Assessing Urban Environmental Justice in two subprefectures of São Paulo, Brazil – a GIS-based synoptic analysis

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Berlin, 31st January, 2014
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I hereby certify that I am the sole author of this master thesis. Furthermore, I confirm that no sources have been used in the preparation of this thesis other than those indicated in the thesis itself. The works of other people included in my thesis, published or otherwise, are fully acknowledged in accordance with the standard referencing practices.

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ABSTRACT

Cities host the greatest concentrations of people and economic activities that exert direct pressure on the occupied space and surrounding areas. Consequently this pressure have repercussions for the environment and urban life. Also, spatial segregation is a phenomenon present in Brazilian urban centres and contributes decisively to the permanence of social inequality patterns and where the pressure over the environment and social life lies.

The Environmental Justice concept relies on the fact that an individual’s environmental quality depends on their household income, affirming that communities with lower social status unduly bears the burden of environmentally detrimental practices, configuring a context of environmental injustice.

The present thesis contributes to the discussion of environmental justice through the application of a synoptic spatial analysis method. This is achieved by understanding the state of the environment of an heterogeneous area within the São Paulo metropolis. The area chosen within the municipality of São Paulo comprises the subprefectures of Santo Amaro and Cidade Ademar, an emblematic region from the socioeconomic and the environmental perspectives. Both subprefectures are located in the transition between the valued urban centre (Santo Amaro) and the deprived urban periphery (Cidade Ademar).

The techniques and methods used for constructing the Urban Environmental Quality and Environmental Justice indices demonstrated a starkly synthesis potential of the socio-environmental context in the study area. Numerous results have been collected and all corroborate with the hypothesis supporting the relationship between low social status and the exposure to contemporary environmental stressors.

The produced outcomes are significant subsidies to assess and develop public policies, especially in a heterogeneous fraction of the urban space. It is thereby impossible to reject the relevance of Environmental Justice as a subject to be considered for future research in the field of urban management. GIS and other geoinformation technologies are a vital support for the synoptic analysis in comprehensive scale, depicting with precision the socio-spatial allocation of environmental pressures.
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To Jessie Wu. For the dedicated effort in trying to bring me to a native writing.

Ao colega Bruno por compartilhar seu sentimento dual com a cidade de São Paulo: “a mais generosa, e uma das tantas mais miseráveis” (Cruz, 2013: p. 164)

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**List of Abbreviations**

<table>
<thead>
<tr>
<th>Abbreviation</th>
<th>Description</th>
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<tbody>
<tr>
<td>Cades</td>
<td>Portuguese: Conselho Municipal do Meio Ambiente e Desenvolvimento Sustentável; Permanent Municipal Council of the Environment and Sustainable Development</td>
</tr>
<tr>
<td>CEM</td>
<td>Portuguese: Centro de Estudos da Metrópole; Centre for Metropolitan Studies</td>
</tr>
<tr>
<td>CETESB</td>
<td>Portuguese: Companhia de Tecnologia de Saneamento Ambiental; Company of Environmental Sanitation Technology</td>
</tr>
<tr>
<td>EJ</td>
<td>Environmental Justice</td>
</tr>
<tr>
<td>EJ-I</td>
<td>Environmental Justice Index</td>
</tr>
<tr>
<td>EJM</td>
<td>Environmental Justice Movement</td>
</tr>
<tr>
<td>EMAE</td>
<td>Portuguese: Empresa Metropolitana de Águas e Energia S.A. Metropolitan Company of Water and Energy</td>
</tr>
<tr>
<td>FABHAT</td>
<td>Portuguese: Fundação Agência da Bacia Hidrográfica do Alto Tietê; Foundation Agency Upper Tietê River Basin</td>
</tr>
<tr>
<td>GCS</td>
<td>Geographic Coordinate System</td>
</tr>
<tr>
<td>GDP</td>
<td>Gross Domestic Product</td>
</tr>
<tr>
<td>GIS</td>
<td>Geographic Information System</td>
</tr>
<tr>
<td>IBGE</td>
<td>Portuguese: Instituto Brasileiro de Geografia e Estatística; Brazilian Institute of Geography and Statistics</td>
</tr>
<tr>
<td>Infraero</td>
<td>Portuguese: Empresa Brasileira de Infraestrutura Aeroportuária; Brazilian Airport Infrastructure Company</td>
</tr>
<tr>
<td>INPE</td>
<td>Portuguese: Instituto Nacional de Pesquisas Espaciais; National Institute for Space Research</td>
</tr>
<tr>
<td>IPEA</td>
<td>Portuguese: Instituto de Pesquisa Econômica Aplicada; Institute of Applied Economic Research</td>
</tr>
<tr>
<td>IPVS</td>
<td>Portuguese: Índice Paulista de Vulnerabilidade Social; São Paulo’s Social Vulnerability Index</td>
</tr>
<tr>
<td>ISA</td>
<td>Portuguese: Instituto Socioambiental; Social Environmental Institute</td>
</tr>
<tr>
<td>LEA</td>
<td>Living Environment Areas</td>
</tr>
<tr>
<td>LOR</td>
<td>German: Lebensweltlich orientierte Räume; Living Environment Areas</td>
</tr>
<tr>
<td>LST-I</td>
<td>Low-Surface Temperature Index</td>
</tr>
<tr>
<td>NGO</td>
<td>Non-Governmental Organization</td>
</tr>
</tbody>
</table>
PG-I - Public Green Index

PSS – Planning Support Systems

QTCC-I – Quality of Tree-Canopy Coverage Index;

