

TEMPORAL ANALYSIS OF URBAN EXPANSION IN THE MUNICIPALITIES OF THE PARAÍBA PAULISTA VALLEY

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ABSTRACT

This study investigates the President Dutra Highway, inaugurated in the 1950s, and its influence on the urbanization process of the Paraíba Paulista Valley. Supported on the findings of Villaça (2001), which point to regional roads as urbanization routes, the President Dutra Highway has taken on a primary role for the growth of cities. In the 1970s, the President Dutra Highway was an important vector of the process of industrial relocation from the Greater São Paulo (LENCIONI, 1998). More recently, the President Dutra Highway was again pointed to in the proposals for the adoption of Territorial Vectors in the State of São Paulo. By means of axial maps, the temporal analysis aimed to explore urban expansion and the urban regional road system. To this end, topographical charts created for the year 1977 and the database of urban roads existing in 2015, obtained from the Open Street Map (OSM) project were used. The cartography resulting from the integration index of the urban roads provided a spatial view of the intra-urban road system revealing indications of a dispersed urbanization process, thus evidencing the President Dutra Highway as a structuring element of the urban-regional space in the Paraíba Paulista Valley.

Keywords: President Dutra Highway, Development Axes, urban sprawl, axial map.

RESUMO / RESUMEN

ANÁLISE TEMPORAL DA EXPANSÃO URBANA NOS MUNICÍPIOS DO VALE DO PARAÍBA PAULISTA

Este estudo investiga a Rodovia Presidente Dutra inaugurada na década de 1950 e sua influência no processo de urbanização do Vale do Paraíba Paulista. Amparado nas constatações de Villaça (2001), que apontou para as vias regionais como vias de urbanização, a Rodovia Presidente Dutra assumiu um papel primordial para o crescimento das cidades. Na década de 1970, tal infraestrutura rodoviária foi um importante vetor do processo de realocação industrial a partir da Grande São Paulo (LENCIONI, 1998). Mais recentemente, a Rodovia foi novamente apontada nas propostas para a adoção dos Vetores Territoriais no Estado de São Paulo. A análise temporal visa, por meio, de mapas axiais explorar a expansão urbana e o sistema viário urbano-regional. Para isso, fez-se o uso de cartas topográficas, elaboradas para o ano de 1977 e da base de dados das vias urbanas existentes no ano de 2015, obtida do projeto Open Street Map (OSM). A cartografia resultante do índice de integração das vias urbanas proporcionou uma visão espacial do sistema viário intra-urbano revelando indícios de um processo de urbanização dispersa, permitindo assim, evidenciar a Rodovia Presidente Dutra como um elemento estruturador do espaço urbano-regional no Vale do Paraíba Paulista.

Palavras-chave: Rodovia Presidente Dutra, Eixos de Desenvolvimento, urbanização dispersa, mapa axial.

ANÁLISIS TEMPORAL DE LA EXPANSIÓN URBANA EN LOS MUNICÍPIOS DE LA VALLE DE PARAÍBA PAULISTA

Este estudio investiga la Carretera Presidente Dutra inaugurada en la década de 1950 y su influencia en el proceso de urbanización del Valle del Paraíba Paulista. Amparado en las constataciones de Villaça (2001), que apunta a las vías regionales como vias de urbanización, la Carretera Presidente Dutra asumió un papel primordial para el crecimiento de las ciudades. En la década de 1970, tal infraestructura vial fue un importante vector del proceso de realocación industrial a partir de la Gran São Paulo (LENCIONI, 1998). Más recientemente, la Carretera fue nuevamente apuntada en las propuestas para la adopción de los Vectores Territoriales en el Estado de São Paulo. El análisis temporal busca, por medio de mapas axiales, explorar la expansión urbana y el sistema vial urbano-regional. Para ello, se hizo el uso de cartas topográficas, elaboradas para el año 1977 y de la base de datos de las vias urbanas existentes en el año 2015, obtenida del proyecto Open Street Map (OSM). La cartografía resultante del índice de integración de las vias urbanas proporcionó una visión espacial del sistema viario intraurbano revelando indicios de un proceso de urbanización dispersa, permitiendo así, evidenciar la Carretera Presidente Dutra como un elemento estructurador del espacio urbano-regional en el Valle del Paraíba Paulista.

Palabras-clave: Carretera Presidente Dutra, Ejes de Desarrollo, urbanización dispersa, mapa axial.

INTRODUCTION

In the Brazilian scenario, the morphological configuration of some urban networks indicates that among other elements, large highways are structurers and conditioners of the urban sprawl process. The importance of road infrastructures in the urban sprawl process is highlighted by Vilaça (2001), who points to the first consequence that a regional highway has on its surrounding area,

the improvement of its accessibility and hence, its increased value [...] There is an increase in value – the creation of value – which is the result of the socially necessary work expended in the construction of the highway and the production of all the points it can contact – all the points of the constructed space.

The author's findings have aided the formulation of this study and when applied to the urban network of the municipalities crossed by the Rodovia Presidente Dutra, they further elucidate the importance of the federal route in the urbanization process of the Paraíba Paulista Valley, from the second half of the twentieth century.

According to Santos and Silveira (2013, p.65), in Brazil the road network has been fundamental for the country's territorial integration, principally for the Southeast Region, which after the second half of the twentieth century received investments for the "construction of several infrastructure projects to connect the various regions between themselves and with the Concentrated Region of the country".

After the 1970s, some road systems and the municipalities under these highways' influence emerged as a spatial configuration model. A typical example of this model of occupation was a continuous urban formation, such as the one identified in the Brazilian Southeast Region, chiefly in São Paulo State. This process has been verified around the highway axis which connects the São Paulo Metropolitan Region and the Baixada Santista Metropolitan Region, Jundiaí and the Campinas Metropolitan Region, and Sorocaba and the Paraíba Valley, in the direction of Rio de Janeiro (REIS FILHO, 2006).

In 1950, the Presidente Dutra Highway was inaugurated in the Valley of the Paraíba Paulista Region, which in connecting the country's two principal economic poles, São Paulo and Rio de Janeiro, came to influence the urbanization process of the Paraíba Paulista Valley.

