5
Sorocaba	873.329	242.659	505,68	1.727,0	479,9	3,6
Aracaju	703.983	178.052	711,11	990,0	250,4	4,0
Londrina	564.768	162.867	311,64	1.812,2	522,6	3,5
Santos	1.350.446	395.757	716,33	1.885,2	552,5	3,4
Joinville	566.106	160.270	606,87	932,8	264,1	3,5
São José do Rio Preto	395.379	120.894	121,81	3.245,9	992,5	3,3
Caxias do Sul	518.069	158.949	271,36	1.909,2	585,7	3,3
Jundiaí	496.413	140.029	275,01	1.805,1	509,2	3,5
Florianópolis	698.447	207.661	647,42	1.078,8	320,8	3,4
Maringá	399.356	116.631	47,82	8.351,2	2.439,0	3,4
Vitória	1.327.342	373.646	845,91	1.569,1	441,7	3,6
Volta Redonda	530.317	153.483	313,64	1.690,8	489,4	3,5
Blumenau	380.273	112.126	512,30	742,3	218,9	3,4
Ipatinga	341.608	90.418	196,05	1.742,5	461,2	3,8
Criciúma	238.867	67.556	275,80	866,1	244,9	3,5
Itajaí	326.236	95.286	287,29	1.135,6	331,7	3,4
Cabo Frio	204.939	59.885	346,57	591,3	172,8	3,4
Mogi-Mirim	196.551	55.382	92,02	2.136,0	601,8	3,5
Guaratingueta	213.180	58.742	114,15	1.867,5	514,6	3,6
TOTAL	71.608.152	20.086.149	30.425,80	2.353,5	660,2	3,6

Source: FIBGE, Demographic Census 2000

Fragmentation

But urban density is not necessarily a guarantee of more dispersed urbanization. The spatial pattern of settlement within each region contributes differentially to the extent of dispersion. When two hypothetical urban areas possess the same density, they may have very different patterns of distribution (as shown by figure 10). Diagram 1 presents a monocentric form of settlement while Diagram 2 is constituted by several spatially separated nuclei. It is the situation which the sprawl

literature calls leapfrog development. Such urbanization is characterized by the fragmentation of urban spaces and it is associated with the physical separation of nuclei of urban development.

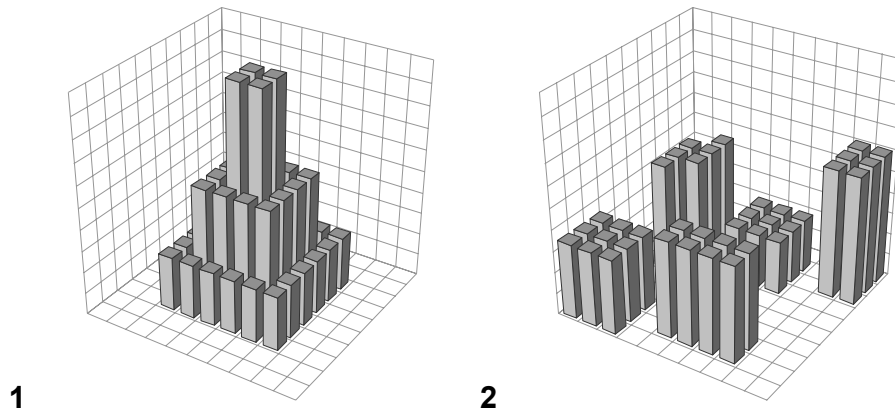


Figure 10 - Schematic models of different urban forms, fragmentation dimension

Leapfrog development can be understood as part of an *unconnectedness* of daily life spaces within the urban agglomeration and it is clearly associated to changes in the spatial displacements of population, given that the continuity of the urban area is no longer necessary for its integration. This form of urban development is, after density, the most characteristic factor of urban sprawl, because it provides spatial evidence of the pattern of population distribution of urban areas. In operational terms, the fragmentation of urban spaces can be apprehended in different ways. As we can observe in an intuitive way from Illustration 13, distances between urbanized areas is a measure of dispersion. In other words, two areas with the same population, distributed in an equivalent urban area, may have similar densities; but one may have a compact form of concentric circles while the other may be polycentric, with urban branches going in different directions.