SABESP – Portuguese: Companhia de Saneamento Básico do Estado de São Paulo. Sanitation Company of the State of Sao Paulo

SEMPLA – Portuguese: Secretaria Municipal do Planejamento, Orçamento e Gestão; Municipal Secretariat of Planning, Budget and Management

SIRGAS – Portuguese: Sistema de Referência Geocêntrico para as Américas; Geocentric Reference System for the Americas

SPMR – São Paulo Metropolitan Region

SVMA – Portuguese: Secretaria do Verde e Meio Ambiente; Municipal Secretariat of Green and Environment

TP-I – Trees Provision Index

UCLA – University of California, Los Angeles

UEQ-I - Urban Environmental Quality Index

UHI – Urban Heat Island

UMID – German: Umwelt und Mensch – Informationsdienst. Environment And Human Health – Information Service

UNEP – United Nations Environmental Programme

UNICEF – United Nations International Children's Emergency Fund

USCCR – United States Commission on Civil Rights

UTM - Universal Transverse Mercator

WGS – World Geodetic System

W-I – Waste Index

WRI – World Resources Institute

WS-I - Water and Sanitation Index
1 INTRODUCTION

1.1 Initial considerations: context and concepts

Brazil has become one of the protagonists of the process of globalization, not only in the regional context but also exerting a strong influence on a global scale. Not just in Brazil, the globalization brought to many the benefits from economic restructuring and the new technologies, “but it is also clear that this developments have magnified many existing inequalities in contemporary societies, such as between rich and poor, men and women, and between racial and ethnic groups.” (Soja, 2010: p.7)

It is in the global scale that this process produces groups of winners and of losers, which are a manifestation of the gaps occurring below supranational level through the exacerbation of regional and consequently intercity and intra-urban disparities fostering the uneven development described by Michael Pacione:

“A systematic process of economic and social development that is uneven in space and time, which is integral to capitalist development process, as capitalists search for the point of maximum profit. Uneven development is evident in all geographic scales” (Pacione, 2009: p.684).

When looking at the scale of urban space, the uneven development highlights situations of spatial segregation and therefore social vulnerability to certain social groups. According to Katzman (1999 apud Fundação Seade, 2013: p.8) the vulnerability of an individual, family or social group refers to a greater or lesser ability to control the forces that affect their well-being, e.g. the control over assets that are required resources for the opportunities offered by the State, market and society.

An important feature of urban and metropolitan poverty consists in the spatial segregation as strong determinant of the very vulnerability condition. Spatial segregation is a phenomenon present in Brazilian urban centres and contributes decisively to the permanence of social inequality patterns (Fundação Seade, 2013).

84.4 % of the 190 million Brazilian inhabitants live in cities (IBGE, 2011), making Brazil to one of the most urbanized countries in the world. Thus, the most relevant environmental issues are now part of everyday urban life. Cities host the greatest concentrations of people and economic activities that exert direct pressure on the occupied space, as well as on the surrounding areas and consequently have repercussions for the urban life. The environmental debate should therefore prioritize the city realm focusing on depicting the differentiated appropriation of the socio-environmental burdens and amenities.

Precisely the concept of environmental justice deals with this matter and it is at the core of the discussion to be promoted with the cartographic product proposed. Understanding and assessing what are the limits and the usefulness of the concept is therefore essential for the development of the proposed methodology and to conduct the debate when presenting the results.
1.1.1 Urban socio-environmental matters and the differentiated appropriation of its amenities and burdens

The role acquired by the environmental issues throughout the twentieth century became the central point of several discussions that permeate all aspects of society, including the urban environment. A new standard presents itself to the shape of human development in all fields of production, making society and environment inseparable concepts.

To pour over into the studies of the city means initially facing the established social-environmental conflict to then address the environmental and social impacts by understanding them as closely related, as two sides of the same coin (Monteiro, 1980). The notion of environment as something picturesque, contemplative, confined in a bubble, is expired. It is essential to understand it as something necessary to establish environmental justice in large urban centres.

In order to evolve in the discussion of environmental justice it is necessary to conduct a review of the scenario that fostered the need for its claims to therefore comprehend how the concept can be better viewed and utilized.

Throughout the twentieth century a biological perspective of the world has become increasingly popular. What is characteristic of this way of looking at the world is that humans and their spiritual, social and intellectual dimensions were not part of the environmental reasoning (Groening, 2004).

It is not surprising within this logic, to realize representations of a city that is said ecological while almost completely neglects the human relationships and achievement in a city. The importance of considering the social, political and economic dimensions of human civilization should be clear to all who believe in bringing an improvement to the evidenced situation (Groening, 2004).

Therefore, it is essential to avoid the conceptual danger that serves to support the vision of nature as something pre-established and man as foreign agent thereon. “Urban environmental problems concern both the construction processes of the city” and therefore the different economical and political options that influence the space configuration, “as the conditions of urban life and the cultural aspects that reflects on the lifestyles and interclass relationships” (Grostein, 2001: p. 15). This entails that the urban socioenvironmental conditions are a direct result of the urbanization process. Decisions and the lifestyle of social groups exert influence on the diffuse and collective dimension of nature, appropriating amenities and benefits it produces and confining the problems caused to socially vulnerable populations.

The generality of the urbanization process is described by Singer (1980, p.79) where the jurist stated that the 'production' of urban space is given in general by incorporating to the town of plots that previously had agricultural use. To the extent that when there is increased demand for land, the agents of urban space production promote the aggregation of new land to the city, expanding the urban area. Lefebvre (1976, 1991)
understands the urban life as original mediations between the city, the countryside and nature. With the development of capitalism, the resulting urban sprawl reduces nature to the condition of rarity, especially in the urban territory. Elements before abundant become rare: potable water, healthy air and green space.