In the 1970s, the industrial reallocation or deconcentration movement, studied by Lencioni (1994 and 1998) and Negri (1996), originated in the Greater São Paulo Region and initiated a restructuring process of the economy and urban-regional space. On the whole, the margin of the President Dutra Highway was selected by industrial capital. The rapid population growth and the demand for new spaces for housing and the development of complementary activities linked to the secondary sector of the economy in the municipalities Jacareí, São José dos Campos, Caçapava, Taubaté, Tremembé and Pindamonhangaba, contributed to the urban-regional space of the Dutra Axis gradually presenting a spatial configuration marked by discontinuities and fragmentation of the urban form.

Recently, the institution of the Paraíba Valley and North Littoral Metropolitan Region (RMVPLN) and the proposal of consolidation of the Paulista Macrometropolis in the Macrometropolis Action Plan (PAM) in 2014, has reignited the discussion regarding road infrastructures in São Paulo State, now understood as vectors of territorial development (TAVARES, 2017).

The methodological processes include the temporal investigation of the urban sprawl in the municipalities of the President Dutra Highway Axis (Sub-region 2 – Dutra A), which confirms it as the structuring element of the urban-regional space, aided by the use of the secondary data from various sources.

This secondary data include Landsat (4-5, 5 e 8) satellite images for the years 1975, 1995 and 2015, obtained from the satellite images catalog on the United States Geological Survey website (USGS). The composition of these georeferenced images was added to the Geographic Information System (GIS), where the delimitation of the urban areas and the calculation of the urban areas on the respective dates was generated.

Another source of secondary data imported to the GIS was the data base of urban roads, which allowed the creation of the axial maps. This data base, formed of georeferenced lines representing the urban roads, was obtained from the Open Street Map (OSM) Project for the year 2015, for the urban

areas of the municipalities of Jacareí, São José dos Campos, Caçapava, Taubaté, Tremembé and Pindamonhangaba. This urban roads data base (for 2015) was overlapped on the GIS with the georeferenced topographic maps for 1977 (on the scale 1:10.000) accessed by the DataGeo (2018). During this stage, the GIS editing tools were used (over the 2015 urban roads data base) to exclude the urban roads, according to the urban area presented in the 1977 maps.

Once the stage of drawing up the files of lines for the urban roads had been completed, the axial maps and the Global Integration Index (IIG) for the years of 1977 and 2015 were created. To comprehend the spatial analysis carried out using axial mapping and the elaboration of the urban roads integration index, it is necessary to understand some fundamentals of Spatial Syntax Theory, created by Bill Hillier and other contributors from University College London (UCL), in the beginning of the 1980s. They sought to describe the outline traced and the relationship between public and private spaces using quantitative measures, which provide knowledge of important aspects of the urban system, such as the accessibility and distribution of land uses (SABOYA, 2007).

Axial mapping results from the calculation of the integration indexes of the physical urban routes (roads, highways and accesses) represented cartographically by axial lines and the integration of these lines in the territory. For Hillier and Hanson (1984, *apud* SABOYA, 2007), “axial lines are the larger straight lines capable of covering all the systems of open space in a determined urban area”, whereas, according Hillier et al. (1993, *apud* SABOYA, 2007), the integration of axial lines consists of

possible measures of syntactic analysis [...] This is useful in the forecasting of pedestrian and vehicle flows and in the understanding of the logic of locating urban uses and social gatherings. The integration measure calculates how "deep", or distant, an axial line is from all other lines in the system

In this article, the road integration index is shown by a chromatic scale, in other words, the closer to the color red, the greater the integration index of the roads, the closer to blue, the less the integration of the roads and, consequently, the lower the physical accessibility potential of the urban subspace¹ (Chart 1).

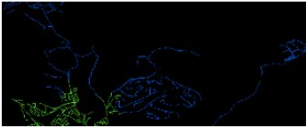




Colors	Integration	Description	Example
Blue	Weak	Low connectivity of urban roads. Shows great distances, suggesting urban dispersions and possible recent occupations.	
Green	Moderate-weak	Average connectivity of the urban roads. Distant locations suggesting urban areas in the process of consolidation	
Yellow	Moderate	Average connectivity of the urban roads (between weak and strong). Presents average distances suggesting urban areas in an advanced process of consolidation	
Orange	Moderate-strong	Connectivity of the urban roads. Suggests consolidated and integrated urban areas. Generally located next to urban roads with strong integration connectivity	
Red	Strong	Strong connectivity between urban roads. Suggests consolidated urban areas with a high integration of the urban roads.	

Chart 1 – Global Integration Index, standardization, description and examples.

Source: OSM, 2015.

The analysis of the integration of urban roads represented by the axial maps for 1977 and 2015 enabled the identification of the Presidente Dutra Highway as a structuring element of the urban-regional space. The use of this methodology facilitated the comprehension of the urban sprawl process, pointing to the transformations of the urbanization process of the municipalities of the President Dutra Highway Axis.

This article analyses the President Dutra Highway as a structuring element of the urban-regional space, since once it was built it has stood out as a regional articulation vector interfering directly in economic development and in the increase of the urban area of the municipalities of the Axis. Therefore, this article is based on the technical elaboration of the axial mapping of the respective urban roads in the years 1977 and 2015, demonstrating the level of road integration exercised by the Presidente Dutra Highway and assisting in the spatial analysis of the specific dispersed urbanization process of the municipalities selected.

STRUCTURING ELEMENTS OF SPACE: REGIONALIZATION ROUTES AND DISPERSED TERRITORIAL OCCUPATION

Studies of road infrastructures demonstrate that highways are definers of territorial organization by directing the urban-regional occupation process. Villaça (2001, p.70) verifies this structuring

phenomenon of transport system infrastructures and their correlation with urban growth, stating that

there seems to be an intimate relationship between regional transport routes and the physical growth of cities. [...] Highways – especially expressways – cause a more rarefied and discontinuous growth.

The hypothesis formulated by the author (2001), show that there is a correlation between of the growth and direction of urban sprawl and the influence of regional routes. According Villaça (2001, p.70)

although they have not been constructed to offer intra-urban transport, [the] routes end up offering this type of transport and the more regionally important become the most important from the intra-urban point of view and end up attracting major urban sprawl along them.