Urbanization by leaps may compromise agricultural uses in outlying areas and also require expansion of the network of infrastructure services - water supply and sewage collection (Angel, Sheppard and Civco, 2005). Environment is an important aspect for this dimension, because both causes and effects may be identified. On the one hand is a growing demand for environmental amenities in residential areas. On the other hand, as urban growth reaches these areas, such amenities are compromised. The trend, then, is the creation of urban spaces more and more disconnected from each other. To measure this dimension, the Average Nearest Neighbor Index was used, using the software ArcGis (version 9.0).

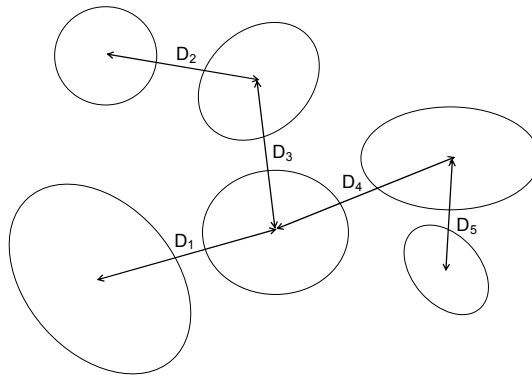


Figure 11 – Illustrative model of the method of calculation of the Average Nearest Neighbor Index

This tool measures the distances between polygons and their respective standard deviations for each study area. The ratio between the average of those distances (D_i) and the average of the distances in a hypothetical area with random distribution is an indicator that allows us to measure the degree of dispersion of the urbanized areas in each of the agglomerations. That indicator was later adjusted so that values varied between zero and one. Values closer to zero represent more compact patterns while values closer to one, the most dispersed patterns. The same procedure was carried out for each of the 37 selected areas. Also using the proportion of non-urbanized areas of the agglomerations, an arithmetic average was calculated of both indices to compose a Fragmentation Index, as shown in Table 4.

Table 4 – Average Nearest Neighbor Index, Non-Urbanized Urban Area Index and Fragmentation Index by Urban Agglomerations

Urban Agglomerations	Average Nearest Neighbor Index	Non-Urbanized Urban Area Index	Fragmentation Index
São Paulo	0.507474	0.596288	0.551881
Rio de Janeiro	0.510043	0.561902	0.535972
Salvador	0.506744	0.867612	0.687178
Belo Horizonte	0.509927	0.799578	0.654753
Fortaleza	0.508427	0.732650	0.620538
Brasília	0.521121	0.999861	0.760491
Curitiba	0.513419	0.993102	0.753261
Recife	0.507797	0.704222	0.606010
Porto Alegre	0.511222	0.859887	0.685555
Belém	0.506698	0.878143	0.692421
Goiânia	0.506272	0.749456	0.627864
Campinas	0.504337	0.670152	0.587244
São Luis	0.502090	0.845094	0.673592
Maceió	0.502942	0.824971	0.663956
Natal	0.504136	0.987652	0.745894
João Pessoa	0.504052	0.775588	0.639820
São José dos Campos	0.511492	0.841248	0.676370
Ribeirão Preto	0.509455	0.902392	0.705924
Sorocaba	0.506870	0.834627	0.670749
Aracaju	0.509277	0.575437	0.542357
Londrina	0.509281	0.992914	0.751097
Santos	0.510989	0.641895	0.576442
Joinvile	0.507831	0.847868	0.677849
São José do Rio Preto	0.506213	0.965161	0.735687
Caxias do Sul	0.509768	0.999941	0.754854
Jundiaí	0.503368	0.738709	0.621039
Florianópolis	0.512588	0.969475	0.741031
Maringá	0.508136	1.000000	0.754068
Vitória	0.506384	0.639759	0.573072
Volta Redonda	0.506874	0.953118	0.729996
Blumenau	0.509180	0.904173	0.706676
Ipatinga	0.506088	0.913666	0.709877
Criciúma	0.504895	0.761600	0.633247
Itajaí	0.510802	0.729249	0.620026
Cabo Frio	0.505387	0.690380	0.597883
Mogi-Mirim	0.505431	0.999999	0.752715
Guaratingueta	0.507099	0.999998	0.753548