The scarcity of natural elements paradoxically fuelled its appropriation as a commodity, a concept arising from the very condition of rarity. At present, the idealization of nature is an important market value allowing the emergence of nature as a product, not just as natural products but as commodities, either as material goods (portions of natural areas), whether as symbolic goods. Today there is a market that feeds from the idea of nature and the need for its protection (Moraes, 2004).

One dimension of the commodification of nature is seen when portions of urban space reserved for natural properties appear as simulacra of nature. They are a way to feed the growing symbolic value attributed to nature constituting the "parks, gardens and captive waters" (Lefebvre, 1991, p.68) posing as parallels to urban environments.

In urban areas, the location factor is a major aspect of real estate valuation (Singer, 1980). The provision and the presence of natural assets in specific areas become crucial for the appreciation of property prices and consequently for the appropriation of the new rareness promoted by those who can pay for the diffuse services of natural amenities. “The most plausible consequence is the increasing social differentiation in the process of appropriation of urban space in the face of disputes over natural amenities” (Barbosa and Costa, 2012).

Clarke and Wilson (1994) emphasize that the modern economies, while permitting access to better conditions and quality of services, produce widespread disparities in individuals’ or households’ access to services across cities and regions. This duality in turns leads to distinctive spatial variations including housing quality, the conditions of the environment and access to goods and services (both public and private). Further in this notion, Carlos (1999) suggests that the spatial reproduction occurs from the social reproduction and the dual process produces new contradictions. In this sense the current spatial reproduction is based on the contradiction between social or collective production and its private appropriation.

Thus the more scant and demanded a good is, the higher exchange value it will get and more socially differentiated its appropriation will be, thus accelerating and intensifying its private appropriation. This notion is consistent with the idea of increasing the urban land value by having the scarcity of nature as one of the vectors of that gain. "In the moment that the nature usufruct happens to be mediated by the market, the more the social spatial contradictions tend to enhance." (Barbosa and Costa, 2012, p.485)

Further on the notion of dual space, Grostein (2001: p.14) emphasizes its expression on the poverty concentration in Brazilian metropolises: “on the one hand, the formal city, concentrating public investment and on the other, its absolute counterpoint, the informal city relegated from the equivalent benefits, which grows exponentially in urban illegality that it constitutes”. The precariousness and illegality are its genetic components and contribute to the formation of “urban spaces with no attributes of urbanity”, exacerbating socio-environmental differences.
In this context, the main result of Brazilian urbanization has been the socio-territorial segmentation. This leads to the proliferation of fragmented cities where the strength of the process of speculation, fomented by the dominant actors of the market and the State action, led the vast majority of poor groups to live in precarious housing conditions deprived of urban and community equipment (Fernandes, 2004).

Not only, the deterioration of environmental quality in Brazilian cities, which manifests unevenly across the territory, is also in the heart of the dominant system of motor car transport and industrial production, sources of atmospheric pollution and high demand for resources. This is the "result of a logic that causes the wealth accumulation to be realized based on the environmental penalty of the dispossessed" (Acselrad, 2010; p.110).

1.1.2 Environmental Justice: the possibilities and constrains of the concept

The environmental justice concept relies on the fact that an individual’s environmental quality depends on their household income, (Harvey, 1996; McGranaha et al., 1996; Pugh, 1996; Marcuse, 1998; Rodriguez, 1998; WRI, 2002; UNICEF, 2005; Davis, 2006; UNEP, 2007; Smith, 2008). Severe air pollution, shortage of access to drinking water, deprived water quality, and scarce sanitation are concerns which in particular trouble impoverished countries (Diekmann and Meyer, 2011). This multiple environmental harms may have cumulative effects on health (Stephens, 2007).

In Brazil, the landmark of the environmental justice concept emergence and the movements that engaged to it was the United Nations Conference held in Rio de Janeiro in 1992. The conference made the opening of the Brazilian Forum of Non-Governmental Organizations - NGOs - and Social Movements for the Environment and Development possible. This became precedent in conjunction to build common agendas between environmental groups and union activism. The platform met demands of the landless movement, the population affected by dams, community movements in the peripheries of cities, rubber tappers, extractives and forest people, and the indigenous population movement. These fall, of course, in the group of more combative activists than professionals, which are more involved in critical discussion of public policy than technical advice to governments and businesses (Acselrad, 2010).

In the United States, where Environmental Justice is broadly used and where the term was developed, it was during the late 1970s and early 1980s that many low-income communities and communities of colour across the country, including African Americans, Asian Americans, Latinos and Native Americans, concluded that unequal social, economic, and political power relationships made them more vulnerable to health and environmental threats than the society at large (USCCR, 2003: p.14).

It was in Texas in 1979 that the first environmental justice case was brought to court. Residents of Northwood Manor in East Houston, Texas, “alleged that the decision to place a garbage dump in their neighbourhood was racially motivated in violation of their civil rights under § 1983 of the Civil Rights Act.2. The district court in Bean v. Southwestern
Waste Management Corporation found that the placement of the dump would irreparably harm the community.” (USCCR, 2003: p. 13)

The creation of the Environmental Justice Movement (EJM) had deep roots in the Civil Rights Movement in the United States. Through this movement, the terms ‘environmental justice’ and ‘environmental racism’ refer to the conviction that “poor and minority communities shoulder an unfair portion of environmental burdens and that the law should seek to rectify this imbalance”. More particularly, ‘environmental racism’ refers to the belief that environmental and public health perils faced by minority communities are the “result of discriminatory public policies, while ‘environmental justice’ refers to efforts to reallocate the risks more equitably.” (Steinberg et al., 2000 apud Braceras et al., 2003: p.181) Consequently the concept has an intrinsic relationship with the roots of social justice, a “normative concept concerned with the equitable allocation of society’s benefits and burdens” (Pacione, 2009: p.365).