In Brazilian case, circulation routes, including the railways constructed in the nineteenth century, have always exercised a conditioning role in territorial use and occupation. From the beginning of Brazilian socio-spatial formation, the first terrestrial paths led to the origin and growth of towns, villages and cities. In a second period, with the expansion and construction of regional routes, the integration had not yet reached the country's entire territorial extension, limited to the regions forming around principal cities. From the 1950s, with highway-based policies, and especially from the 1970s, highways indeed became the defining elements of the country's spatial organization model, providing the base of a truly national integration. Santos and Silveira (2013, p.65) highlight the growth of the road network in that territorial integration process, when “the extension of the Brazilian road network rose from 302.147 kilometers in 1952 to 1.657.769 kilometers in 1995; the greatest growth occurring in the 1970s”.

In the 1970s, in São Paulo State, the highways conducted the industrial deconcentration process from the capital, exercising a strong influence on the urbanization of the interior. The regional routes played a fundamental role in the orientation of the urban-industrial expansion in that period. Negri (1996, p.169) explains that at this time the population began to concentrate

proportionally more around the urban centers in the eastern

region of the state, following their greater modernization, diversification and agricultural expansion, the agroindustrial development and the relative “industrial decentralization”, especially on the penetration axis of the Dutra Highway (until São José dos Campos and Taubaté), the Anhanguera Highway (until Ribeirão Preto), the Washington Luiz Highway (until São José do Rio Preto) and the Castelo Branco Highway (until Sorocaba).

In the same decade, alongside the II PND discussions, the spaces crossed by highways were diagnosed in the proposals of the regional plans elaborated by the government of the State of São Paulo, with an emphasis on the Paulista Macro-Axis Regional Plan. This document presented the guidelines for the integrated development and the mitigation of the impacts of the Greater São Paulo urbanization process (SÃO PAULO, 1978).

In the 1990s, with Pluriennial Plans (PPA) elaborated by the federal government from 1996 to 1999 and between 2000 and 2003, these regional routes were reaffirmed as national development axes.

For Tavares (2016, p.681), the concept that would be consolidated as an axis is linked to the idea of “a larger area under the influence of a highway with a development potential that is constituted in a region that is subject to the provision of infrastructure and planning actions”.

More recently, after the decade of 2010, on the scale of the Paulista Macrometropolis (MMP), the Macrometropolis Paulista Action Plan 2013-2014 (PAM) was drawn up, with regional routes understood as “territorial vectors” and being highlighted for the regional planning. According to Emplasa (2014, p.22), territorial vectors are described as

connections that have specific functions on the inter-metropolitan level, including the new connections created by productive or urban dynamics. Or, still, circuits that result in the conformation and / or

reinforcement of the new centralities.

From a spatial point of view, the idea of development vectors has created a tendency in São Paulo State that reinforces the recurring occupation mode in the territory, known as dispersed or diffuse urbanization. For Reis Filho (2006, p.94), in São Paulo State, urban dispersion is “a consequence of the road system”. The chronological analysis of the urban dispersion process in the State points to the 1970s, when the urban-industrial deconcentration from the Paulista Metropole began, intensifying the fragmented and dispersed occupation of the urban network along the state’s main highways. Locational factors and the principle of spatial selectivity² directly influence the growth of the cities. For Oliveira and Gomes (2010, p.55),

urban growth is governed by the strategic value that the geographical location acquires and by the selectivity of its choice for the occupation of new areas and the installation of new activities. Encouraged by the processes of parceling large portions of land, the implantation of great highways and other infrastructures, building large industries, commerce and services, with notable losses of green areas, the production of urbanized space tends to establish the deconcentration of new urban developments (which are linear or periodic), through the continuous displacement of the most favored social segments and the consequent aggravation of segregation.

This theoretical approximation regarding the structuring axes of urban-regional space and urban morphology are quite pertinent in understanding the selective production of the urban-regional space of the Paraíba Paulista Valley. In this case, the territorial cut established by the Dutra Highway Axis and limited to the municipalities of Jacareí, São José dos Campos, Caçapava, Taubaté, Tremembé and Pindamonhangaba reveals some socio-spatial similarities and inequalities, the result of a historic process of urban network formation in the Paraíba Paulista Valley Region, as described in the following section.

HISTORICAL ASPECTS AND THE SOCIO-SPATIAL DYNAMIC OF THE MUNICIPALITIES OF THE PRESIDENTE DUTRA HIGHWAY AXIS

Located in the extreme east of São Paulo State, between the country’s two principal economic poles – São Paulo and Rio de Janeiro –, the Paraíba Paulista Valley Region is crossed by Presidente Dutra Highway, which traverses 14 of the 39 municipalities that make up the existing RMVPLN. The current study is based on the delimitations of the areas established by the Macro-Axis Paulista Regional Plan drawn up by the Development Secretariat of São Paulo State in 1978. In this document, the Paraíba Paulista Valley Region was divided into five sub-regions. Sub-region 2 (DUTRA A) is composed of the municipalities of Jacareí, São José dos Campos, Caçapava, Taubaté, Tremembé and Pindamonhangaba and was defined as the territorial cut for this analysis (Figure 1).