Orientation/Linearity

The geographic orientation of cities also plays an important role in urban expansion and in the amount of sprawl. Some urban agglomerations grow conditioned by physical constraints such as mountains, rivers, oceans or other natural barriers. They may also have a direct relationship with other elements such as highways, railroads, and regional economic poles.

Under such conditions, urban areas grow in different ways, which should be taken into account when urban form is analyzed. An urban agglomeration that grows on the basis of concentric circles potentially has a greater capacity to optimize the distribution of service infrastructure compared to a region that develops following a highway, for instance. This way, it is

important to differentiate areas in terms of the orientation of expansion; in other words, whether the form is more circular or more elipsoidal. Referring again to the diagrams of hypothetical areas (Figure 12), we can observe two areas with the same density and little fragmentation. However, the pattern of urban development in Model 2 is linear and tends toward more sprawl, as we can see intuitively in Diagrams 1 and 2.

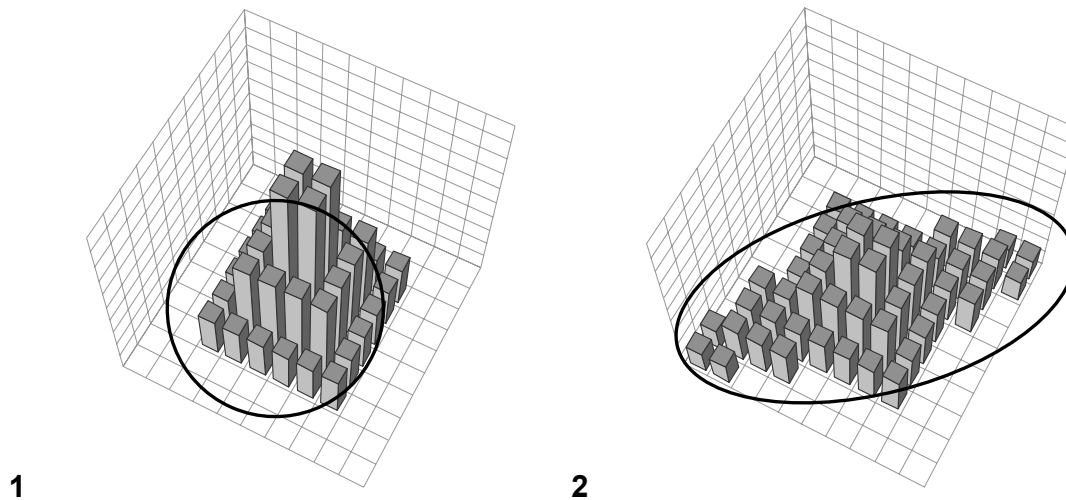


Figure 12 - Schematic models of different urban forms, orientation/linearity dimension

With the Directional Distribution tool of the software ArcGis (version 9.0), it is possible to measure whether a distribution of polygons follows a certain directional tendency. A polygon is generated in elliptic format, and axes are obtained by the standard deviation of the centroids of the polygons in relation to the rotation axis. The difference between the axes allows us to compare urban areas in terms of the orientation of urban development. In Diagrams 1 and 2 of the illustration, the difference between the axes indicates the degree of "flattening" of the ellipse. In the same way, when the difference between the axes is close to zero, as in Diagram 1, the tendency is for the ellipse to be closer to a circle. In terms of the analysis of sprawl, more circular forms are considered more compact. With standardized data, varying from zero to one, numbers closest to zero are more circular, and those closer to one more linear. Table 5 synthesizes the information obtained by this procedure and presents the Orientation/Linearity Index.