Corroborating with this perception, Soja (2010: p.52), who approximates the term to the notions of spatial justice, affirms that the EJM was fundamentally centred on racial issues and it began as an attack on what was called environmental racism, which is defined as “the tendency for poor and minority populations, especially African Americans, to suffer disproportionately from air and water pollution and the sitting of hazardous or toxic facilities.”

The EJM had close connections to University of California, Los Angeles (UCLA) Urban Planning and was responsible for an increased awareness to locality and neighbourhood community, thus having “important roles in the emergence of new and expanded labour-community coalitions in the 1980’s.” (op. cit.: p.135)

Within this context, to promote environmental justice is to endorse the “fair treatment of people of all races, income, and cultures with respect to the development, implementation and enforcement of environmental laws, regulations, and policies, and their meaningful involvement in the decision-making processes of the government.” (Todd et al., 2001 apud USCCR, 2003)

Soja (2010), in his manifest for spatial justice, made a fine analysis on the origins and development of the concept and its associated social movements. He states that, although there is a vast bibliography on environmental inequalities and the EJM, the strong focus on racial issues has made the term move away from the quest for spatial justice. The consequence was the adoption of very few references on a critical spatial perspective on the environment, contributing less to the debate of the ‘Geography of unequal spatial advantage.’

Regarding the appropriation of the EJM struggle by more liberal environmentalism the author assert the following:

“Rather than an explicitly spatial perspective, many forms of passionate environmentalism tend to emphasize physical or natural casualty. Leading to such overly idealized notions as the sanctity of Mother Earth and to activism that focuses on narrowly defined targets and highly localized and unique cases of discriminatory environmental impacts.” (op. cit.: p.53)
For him (op. cit, p.53), “the alternatively radical and romantic environmentalism that often drives the EJM markedly contrasts with the critical spatial perspective that is behind the struggle to create more just geographies”. In his seek for spatial justice, Soja believes that in the concept coined for environmental justice, the influential force is displaced from the spatial to the environmental. This notion deflects the search for a deeper understanding of the consequential spatiality of justice and limit a potential for generating new ideas and innovative strategies of application. He ponders although that the movement contributes in a manner to the concept of spatial justice, e.g. by “adding locational bias to the concept of civil rights including racial, class and gender discrimination” (op. cit.: p.52).

The Marxist geographer David Harvey made even more provocative critiques of concepts related to environmental justice. Regarding the movements that embrace the green flag, he affirms that “The long-standing hostility of what now passes in the public eye for the environmental movement to the very existence of cities has created a blind spot of startling proportions” (Harvey, 1996: p. 391), and he argues cogently in fostering the integration of urban issues into the environmental justice agenda to avoid the fragmenting effect on larger class and labor struggles. To this narrow-mindedness process he refers as ‘Militant Localism’ and claims for the necessity of conjoining the particularisms to overcome the disaggregation over social justice. For him this is the most glaring objective in order to understand the circulation and accumulation of capital as the dictating process of environmental transformations.

Nevertheless, he agrees that environmental justice proponents - as well as political ecologists, ecosocialists and ecofeminists - have made cogent critiques of liberal environmentalism, seeing a possibility of reconciliation with a more contributive environmentalism with dialectical practices towards social justice. This can only be achieved by positing the transformative actions of humans as ecological processes, and with keeping social relations and their justness primary within its realm of concern (op. cit.).

“If the current rhetoric about handing on a decent living environment to future generations is to have even one iota of meaning, we owe it to subsequent generations to invest now in a collective and very public search for some way to understand the possibilities of achieving a just and ecologically sensitive urbanization process under contemporary conditions” (Harvey, 1996: p. 438).

In the author’s analysis, the environmental justice movements must tackle the currents of modernization theories, a notion that designates the process by which political institutions internalize environmental concerns in order to reconcile economic growth with the resolution of environmental problems, emphasizing on the technological adaptation, on the celebration of the market economy, and on the belief in collaboration and consensus (Blowers, 1997 apud Acselrad, 2010). In more geopolitical terms, this means “a view of the Third World development as a convergent and evolutionary process” in which dissemination of economic and cultural innovation from the West would trickle down and permit less developed societies to move “towards the kind of advanced economic, social and political structures that prevailed in North America and Western Europe.” (Pacione, 2009: p.680)
This modernization indicates a displacement of a contestation project by technical-scientific activities associated with consensualist speech, apology of public-private partnership, the delegitimization of the national level in favour of the local sphere, and the favouring of piecemeal actions instead of the political articulated action coherence, all advocated as a common purpose by multilateral organizations, governments and polluters (Acselrad, 2010).

The process results in the neutralization of socio-environmental struggles, an effort that generated a "rootless environmentalism" (Arnt & Schwartzman, 1992; p.125 apud Acselrad, 2010; p.106) devoid of ties with social movements.

To radicalize this entails what Harvey depicts as the ‘rational ordering’ of activities at different scales. This means that the range of environmental and social justice struggles will have to recoup a “noncoopted and nonperverted version of the theses of ecological modernization” (Harvey, 1996.: pp.400–401).