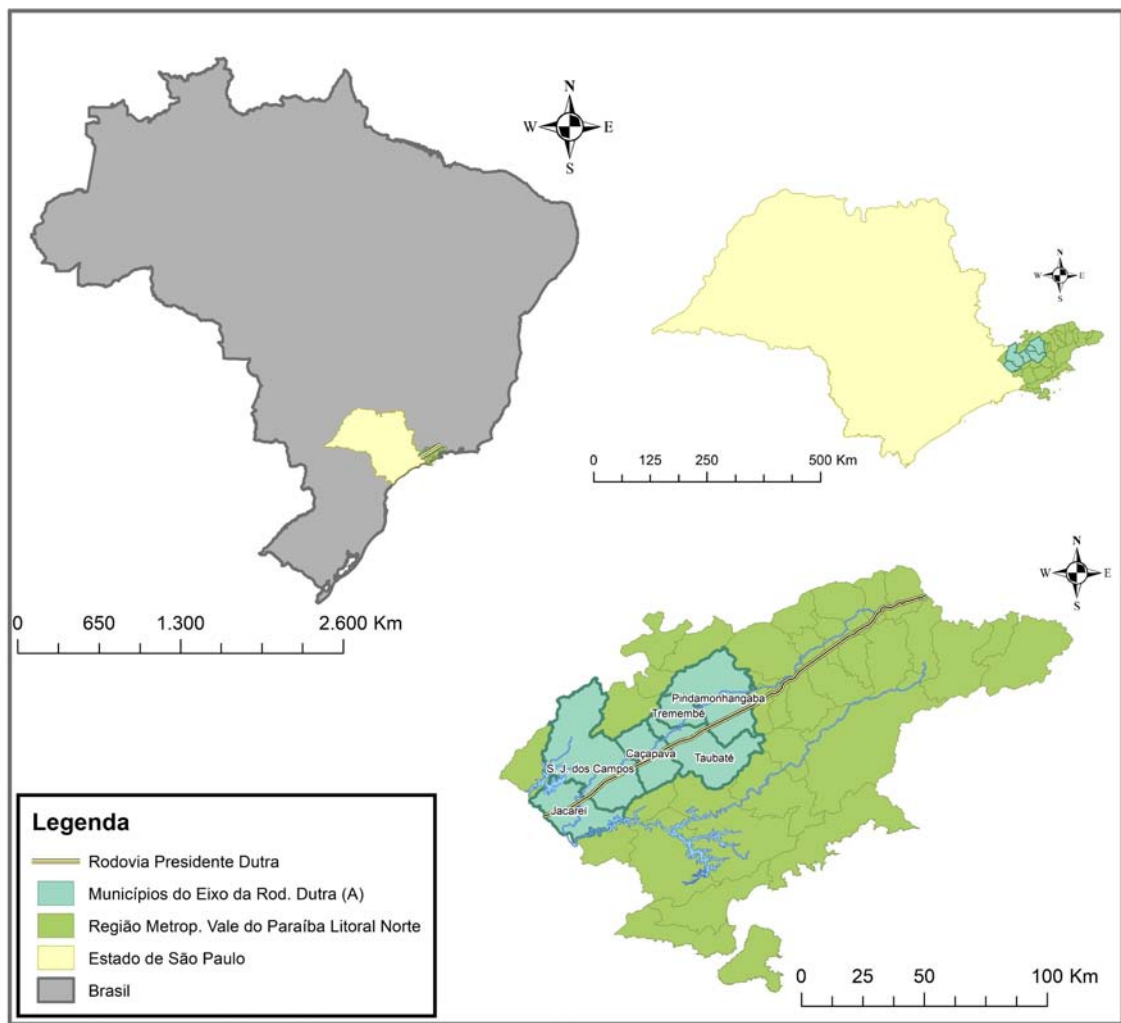


Figure 1 – Location of the Presidente Dutra Highway Axis. Source: IBGE, 2018.

Elaborated by the author.

The formation of the urban network of the municipalities of the Presidente Dutra Highway Axis (Sub-region 2 – Dutra A) took place in the midst of a series of events, whose records refer to the context of the occupation of the Brazilian territory by the first Portuguese explorers and settlers in the seventeenth century.

However, for this study, the temporal reference is demarcated by three periods, firstly the inauguration of Presidente Dutra Highway, as defined by Müller’s (1969) study of the urbanization process of the Rio Paraíba do Sul Hydrographic Basin as an industrial stage. Secondly, the decade of 1970, when the Region was affected by São Paulo city’s industrial deconcentration process (LENCIONI, 1998), and thirdly, when the Region’s more industrialized and urbanized municipalities underwent transformations that point to a more effective economic participation of the tertiary sector with effects on the organization of the urban-regional space.

According to Müller (1969), the period between 1945 and 1965 was marked by the adoption of public politics directed at the economic and regional development of the Paraíba Paulista Valley. The 1950 Plano de Metas pointed to the investments in the territorial integration project.

The inauguration of the Presidente Dutra Highway in 1951 was included in these investments of the national developmentalist project of the second half of the twentieth century and started a new stage in the urbanization process of the Paraíba Valley and the North Coast of the State of São Paulo. In the words of Ronca and Vitale (2004, p.140), the

national development model adopted after 1950 was based on the allocation of infrastructures to propitiate the industrialization process in the country as form of achieving economic growth [...] “among the infrastructures established in São Paulo State, especially the Vale do Paraíba Region, the road system is noteworthy, [...] as the main road infrastructure for the development and flow of economic production.

In the 1970s, a spatial and social reallocation movement of the industry in São Paulo State began. According to Lencioni (1994, p.201), the “industrial deconcentration policy mainly meant a dispersion covering a radius about 150 km from the capital and going beyond this distance along the main highway axes”.

In this intense industrialization and urbanization process, the technology sector in the Paraíba Paulista Valley stood out, which from the 1950s was strategically planned by the action of the Brazilian State and was consolidated by means of the Planos Nacionais de Desenvolvimento I and II in the 1970s. For Becker and Egler (2003, p.133), the policy of technological appropriation included in the II Plano Nacional de Desenvolvimento (1975-1979) effectuated efforts and resources in science and technology. According to these authors, the government enterprises in that sector (2003, p. 133-134) “were partially linked to state and military research and development (R & D) centers”. The Paraíba Valley was selected as the “*locus* of the modern geopolitical project [...] where the objective of constructing a military-industrial complex continues in evidence”.

Between the 1970s and 2010, beyond the industrialization process focused on the six municipalities of the Axis of the Presidente Dutra Highway (Sub-region 2 - Dutra A), demographic transformations were also evident. In the 1970s, São José dos Campos had a total of 132.467 inhabitants, forty years later the municipality reached the incredible number of 617,106 inhabitants living in the urban area; an increase of about 366%. In the same way, Taubaté had an expressive growth in the order of 173%, with a rise in the population of 99.969 inhabitants in 1970 to 273.673 in 2010 (Table 1)

Municipalities	Urban (1970)	Rural (1970)	Urban (1991)	Rural (1991)	Urban (2010)	Rural (2010)	(%) Growth. Pop. Urban 1970 - 2010
Caçapava	24.634	6.078	58.316	7.742	72.517	12.235	194,38
Jacareí	48.529	12.687	157.026	6.843	208.297	2.917	329,22
Pindamonhangaba	29.346	18.876	95.611	6.452	141.708	5.287	382,89
São José dos Campos	132.467	15.865	425.515	16.855	617.106	12.815	365,86
Taubaté	99.969	10.616	197.801	9.164	272.673	6.013	172,76
Tremembé	7.297	4.392	24.317	3.255	36.936	4.048	406,18
Total	342.242	68.514	958.586	50.311	1.349.237	43.315	1.851

Table 1 – Demographic data of the Dutra A municipalities in the years 1970, 1991 and 2010. Source: IBGE, 2018.