Table 5 – Calculation of the Orientation/Linearity Index, axes and difference between axes

Aglomeração Urbana	Axe 1	Axe 2	Difference between axes	Orientation/Linearity Index
São Paulo	0,441176	0,194153	0,247023	0,597555
Rio de Janeiro	0,199811	0,897000	0,697189	0,757158
Salvador	0,231182	0,134745	0,096437	0,538413
Belo Horizonte	0,368077	0,459865	0,091788	0,536567
Fortaleza	0,324692	0,228447	0,096245	0,538337
Brasília	0,549457	0,754262	0,204805	0,581138
Curitiba	0,381371	0,495693	0,114322	0,545509
Recife	0,186138	0,385728	0,199590	0,579099
Porto Alegre	0,373645	0,621580	0,247935	0,597908
Belém	0,213778	0,110328	0,103450	0,541197
Goiânia	0,255034	0,101435	0,153599	0,561037
Campinas	0,321116	0,236737	0,084379	0,533622
São Luis	0,085513	0,049549	0,035964	0,514344
Maceió	0,106719	0,064356	0,042363	0,516895
Natal	0,218222	0,097758	0,120464	0,547942
João Pessoa	0,031081	0,133998	0,102917	0,540986
São José dos Campos	0,204088	0,470597	0,266509	0,605076
Ribeirão Preto	0,400174	0,139164	0,261010	0,602958
Sorocaba	0,241025	0,195505	0,045520	0,518154
Aracaju	0,101968	0,196912	0,094944	0,537820
Londrina	0,213863	0,353992	0,140129	0,555721
Santos	0,084895	0,426765	0,341870	0,633776
Joinville	0,263922	0,175317	0,088605	0,535302
São José do Rio Preto	0,096826	0,202400	0,105574	0,542040
Caxias do Sul	0,184828	0,445323	0,260495	0,602759
Jundiaí	0,243963	0,103869	0,140094	0,555707
Florianópolis	0,531899	0,316013	0,215886	0,585462
Maringá	0,150571	0,237719	0,087148	0,534723
Vitória	0,128774	0,357987	0,229213	0,590648
Volta Redonda	0,324912	0,195729	0,129183	0,551394
Blumenau	0,512855	0,197006	0,315849	0,623941
Ipatinga	0,100394	0,205147	0,104753	0,541714
Criciúma	0,137581	0,195778	0,058197	0,523204
Itajaí	0,217323	0,034300	0,183023	0,572610
Cabo Frio	0,103695	0,184237	0,080542	0,532097
Mogi-Mirim	0,242095	0,171656	0,070439	0,528078
Guaratingueta	0,177504	0,200793	0,023289	0,509290

Integration/Commuting

In spite of all of the dimensions considered here, it is important to remember that if there is no integration among the urbanized areas, form does not matter. A very sprawled area in spatial terms, but where in practice commuting flows are minor, can be considered less sprawled because there is no real impact of a fragmented area. For this reason we added an indicator of commuting to measure the integration dimension of the urban agglomeration.

Two integration indicators were used: the proportion of commuters within an urban agglomeration with non-polarized destinations and the proportion of commuters to total population. The first refers to the pattern and direction of movements because urban agglomerations that have commuting patterns with multiple destinations or more than one destination can be understood as

more sprawled than one with a single destination. The proportion of commuters in relation to total population serves as a standardization parameter, which weighs commuter flows by the importance of this kind of movement. The integration index was calculated for each of the 37 urban agglomerations and is summarized in Table 6.