He claims that for this to arise, the role of the environmental justice movement is to confront “the fundamental underlying processes (and their associated power structures, social relations, institutional configurations, discourses, and belief systems) that generate environmental social justices” (op. cit.: p. 401).

Harvey’s assertive, however generalist position, finds more sense in the purpose imagined by Soja. The concept may come close to a substantial contribution if there is a pursuit for a convergence between two versions of the quintessential struggles over geography: for spatial justice and for democratic rights to urbanized space. Therefore reviving the ‘right to the city’ idea in global, national, regional, and urban social movements (Soja, 2010).

Moreover, the origins of specifically environmental justice local struggles and the right to the city are embraced by global movements for planetary sustainability and universal human rights. With this belief, Soja verifies that local movements can benefit significantly from a “greater awareness of the interactive and multiscalar geographies of place-based discrimination that shape environmental justice” and then he illuminates the most important contribution of the concept to the present work. “Environmental justice must be best considered and conceptualized as a subfield of spatial justice focusing on geographical discrimination with regard to negative environmental impacts.” (op. cit.: p.53)

As the public becomes more conscious of the environmental justice concerns, pressuring policies to shifts in this direction, the part of the academia leaning on this topic has to produce the methodology necessary to measure the distribution of environmental harms and environmental responsibilities. Likewise, the experts need to develop new methods to deal with the challenges of answering more imperative but complex questions: e.g., “How do we measure the distribution of multiple or cumulative impacts on poorer groups? How do we quantify the responsibility of richer citizens in the world for the environmental harms distributed unequally to the poorer citizens?” (Stephens, 2007: p.2)

Environmental justice in a city can only be dealt with when it is considered as a multi-dimensional topic because it requires an integrated analysis and representation of
Assessing Urban Environmental Justice in Santo Amaro and Cidade Ademar subprefectures, São Paulo, Brazil


First and foremost, there is a substantial need for a systematization and a regular conduct of studies on the social and spatial distribution of environmental pressures and benefits. “Geographical Information Systems (GIS) offer a good basis for establishing spatial references.” (Bunge; Hornberg and Pauli, 2011: p.9)

1.2 Inspiring sources

A plain search for GIS related projects regarding urban environment and environmental justice results in a plethora of available sources all over the world. The present topic gives an overview of five relevant references selected for the study, referenced herein (Table 1-1).

Table 1-1 - Reference Works.

<table>
<thead>
<tr>
<th>Author</th>
<th>Title</th>
<th>Year</th>
<th>Comment</th>
</tr>
</thead>
<tbody>
<tr>
<td>SVMA et al.</td>
<td>GEO Cidade de São Paulo</td>
<td>2004</td>
<td>Model based on the UNEP Methodology that is already on its 3rd version (UNEP and Parceria 21, 2009)</td>
</tr>
<tr>
<td>Bunge and Gebuhr</td>
<td>Environmental justice in the State of Berlin</td>
<td>2011</td>
<td>A pilot project from UMID (Umwelt und Mensch – Informationsdienst). Example of a GIS-based methodology that explicitly deals with the subject of environmental justice;</td>
</tr>
<tr>
<td>Johnson, and Kirk</td>
<td>Mapping of Environmental Justice Census Characteristics</td>
<td>2004</td>
<td>Produced by the state of Oregon, United Sates of America</td>
</tr>
<tr>
<td>Grineski et al.</td>
<td>Criteria Air Pollution and Marginalized Populations: Environmental Inequity in Metropolitan Phoenix, Arizona</td>
<td>2007</td>
<td>Study produced in the state of Arizona, United Sates of America</td>
</tr>
<tr>
<td>Fiocruz and Fase</td>
<td>Map of conflicts involving environmental injustice and Health in Brazil</td>
<td>2013</td>
<td>Result of a project jointly developed by Fiocruz and Fase, with the support of the Department of Environmental Health and Occupational Health, Brazilian Ministry of Health</td>
</tr>
</tbody>
</table>

The cited works are key landmarks guiding the methodological development intended, and have been selected by the scope and relevance of the techniques. However they are not the only ones that serve as reference for the preparation of the GIS data methods utilized. These are best analyzed in Chapter 3.
1.2.1 GEO Cidade de São Paulo

The City of São Paulo has been developing the project "São Paulo’s Environmental Indicators" since 2003. The project entails the creation of an environmental indicator system to assess the state of the environment of the metropolis, the impacts of environmental degradation on human health, quality of life and public finance, as well as evaluating the effectiveness of public policies and the responses of civil society in addressing environmental issues. The São Paulo GEO Cities Report (GEO Cidade de São Paulo) was originally released in 2004 and, although not specifically a GIS-focused publication, is coupled with the São Paulo Environmental Atlas (SVMA and SEMPLA, 2013), released in 2002. With this contribution, the ‘GEO Cidade de São Paulo’ is so far the only printing that provides the overview on the state of São Paulo’s environment, summarizing the results of the city’s environmental assessment process made during 2003 and early 2004. (SVMA et al., 2004)

The report was conceived under the UNEP’s – United Nations Environment Programme - Geo Cities methodology, which is already on its third version (UNEP and Parceria 21, 2009). It was first formulated in 2003 with the partnerships of Brazilian NGOs working especially with urban environmental issues, with a specific focus on the Latin American and Caribbean context.