Elaborated by the author.

Still according to table 1, the municipality registering the lowest urban population in the Axis of the Presidente Dutra Highway (Sub-region 2 - Dutra A) was Caçapava with 24.634 inhabitants in 1970, rising to 72.517 inhabitants in 2010, which was equivalent to a growth of about of 194%. In the case of Tremembé, although not located close to the Dutra Highway, it registered the highest growth, 406% between 1970 and 2010, although the municipality has a dissonant absolute population value from the rest of the municipalities on the Presidente Dutra Axis (Sub-region 2 - Dutra A). The municipality of Tremembé grew from 7.297 in 1970, to 36.936 inhabitants living in the urban area in 2010.

Alongside the demographic growth, in the period from 1970 to 2010, there was an increase in the areas of urban sprawl of the Presidente Dutra Axis (Sub-region 2 - Dutra A) located in the surrounding areas of the Presidente Dutra Highway. In the municipalities of São José dos Campos, Taubaté and

Caçapava the growth of occupation in these areas as higher than the growth registered in the municipalities of Jacareí, Pindamonhangaba and Tremembé.

The mapping of the urban occupation process in the municipalities selected, for the years 1975, 1995 and 2015, show growth along the Axis, notably the municipalities of Jacareí, São José dos Campos, Taubaté and Caçapava that had the greatest growth in their respective urban areas. There was also a greater sprawl of urbanized areas in the southern direction of the Presidente Dutra Highway in the municipalities of Jacareí, São José dos Campos and Caçapava. In the rest of municipalities, the territorial occupation showed a consolidation of urban areas to the north (Figure 2).

Based on the spatialization presented herein, it is evident that between 1995 and 2015 there was a consolidation of a great urbanized and conurbated area, formed by the municipalities of Jacareí, São José dos Campos and Caçapava. Still according to the data calculated for the extension of the urban area, obtained by means of mapping for the all periods, it was verified that the period of greatest growth in the urbanized area was between 1975 and 1995, when the growth of the urbanized area calculated in the six municipalities reached approximately 133%.

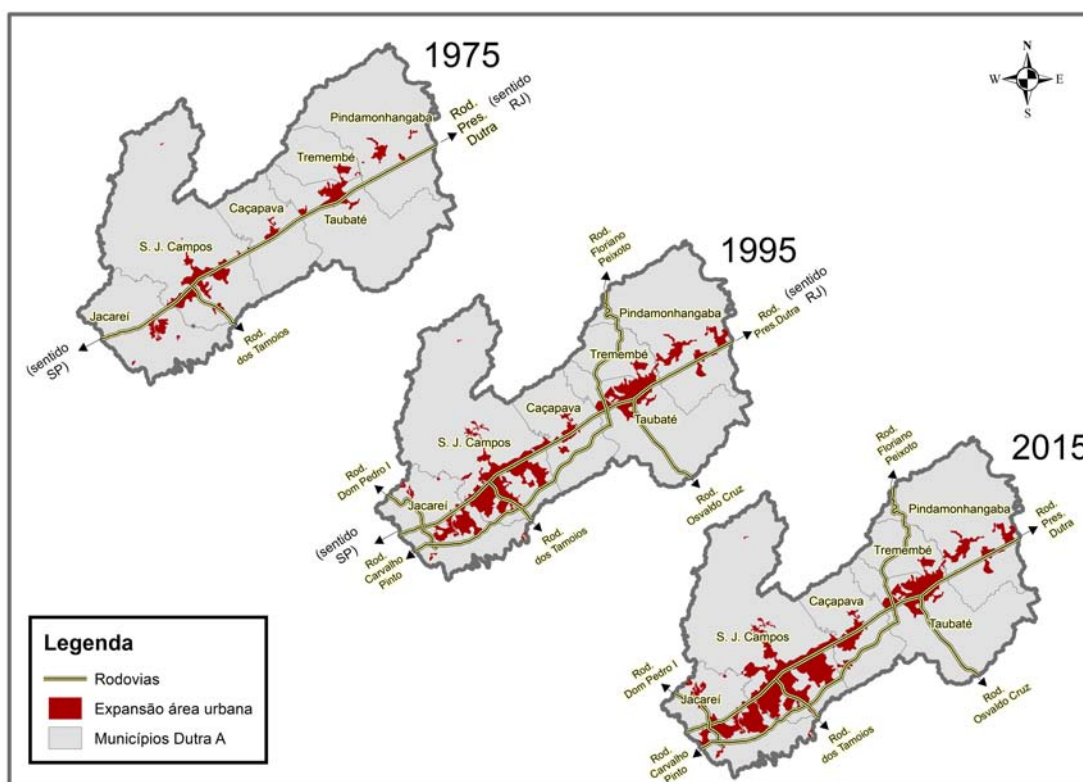


Figure 2 –Area of urban sprawl in 1975, 1995 and 2015. Source: USGS, 2017.

Elaborated by the author

In the period between 1995 and 2015, the urban sprawl of the six municipalities was less than in the previous period, nonetheless, the all municipalities grew in the order of 28% in 20 years (Chart 2).

Year	Urbanized area in the municipalities of Pres. Dutra Highway Axis (Km²)	Total area of the municipalities of Pres. Dutra Highway Axis (Km²)	% of urban area occupied in the Pres. Dutra Highway Axis	% of growth between years 1975 - 2015
1975	139	3.477	4,00	(base year)
1995	324		9,32	133,09 (between 1975 - 1995)
2015	416		11,96	28,40 (between 1995 - 2015)

Chart 2 – Area of urban sprawl in 1975, 1995 and 2015. Source: USGS, 2017.