Table 6 – Population, proportion of commuters to the agglomeration core, proportion of commuters and Integration/Commuter Index

Urban Agglomeration	Population	Commuters to the agglomeration core		Commuters		Integration/Commuter Index
		N	%	N	%	
São Paulo	17.829.352	585.650	58,3	1.003.764	5,6	0,83598
Rio de Janeiro	10.943.847	487.767	68,3	714.649	6,5	0,88946
Salvador	3.012.837	25.327	45,6	55.548	1,8	0,69942
Belo Horizonte	4.273.274	245.625	71,8	341.888	8,0	0,91607
Fortaleza	2.899.231	54.076	79,0	68.418	2,4	0,82831
Brasília	2.747.993	112.165	95,0	118.114	4,3	0,91875
Curitiba	2.669.472	142.694	80,4	177.440	6,6	0,92679
Recife	3.323.422	197.892	77,4	255.767	7,7	0,92922
Porto Alegre	3.557.772	186.556	60,2	309.861	8,7	0,88029
Belém	1.795.536	91.262	87,1	104.746	5,8	0,93129
Goiânia	1.582.680	86.138	95,7	89.983	5,7	0,94655
Campinas	2.156.235	61.663	48,8	126.365	5,9	0,79780
São Luis	1.053.600	28.083	93,4	30.078	2,9	0,87997
Maceió	884.346	6.869	83,7	8.202	0,9	0,81674
Natal	1.043.321	34.900	86,3	40.454	3,9	0,88723
João Pessoa	844.171	22.967	83,0	27.655	3,3	0,86267
São José dos Campos	1.211.748	14.804	44,2	33.523	2,8	0,70908
Ribeirão Preto	609.363	9.622	84,9	11.338	1,9	0,83504
Sorocaba	908.217	17.053	64,7	26.362	2,9	0,79331
Aracaju	714.681	38.026	89,4	42.555	6,0	0,93799
Londrina	588.731	16.665	85,1	19.583	3,3	0,86980
Santos	1.353.374	64.717	65,0	99.504	7,4	0,88851
Joinville	596.343	3.816	41,7	9.142	1,5	0,67992
São José do Rio Preto	418.400	4.675	86,8	5.386	1,3	0,83047
Caxias do Sul	586.791	2.463	38,1	6.467	1,1	0,66083
Jundiaí	529.990	25.117	76,6	32.811	6,2	0,91008
Florianópolis	749.067	52.122	71,6	72.793	9,7	0,92203
Maringá	410.507	20.247	94,8	21.355	5,2	0,93690
Vitória	1.337.187	94.144	66,0	142.544	10,7	0,90597
Volta Redonda	542.918	16.199	73,4	22.082	4,1	0,85365
Blumenau	427.709	5.657	57,8	9.782	2,3	0,75448
Ipatinga	347.618	7.748	81,7	9.487	2,7	0,84486
Criciúma	265.679	6.372	70,9	8.988	3,4	0,82726
Itajaí	338.284	6.626	40,7	16.291	4,8	0,73618
Cabo Frio	223.348	4.861	55,3	8.791	3,9	0,78283
Mogi-Mirim	214.551	2.236	42,8	5.224	2,4	0,69733
Guaratingueta	228.228	2.322	44,3	5.242	2,3	0,70123
TOTAL	73.219.823	2.785.126	68,2	4.082.182	5,6	-

Source: FIBGE, Demographic Census 2000

A sprawl index for Brazilian urban agglomerations

On the basis of the dimensions of sprawl considered above, a sprawl index was calculated from the average of those dimensions. According to Lopez and Hynes (2003:331), a sprawl index should not be influenced by the size of population or territory, because the index must consider

different characteristics in terms of form, shape and integration. Table 7 summarizes the four dimensions and the sprawl index. Values near zero represent less sprawl and values near one, more sprawl. Alongside the numeric index, the rank of each urban agglomeration shows the results in a comparative perspective, with Blumenau the most sprawled area and Maringá the most compact. São Paulo also ranks as one of the most compact agglomerations, despite its position as the largest city of Brazil in terms of population and territorial size.