Through the systematic use of environmental indicators, the ‘GEO Cidade de São Paulo’ model lays the foundation for the technical development of the ongoing environmental assessment process of the municipal territory, yet the adoption and subsequent institutionalization of this model in the local administration are still awaiting for the approval of the Permanent Municipal Council of the Environment and Sustainable Development (Cades). (SVMA, 2013)

In the meantime, through the responsible municipal agencies, the city of São Paulo sporadically releases some urban environmental indicators, such as charts, thus providing useful public access to data, information and knowledge of relevant environmental management of the city. This information will comprise the cross-analysis to be presented in Chapter 2, as well as data inputs relevant to the composition of the thematic maps.

1.2.2 Pilot Project: Environmental Justice in the State of Berlin

The discussion on this method is conducted with the information provided in the last report of the pilot project Environmental Justice in the State of Berlin. The report, edited by Bunge and Gebuhr (2011), presents the results of the project for the whole State of Berlin through articles from the specialists involved and also provides a debate on strategies for more environmental justice including fields of action for research, policies and practice.

Being a publication of the German Action Program for Environment and Health, the UMID reports have their bias coupled with policies and government actions in public health. In this sense, the pilot project pursues a new methodological model for integrated
reporting on environment, health, social issues and urban planning (Bunge and Gebuhr, 2011).

The four major topics were noise, air quality, bioclimate and green space provision. These topics were considered particularly relevant within the high population density in the city centre of Berlin and in relation to environmental health and climate change perspectives (Klimeczek, 2011).

With the objective of creating a socio-spatial environmental impact investigation as a subsidy for interdepartmental approaches at the interface of the health related areas of urban development, urban architecture and environment, the Pilot Project provided an initial assessment as well as important information and arguments in advance of decisions, and detailed planning procedures. The product can be configured as a new socio-spatially based management tool which becomes predominantly “relevant in the development of strategic concepts in realistic scenarios – in terms of modelling possible developments for differently stressed areas of the city.” (Hoff, 2011: p. 46)

### 1.2.3 Mapping of Environmental Justice Census Characteristics, Oregon, United States

In compliance with the regulations established by the U.S. Environmental Protection Agency on environmental justice, many entities utilizing United States’ federal funds were responsible for integrating environmental justice into its programs and planning activities. The Oregon Department of Transportation developed the ‘Mapping of Environmental Justice Census Characteristics’. “The objective of this project was to assemble a Geographic Information System (GIS) database which identifies census tracts and block groups state wide where low-income and minority populations reside” (Johnson, and Kirk, 2004: p. i). In addition to minority and low-income groups, the project used the census database to include the elderly, linguistically isolated, people dependent on public transportation, and people with go-outside-the-home disabilities.

The mapping of the concentrations of population with the mentioned characteristics was carried in census tracts level in order to obtain a useful screening tool for transportation planners and project managers to determine where environmental justice issues may have to be addressed and consequently supporting the Department of Transit to more effectively fulfil its responsibilities to the citizens. The project claims that the identification of such communities is vital for enhancing the public involvement process and thus avoiding disproportionately high and adverse impacts of transportation projects and programs.

According to Johnson and Kirk (2004), the census tracts level do not provide the desired resolution for a project assessment in the case of rural areas, which led the project to combine block groups information in areas of less density. In the context of urban areas, this level of analysis is sufficient due to the fact that a census tract can be as small as a block and therefore carry satisfactory information in a compact area.
The result is a set of GIS layers, provided in shape file format, that can generate tens of maps according to the desired need in the composition of cartographic information regarding environmental justice.

1.2.4 Criteria Air Pollution and Marginalized Populations:

Environmental Inequity in Metropolitan Phoenix, Arizona

The modelling of the dispersion and concentration of air pollution offers researchers on environmental justice a robust data source for representing chronic environmental hazards. The work developed by Grineski et al. (2007) proposed to examine spatial relationships between modelled criteria air pollutants (i.e., nitrous oxides, carbon monoxide, and ozone) and sociodemographics in metropolitan Phoenix, Arizona.

The researchers adopted multiple regression equations to forecast criteria pollution levels using sociodemographic variables at the Census block group level.

The researchers’ findings demonstrated “clear social-class and ethnic-based environmental injustices in the distribution of air pollution”. Even though all the production of air pollutants is a diffuse source of environmental hazard, lower-income and ethnic-minorities are disproportionately exposed in metropolitan Phoenix. The researchers defend the thesis that white privilege population in the historical and contemporary development of industrial and transportation corridors in Phoenix were given preference in relation to racially segregated neighbourhoods (Grineski et al., 2007)

1.2.5 Map of conflicts involving environmental injustice and Health in Brazil

As stated by Fiocruz and Fase (2013), the major objective of the initiative is, from an initial mapping, to support the struggle of many people and groups affected in their territories by projects and policies based on a vision of development considered unsustainable and detrimental to health for these populations. The map seeks to systematize and socialize information available, giving visibility to complaints by communities and partner organizations. The cases were selected based on their environmental and health relevance, reliability and consistency of the information presented. The aim is to contribute to the monitoring of actions and projects that address situations of environmental injustice and health problems in different territories including urban, rural, forest and coastal zone populations.

This is a vast cartographic compilation developed by independent research groups fully released online and updated frequently. It presents 300 conflict cases all over Brazil that were raised based on the situations of environmental injustice discussed in different forums and networks, in particular the Brazilian Environmental Justice Network,
from the beginning of 2006. It consist mainly of documents made publicly available by entities and several partner institutions: technical reports, academic articles and materials in law actions undertaken by the public prosecutors that present demands and problems related to the population.

The interactive information offers an initial record with municipalities and affected population, environmental risks and impacts, as well as related health problems. Clicking on the complete record of the conflict leads to more detailed information, including affected populations, damages caused, a synthesis of the conflict and the sources of information used.