Elaborated by the author

For a broader investigation of the urban sprawl process the morphology of the urban roads in the six municipalities studied was considered, between 1977 and 2015, reaffirming the role of the Presidente Dutra Highway as a structuring element of the urban-regional space. For this temporal analysis, axial cartographic representations were generated by means of an index of the integration of urban roads with the Presidente Dutra Highway in order to indicate the potential of accessibility, as well as the expansion of the urban sprawl of the municipalities. The cartography generated for the years 1977 and 2015 allowed the visualization of the spatial transformations of the constructed area in the municipalities of the Axis and the more dispersed or discontinuous occupation from the Presidente Dutra Highway.

AXIAL MAPPING AND THE INTEGRATION INDEX OF THE URBAN ROUTES IN THE PRESIDENTE DUTRA HIGHWAY AXIS

To better understand the evolution of the urban sprawl that occurred in the Presidente Dutra Axis (Sub-region 2 - Dutra A) for the urban routes for the years of 1977 and 2015, the methodological procedures of axial mapping and the calculation of the Global Integration Index (IIG) were used. The spatial analysis enabled the affirmation of the condition of the Presidente Dutra Highway as a structuring element of the urban-regional space (in the longitudinal east-west sense), at the same time as indicating the discontinuity or dispersion process (considering the latitudinal north-south sense) in the respective urban areas of the six municipalities.

The mapping and the integration index for the year of 1977, in the longitudinal sense of the Presidente Dutra Highway, indicates a strong integration of the urban routes in the Taubaté municipality (colored red). The formation of a more compact urban area near the Dutra Highway demonstrates the existence (in the decade of 1970) of a strong integration index resulting from the connectivity of urban routes with Presidente Dutra Highway (Figure 3).

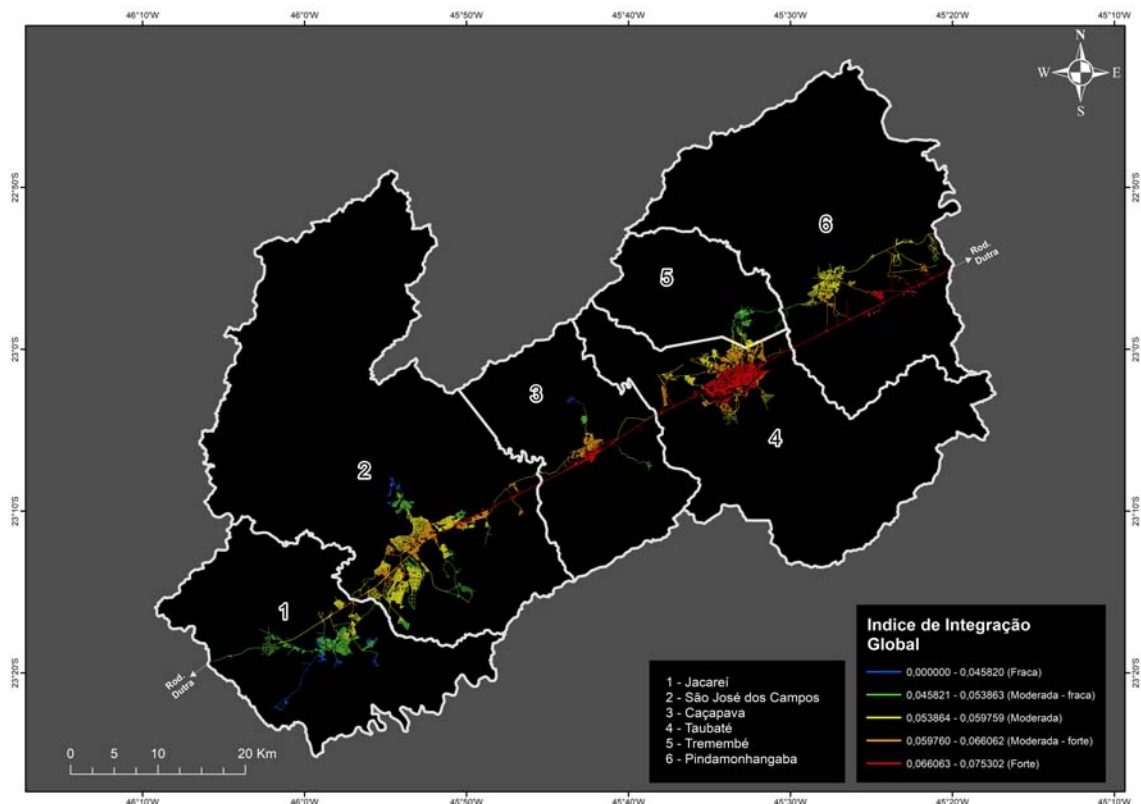


Figure 3 – Axial map of the urbanized area in the year 1977. Source: IGC, 1977.

Elaborated by the author.

According to figure 3, the result of the IIG for 1977, pointed to other locations with strong integration places along the Presidente Dutra Highway in the municipalities of Caçapava, Pindamonhangaba and the in the east of São José dos Campos municipality (color red index). From the chromatic variation of the IIG (from orange to green), the existence of moderate-strong, moderate and moderate-low level connectivity was verified in the surrounding areas of the Dutra Highway in the stretches of the municipalities of São José dos Campos and Jacareí. The axial map for 1977 reveals a moderate integration, in the longitudinal sense along the Presidente Dutra Highway from the municipality of Taubaté, in the direction the São José dos Campos municipality, while the low integration index occurred from the São José dos Campos municipality in direction of the municipality of Jacareí.

According to figure 3, the image of discontinuous urban occupation for 1977 suggests the analysis of the varied ramifications of the routes in the latitudinal sense (north and south). In other words, the IIG visualization identifies discontinuities in the routes in the urban sprawl of the municipalities. For that year, the presence of discontinuities, shown by the blue coloration (low integration), was detected south of Jacareí municipality extending far from the Presidente Dutra Highway⁴. In the municipalities of São José dos Campos and Caçapava, the discontinuities of occupation demonstrated by routes with low and moderate-low integration indexes (colors in blue and green) were identified in areas far to the North and South of the Presidente Dutra Highway. The analysis of the ramifications of the urban routes and the urban occupation revealed that in the remaining municipalities of the Dutra Axis (Taubaté, Tremembé and Pindamonhangaba) the latitudinal IIG points to a reduced presence of discontinuous areas from the Dutra Highway. In the specific case of Tremembé municipality, the low integration index with the Presidente Dutra Highway is explained by its location, approximately 6,5 Km away from the Dutra Highway.