Table 7 – Dimensions of Sprawl and Sprawl Index

Urban Agglomeration	Density		Fragmentation		Orientation		Integration		Sprawl Index	
	Indicator	Rank	Indicator	Rank	Indicator	Rank	Indicator	Rank	Indicator	Rank
São Paulo	0.22441	36	0.55188	35	0.59755	8	0.16402	17	0.38447	36
Rio de Janeiro	0.49560	25	0.53597	37	0.75716	1	0.11054	26	0.47482	17
Salvador	0.26499	35	0.68718	16	0.53841	24	0.30058	4	0.44779	28
Belo Horizonte	0.47156	29	0.65475	23	0.53657	27	0.08393	29	0.43670	31
Fortaleza	0.54578	18	0.62054	28	0.53834	25	0.17169	14	0.46909	21
Brasília	0.64495	8	0.76049	1	0.58114	11	0.08125	30	0.51696	8
Curitiba	0.50934	23	0.75326	5	0.54551	19	0.07321	32	0.47033	18
Recife	0.38266	30	0.60601	30	0.57910	12	0.07078	33	0.40964	34
Porto Alegre	0.47688	28	0.68555	17	0.59791	7	0.11971	23	0.47001	19
Belém	0.31464	34	0.69242	15	0.54120	22	0.06871	34	0.40424	35
Goiânia	0.50816	24	0.62786	26	0.56104	14	0.05345	37	0.43763	30
Campinas	0.55500	17	0.58724	32	0.53362	30	0.20220	11	0.46952	20
São Luis	0.48408	26	0.67359	20	0.51434	36	0.12003	22	0.44801	27
Maceió	0.36967	31	0.66396	22	0.51690	35	0.18326	12	0.43345	33
Natal	0.33465	32	0.74589	8	0.54794	18	0.11277	24	0.43532	32
João Pessoa	0.48009	27	0.63982	24	0.54099	23	0.13733	20	0.44956	26
São José dos Campos	0.63034	9	0.67637	19	0.60508	4	0.29092	6	0.55068	4
Ribeirão Preto	0.53713	20	0.70592	14	0.60296	5	0.16496	16	0.50274	12
Sorocaba	0.57631	12	0.67075	21	0.51815	34	0.20669	10	0.49298	16
Aracaju	0.68414	4	0.54236	36	0.53782	26	0.06201	36	0.45658	25
Londrina	0.55529	16	0.75110	7	0.55572	15	0.13020	21	0.49808	14
Santos	0.54050	19	0.57644	33	0.63378	2	0.11149	25	0.46555	22
Joinville	0.67803	5	0.67785	18	0.53530	28	0.32008	2	0.55282	3
São José do Rio Preto	0.32697	33	0.73569	10	0.54204	20	0.16953	15	0.44356	29
Caxias do Sul	0.52397	21	0.75485	2	0.60276	6	0.33917	1	0.55519	2
Jundiaí	0.56192	14	0.62104	27	0.55571	16	0.08992	28	0.45715	24
Florianópolis	0.65224	6	0.74103	9	0.58546	10	0.07797	31	0.51418	10
Maringá	0.01202	37	0.75407	3	0.53472	29	0.06310	35	0.34098	37
Vitória	0.59490	10	0.57307	34	0.59065	9	0.09403	27	0.46316	23
Volta Redonda	0.57166	13	0.73000	11	0.55139	17	0.14635	19	0.49985	13
Blumenau	0.69802	2	0.70668	13	0.62394	3	0.24552	8	0.56854	1
Ipatinga	0.58543	11	0.70988	12	0.54171	21	0.15514	18	0.49804	15
Criciúma	0.68656	3	0.63325	25	0.52320	33	0.17274	13	0.50394	11
Itajaí	0.64718	7	0.62003	29	0.57261	13	0.26382	7	0.52591	6
Cabo Frio	0.71780	1	0.59788	31	0.53210	31	0.21717	9	0.51624	9
Mogi-Mirim	0.51595	22	0.75271	6	0.52808	32	0.30267	3	0.52485	7
Guaratingueta	0.55924	15	0.75355	4	0.50929	37	0.29877	5	0.53021	5

The index respects the criterion of not being influenced by the region's size, as Figure 13 shows. Although the urban sprawl index does not contemplate all of the possible dimensions for the analysis of urban expansion, it includes the principal dimensions mentioned in the literature. The relatively precarious data is compensated by its completeness and uniformity, allowing us to build a set of indicators for the whole country.