1.3 Objectives

The thesis contributes to the discussion of environmental justice through the application of a synoptic spatial analysis method. This is achieved by understanding the state of the environment in urban settlements, with a focus on São Paulo’s context, by depicting environmental aspects of a heterogeneous area within the metropolis.

It is plainly justifiable when one looks to the need of improving towards urban indexes capable of better describing intra-urban relations in a more complete form. In this sense, the relevance of the present research is on the contribution to the discussions concerning the gains provided by GIS in the current assess of environmental justice.

The main objectives of this research are sustained on a tripod of empirical, methodological, and theoretical purposes:

- **Empirical objective:** Understood as primary purpose of the research, this objective intends to verify if there is a pattern in the distribution of social and environmental characteristics and on the distribution of urban amenities of the study area, enabling a better understanding of the conditions of environmental justice. The empirical purpose is performed on the simulation of the created index.

As a result of the work the effort is converted into a range of products to contribute to the objectives of the research.

The most primary result is the cartographic production of environmental indexes for different indicators, which together result in a synoptic map, evidencing where social and environmental pressure areas lie and where the need for action is mostly high. Secondary outcomes will be obtained from field surveys and primary and secondary data collection, which together can substantiate the arguments presented in order to provide information to public authorities and institutions working in the areas of environment and health, as well as for urban professionals and interested members of the public.
Two secondary objectives derived from the primary purpose:

- **Methodological objective:** with the purpose of providing the simulation ballast, it is crucial to explore the methodological options available by analyzing and synthesizing them. As a result it will be to compose an experimental index that comprises an integrated analysis of urban environmental justice. The index should be able to respond the heterogeneity and complexity of the spatial distribution of the variables by assessing social and environmental indicators in a comparative way. It should also be sufficient to permit joint consideration of their feasibility, applicability, possibilities and constraints.

- **Theoretical objective:** secondarily it is proposed to undertake a discussion regarding social and environmental impacts in an urban context integrated with the considerations on the subject of environmental justice. The discussion presents itself as a support to the understanding of socio-spatial disparities. This will enable sufficient grounding for the construction of the index.

### 1.4 Hypotheses and Research questions

The persistence of social inequalities is a strong indicator of the need for new methodological proposals and policies to reverse this process. “The production of socioeconomic indicators that consider the territory and its different realities is crucial to assist the planning and targeting of public policies” (Genovez et al., 2007: p.64). The territory here is understood as a spatial cut-out for the capture and representation of quantitative data.

As argued previously, there are important theorists who point to a clear relationship between low social status with the exposure to contemporary environmental impacts. One hypothesis supported by the current research is that if the method proves to be applicable, with the set of maps provided, it will be possible to demonstrate this relationship in detailed spatial scale and thus by assessing environmental justice for the study area.

GIS-based mapping is widely considered a vital support for decision makers. A synoptic analysis in comprehensive scale and the depiction of the socio-spatial allocation of environmental pressures can strengthen this notion: It subsidizes the assessment and the development of public policies, especially in a heterogeneous fraction of the urban space; it provides an imperative starting point for the implementation of social and environmental policies as well as urban design measures (Bunge et al., 2011); and it offers a better understanding of the role of the knowledge agents and spatial configuration of the dynamic in intra-urban areas, posing as essential for resource allocation and the location of public services and equipment (Gheno, 2009).

Using indicators and indexes that take the city as a whole, especially when assessing quality of life, can lead to the pasteurization of the wellbeing by preventing the demonstration of intra-urban dynamics. Consequently, an indicator cannot be used singly to
understand what happens in a city or even a district, especially in a contrasting society such as the Brazilian, and in an urban environment where the social disparities are even more glaring.

It is believed that, to forward on this matter a good contribution can come from GIS techniques by creating a measurement that exposes disparities in space and, above all, within a certain area. With the introduction of the spatial distribution of the variables, one can envision the possibility of better utilizing the information that the indices can reveal. Such as the ones related to the environmental aspects of the urban context. When especially considering environmental aspects, its indicators when gathered in a synthesis map are able to simplify complex information about the state of the environment and human-environment relationships. More than producing measuring forms as spatialized contents, to have them available for a combined analysis can identify problem areas and reveal underlying trends for urban planning.

Having in mind the research objectives within a technical approach to spatial representation, some questions can be best structured in a more objective perspective.

1. Can urban environmental quality be measured within the study area? On what scale?
2. What are the methodological possibilities and techniques of developing an integrative index capable of measuring the distribution of multiple or cumulative impacts on poorer groups within the context of environmental justice?
3. What are the constrains of these techniques?
4. How can GIS better subsidize decision makers and contribute to the discussions regarding just and sustainable urban areas?
2 STUDY AREA

The city of São Paulo, capital of the most populous Brazilian state, is the epicentre of economic activity and consumption in Brazil. With 11.2 million inhabitants just at the municipality and almost 20 million for the whole São Paulo Metropolitan Region (SPMR), the area today represents 10% of the national population and just about 20% of the gross national product (IBGE, 2010).

The SPMR comprises 39 municipalities, many with hundreds of thousands of inhabitants, making it one of the largest conurbations in the world. It concentrates in its territory financial, trade and services activities, which are increasingly sophisticated and specialized. Its urban area spreads out in all directions notwithstanding the physiographic limitations. One will find nothing but urban landscape in 80 kilometres from west to east and 40 kilometres from north to south. The São Paulo municipality itself is divided in 31 subprefectures and 96 districts. The FIG.2-1 presents the Political division of São Paulo within the SPMR.