In 2015, the expansion of the urban sprawl seen from the construction of highways brought a new urban conformation of the Presidente Dutra Highway Axis. Over approximately forty years, the first change shown by the 2015axial mapping refers to the growth of the route ramifications in practically all the Presidente Dutra Axis (Sub-region 2 - Dutra A) municipalities. Another change observed relates to the IIG longitudinal analysis, which in 2015 demonstrated the existence of a strong integration (red color) of the Presidente Dutra Highway and its accesses in the São José dos Campos municipality, different to that observed in 1977, when the highest IIG centered on the Dutra Highway stretches in the Taubaté municipality.

The strong integration index of the Dutra Highway in the stretches of the São José dos Campos municipality can be understood if the alterations in land use along the margins of the Dutra Highway are taken in to account, promoted, mainly, by modern economic sectors, including the activities of the industrial, commercial and services sectors. The creation of several corridors and routes alongside the Dutra, the accesses to industrial establishments, malls, hypermarkets, wholesale companies, technological production spaces and the other connectivities to neighborhoods near the Dutra Highway can be taken as indicators of the high IIG verified in the municipality in 2015.

The axial mapping (figure 4) in the same year in Caçapava municipality shows the existence of occupation patterns in areas near the Dutra Rodovia similar to the municipality of São José dos Campos, with which it is conurbated. This characteristic helps understand the strong integration index of accessibility in the Presidente Dutra Highway stretches in the Caçapava municipality.

Taubaté municipality, due to the somewhat compact format of its urban consolidation, continued to present a high occupation in its territory, occasioning the construction of more routes and accesses. If compared to the preceding period approximately forty years ago, despite the significant growth in the urban sprawl alongside the Presidente Dutra Highway in the municipality, it does not seem to have been a priority for occupations and their respective roads and accesses, which helps explain this reversion in the IIG in 2015. The case of Jacareí municipality, which presented growth in urbanized areas similar to Caçapava municipality, also presented a strong and moderate-strong irradiations index (red and orange colors) in the occupations alongside the Presidente Dutra Highway. In the recent period, the land located

along the Dutra Highway was parceled out for use by the industrial, commercial and service sectors, as well as residential use distributed in neighborhoods located near the Dutra Highway.

The IIG mapping showed that, unlike 1977, when the Dutra Highway stretch of the Pindamonhangaba municipality demonstrated the existence of a strong road integration, this was not the case in 2015, since the area was not affected by changes in occupation and its accesses. Thus, compared to other municipalities, the Pindamonhangaba stretch is classified by its moderate index of road integrations (Figure 4).

However, as explained above, although the municipality of Tremembé is not directly connected to the Presidente Dutra Highway, figure 4 shows a growth in the urban area and the creation of access roads to land with more discontinuous occupation. This discontinuous occupation visualized on the map as a low integration index represents a tendency in Tremembé's territorial occupation in areas located in the northwest of the municipality, considerable distances from the urban center.

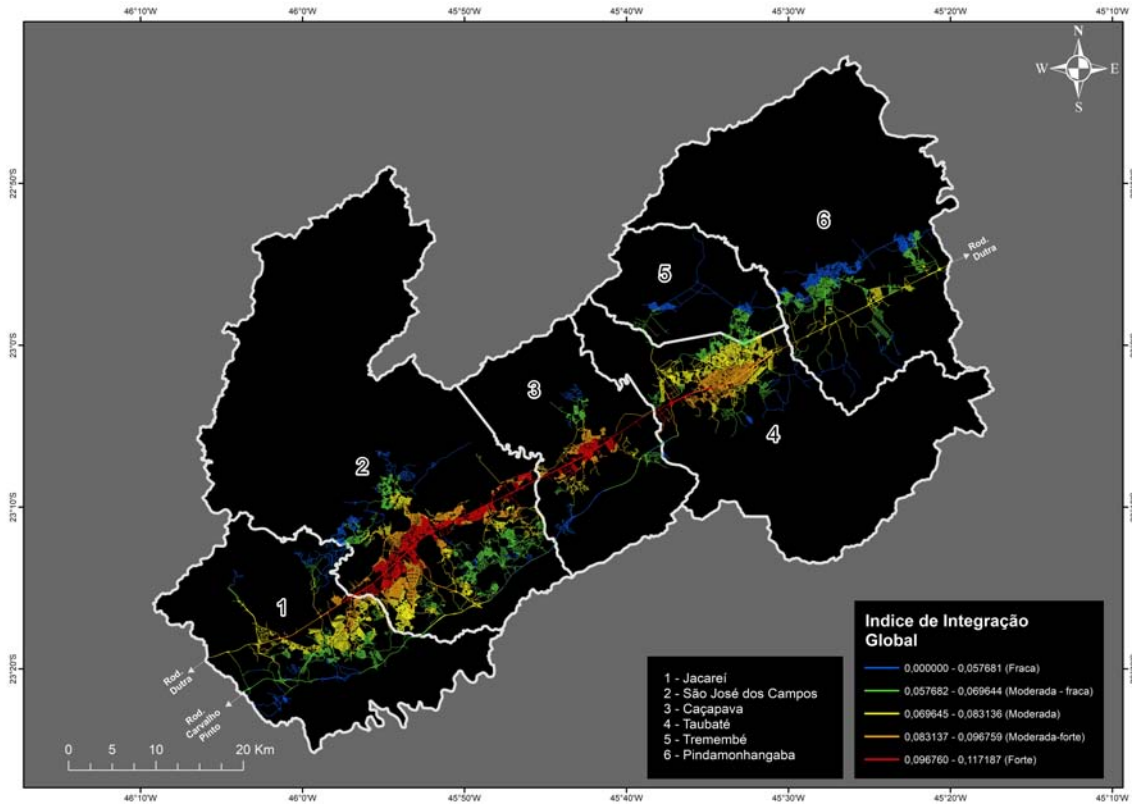


Figure 4 – Axial map of the urbanized area in the year 2015. Source: OSM, 2015.

Elaborated by author.