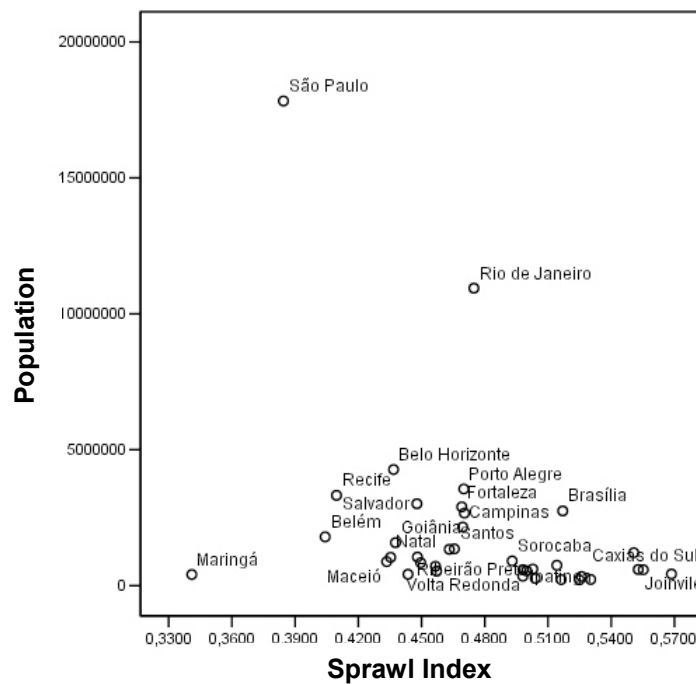


Figure 13 – Sprawl Index versus Population

As we have seen, the indicator captured the dimensions of dispersion and permitted us to classify regions on the basis of general criteria without taking into account peculiar or historical characteristics. Population size, contradicting some expectations, is not positively correlated with the degree of sprawl. In Figure 14, the most dispersed areas are found in the South-Southeast portion of the country, except for Brasília. Urban agglomerations located in the North and Northeast are all among the most compact, except for Fortaleza, which is in the intermediate group. This can probably be explained by regional characteristics of economic integration, expansion of transportation technology or even by overarching globalization processes. Independently of the answer in each case, it is a finding which merits further investigation, following this first effort of comparative analysis.

A negative statistical correlation was found with the proportion of homes with at least one automobile. In other words, the lower the sprawl index, the larger the proportion of homes with at least one automobile. That result was expected, since the literature already pointed to that tendency, which, indeed, seems obvious. If an area has greater urban dispersion, the need for transportation should be also greater. Especially in a developing country, household income has an important role in this regard, although the same negative correlation is found in all classes of *per capita* income. From households with lower *per capita* income up to those with more than 2 minimum wages per person, the correlation stays statistically significant. As we can see in Figure 14, more dispersed urban agglomerations have a larger proportion of automobiles, independently of income.