Finally, figure 4 shows the influence of the Carvalho Pinto Highway, which was built in the 1990's, indicating another important road infrastructure positioned linearly and parallel to the Presidente Dutra Highway. This important regional road infrastructure crosses the municipalities of Jacareí, São José dos Campos, Caçapava and parts of the south-west Taubaté. The expansion of the road ramifications presented in figure 4 indicates urban occupation in a southerly direction, in areas between the Dutra Highway and the Carvalho Pinto Highway. These urban road occupations and constructions in the southerly direction of the Carvalho Pinto Highway are verified with greater intensity in the municipalities of Jacareí and São José dos Campos. In both municipalities, the moderate and moderate-low intensities of IIG indicate an occupation and construction process of the urban route in a consolidation stage. In Caçapava municipality the occupation process is occurring in an embryonic fashion (more recent occupations) and is less intense, but, still significant in the proximity of the Carvalho Pinto Highway.

Thus, based on the temporal analysis of the mapping for 1977 and 2015, it was observed that the

construction of the Presidente Dutra Highway (in the 1950s) played a preeminent role in the structuring of urban-regional space in the Paraíba Paulista Valley. This can be visualized by the evolution of the urban sprawl using satellite images for 1975, 1995 and 2015, and subsequently by overlapping the urban routes, axial mapping and the calculation of the global integration index. In addition to reaffirming the important role of Dutra Highway in the structuring of the urban-regional space between 1977 and 2015, the latter enabled the identification of the evidence of the process of dispersion and discontinuities in the urban occupation, which is occurring at greater distances from the Presidente Dutra Highway.

CONCLUSION

This study investigated the Presidente Dutra Axis (Sub-region 2 - Dutra A) between the years of 1975 and 2015, which is considered an important structuring element of the urban-regional space of the Paraíba Paulista Valley. The analysis of the information extracted from satellite images for the years 1975, 1995 and 2015 aided in the findings that the growth of the urbanized area along the Presidente Dutra Axis (Sub-region 2 - Dutra A) was strongly influenced by this highway, confirming the affirmations of Villaça (2001) regarding the role of regional routes in territorial integration and their action as catalyzers of the urbanization process.

The information obtained through this cartography points to the existence of a spatial selectivity in the urban occupation in the proximities of the Presidente Dutra Highway, mainly in the municipalities of São José dos Campos, Caçapava and Taubaté. At the same time, the mappings for the years in question showed that the urban expansion took place to the north and south of the Presidente Dutra Highway.

A more detailed understanding of the process of expansion of the urban area in the period between the decades of 1970 and 2010 was achieved by creating axial maps for the years 1977 and 2015 with their respective urban road integration indexes. This process permitted an investigation of the transformation occurring in the territorial organization of the municipalities in the Presidente Dutra Axis (Sub-region 2 - Dutra A). The axial mapping indicated a strong integration (colored in red) along the margins of the Presidente Dutra Highway, mainly in the municipality of Taubaté in 1977 and the municipality of São José dos Campos in 2015.

Another analysis extracted from the axial mapping and the urban roads integration index refers to the ramifications of the highways and their respective distances from the Presidente Dutra Highway. Both to the north and south, the low integration index (colored blue) found in municipalities on the Axis suggests the occupation of lands increasingly discontinuous (dispersed) and distant from the Presidente Dutra Highway. The use of the integration index enabled the identification of the urban dynamics of territorial occupation, progressively characterized by urban discontinuities or dispersions (REIS FILHO, 2006), typical of the economic and social transformations evidenced in the current stage of the capitalist economy.

In the 1970s, the Presidente Dutra Highway was an important vector for the deconcentration process of industrial activities from the Greater São Paulo (LENCIONI, 1998). At present, the urban and regional planning of the Paraíba Paulista Valley – exemplified by the Regional Plan of the Paulista Macro-Axis, demonstrates through a diagnosis of physical, economic and demographic conditions, a preoccupation aimed at softening the negative impacts of the fast movement of industrial reallocation and the intensification of urbanization process. In the decade of 2010, the organization model of regional space, based on development vectors (TAVARES, 2017) has been taken up again in the regional planning of the State of São Paulo through the PAM (EMPLASA, 2014) and, particularly, by the planning proposal for the Vale do Paraíba Development Vector. In this document, the concept of the Development Axis is emphasized by the productive dynamics and urban characteristic of the current stage of the capitalist economy and the conformation or reinforcement of new centralities.

To conclude, the results obtained in this study are a good sample of the temporal growth of the RMVPLN, especially in the urban areas of the municipalities of the Presidente Dutra Axis (Sub-region 2 - Dutra A), aiding in the comprehension of the orientation of the Presidente Dutra Highway in the organization process of urban-regional space, which at present is characterized by the presence of discontinuous and dispersed forms of urban occupation.

NOTES

1 The axial mapping and the IIG generated in this study was manipulated on DephtMap software. When exported to the GIS, some standardizations were made, such as the reclassification of the integration index's classes from 10 to 5 and the variation of the colors in the key (blue, green, yellow, orange and red).

2 In the view of Santos (2003, p.126), the principle of spatial selectivity “manifests both in the economic and the social plan, [and] hold the key of the elaboration of a spatial theory”. The principle of spatial selectivity is better described by the convergence of relationships and the interests of agents and actors materialized in the territory, in other words, in a point in space, in a spatial location.

3 Still according Lencioni (1998, p.34) the eastern point of the Paulista capital, towards Rio de Janeiro State, the Presidente Dutra road axis, already has the Centro Tecnológico da Aeronáutica, which concentrates the country's most important aeronautics, electronics and mechanical engineering center. This is where Embraer, an aircraft-producing industry, an important oil refinery and auto industries, such as General Motors, Detroit Diesel, Ford engine plant and Volkswagen are located. Also, since the late 1970s, foreign companies have sought to settle in the region, such as Takai, Kopper, Blindex, Nestlé, Mannesman, Monsanto, Kodak, National, and Hitachi.

4 Physical-environmental conditions (geomorphological and hydrological) in the Paraíba Paulista Valley municipalities acted as limiters of urban growth. In Jacareí municipality the plains of the Paraíba do Sul River help explain the formation of the city center parallel to the Dutra Highway. This fact indicates the existence of large empty areas – some being floodplains of the Paraíba do Sul River – between the city center of the urbanized area and the Presidente Dutra Highway.

5 In the case of Pindamonhangaba municipality, the historic urban center was selectively located on the banks of the Paraíba do Sul River, thus, this urban area grew parallel to the Presidente Dutra Highway

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