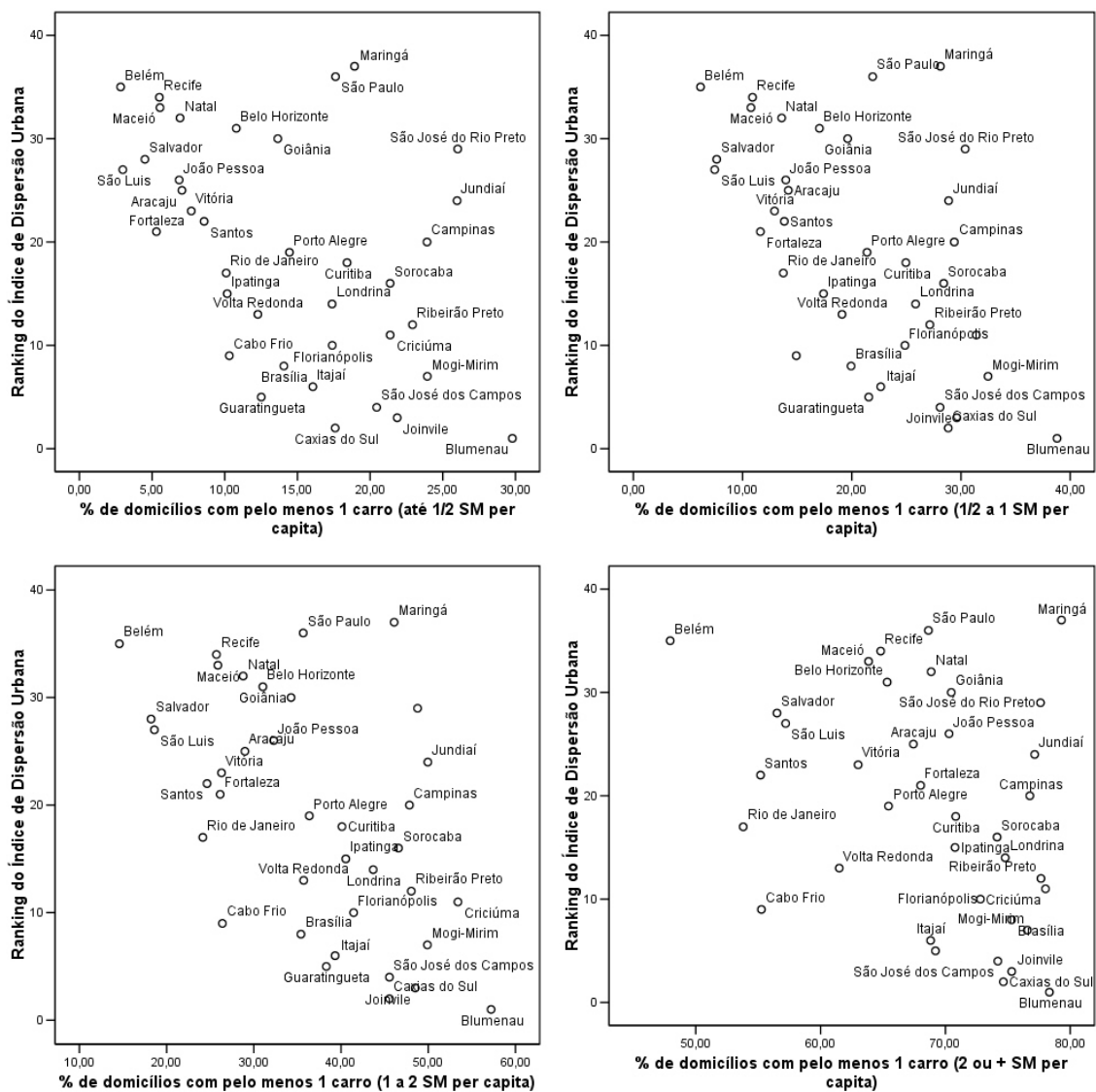


Figure 14 – Sprawl Ranking versus Proportion of homes with at least one automobile by income classes

These results raise important challenges for the future of sustainable urbanization in post-transitional countries, considering that urbanization is now at a turning point. Urban areas are increasingly complex, with fragmentation, integration and an intensification of commuting. New migration flows are becoming more evident and probably will have a huge impact on urban structures, especially for access to public services by the poor. Many social problems typical of developing countries become worse with sprawl.

If we all expect to live in urban areas by the end of this century, what would be the best urban form for a sustainable world? What are the specific impacts of this kind of urbanization in developing countries? The analysis of the most well-known cities in terms of world prospects frequently does not consider the diversity of urban realities that becomes more and more relevant into developing countries. Results appear to tell us that urban agglomerations in Brazil have an important commuting element that leads to a sprawling urbanization. These sprawling regions are

transforming land use, reducing green and open spaces around cities and increasing automobile dependence, air pollution and costs of public services. New challenges are posed for urbanization in developing countries and if we are unable to understand this process and its consequences in the near future, we can expect to see developing countries in an even more difficult dilemma: facing developing country problems (poverty) and developed country problems (sprawl) simultaneously.

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