This chapter provides the location and description of the study area, as well as a concise historical-geographical analysis of the city of São Paulo, with emphasis on the region of interest to the research.
2.1 Study Area

The area chosen within the municipality of São Paulo comprises the subprefectures of Santo Amaro and Cidade Ademar, an emblematic region from the socioeconomic and the environmental perspectives representing the *mélange* of São Paulo’s heterogeneous urban structure.

Both subprefectures consist of five districts: Campo Belo, Santo Amaro and Campo Grande (Santo Amaro Subprefecture); Cidade Ademar and Pedreira (Cidade Ademar Subprefecture) (FIG.2-2).

The area is located at São Paulo’s Southern Zone, and borders two municipalities of the metropolitan region: Diadema and São Bernardo do Campo.
The FIG.2-2 above presents the study area with the respective districts. The thin grey lines represent the census tracts, normally determined by urban quartiers or by an enclosure of a relatively homogeneous area. For each of these census tracts it is possible to access a range of data collected in the last 2010 census. Those are the smallest possible fragments of feature analysis. The same area can be seen on satellite image below in FIG.2-3. Two of the main São Paulo’s watersheds are visible at the bottom of the image, together they comprise the Billings-Guarapiranga water reservoir complex.
The Table 2-1 below locates the geographical boundaries of the study area.

Table 2-1 – Geographical boundaries of the study area.

<table>
<thead>
<tr>
<th>Point</th>
<th>Coordinates</th>
<th>Description</th>
<th>District</th>
</tr>
</thead>
<tbody>
<tr>
<td>southernmost</td>
<td>331682 m E / 7374577 m S</td>
<td>Billings Reservoir</td>
<td>Pedreira</td>
</tr>
<tr>
<td>northernmost</td>
<td>328939 m E / 7388108 m S</td>
<td>Intersection between Santo Amaro and Bandeirantes Avenues</td>
<td>Campo Belo</td>
</tr>
<tr>
<td>westernmost</td>
<td>323915 m E / 7384036 m S</td>
<td>Pinheiros channel under the João Dias bridge</td>
<td>Santo Amaro</td>
</tr>
<tr>
<td>easternmost</td>
<td>335223 m E / 7376908 m S</td>
<td>Vegetation fragment near Rufino's road</td>
<td>Pedreira</td>
</tr>
</tbody>
</table>

2.1.1 **Sociodemographic characteristics**

The **Table 2-2** shows demographic data for districts of the study area.

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Santo Amaro</strong></td>
<td>Campo Belo</td>
<td>8.8</td>
<td>71.688</td>
<td>66.756</td>
<td>65.752</td>
<td>7.472</td>
</tr>
<tr>
<td></td>
<td>Campo Grande</td>
<td>13.1</td>
<td>87.272</td>
<td>91.298</td>
<td>100.713</td>
<td>7.688</td>
</tr>
<tr>
<td></td>
<td>Santo Amaro</td>
<td>15.6</td>
<td>67.044</td>
<td>60.673</td>
<td>71.560</td>
<td>4.587</td>
</tr>
<tr>
<td><strong>Cidade Ademar</strong></td>
<td>Cidade Ademar</td>
<td>12</td>
<td>238.214</td>
<td>243.297</td>
<td>266.681</td>
<td>22.223</td>
</tr>
<tr>
<td></td>
<td>Pedreira</td>
<td>18.7</td>
<td>107.047</td>
<td>126.989</td>
<td>144.317</td>
<td>7.717</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td></td>
<td>68.2</td>
<td>571.265</td>
<td>589.013</td>
<td>649.023</td>
<td>9.516</td>
</tr>
</tbody>
</table>

Source: IBGE Census, 2010 (IBGE, 2011)

The nearly 650,000 residents of the five boroughs are distributed fairly heterogeneously, where the districts have discrepant levels of population density.

The disparities between the districts do not cease in the population count. Both subprefectures are located in the transition between the valued urban centre (northern districts) and the deprived urban periphery (southern districts). A remarkable fact is shown with population growth between 1996 and 2010 that presents opposite tendencies when comparing the districts north of the study area, (Campo Belo, Santo Amaro), and the southern districts or peripherals (Campo Grande, Cidade Ademar and Pedreira). While the north districts presented declining populations, the southern districts evidenced significant increase in their residents. This fact reflects a recurrent process throughout the metropolitan area. In recent decades it became clear that a populace circumvention of the central districts, much of this contingent, was absorbed into the periphery.

Still, the supply of labour in any of the three economic sectors is massively located in the central districts (**FIG.2-4**), relying on the enhanced urban infrastructure for the better of carrying out economic activities. Due to the scarce supply of jobs, the outer districts perform the monofunctional role of dormitory areas despite hosting most of the economically active population of the metropolis.
According to the publication of the Secretariat of Planning, Budget and Management - SEMPLA, even with data for the year 2000, it is observed in the outskirts of the city the “frequent occurrence of areas where between 25% and 35% of young people aged 15 to 19 years old were not studying nor working” (SEMPLA, 2007: p.36). This situation of exclusion / marginalization characterizes youth, especially males, who abandon school and, given the difficulties imposed by the market, no longer look for work.

The phenomenon of unemployment focuses more strongly on the black population with an average rate of 18.3% in the period of 2005-2006 for this segment of the population than on the segment considered non-black, for which the average rate was 13.0% (SEMPLA, 2007). The data grouped by districts indicates that unemployment in the black population reaches the highest rates in the periphery areas that group the most distant districts of the economic centre of the municipality.

It is noteworthy that the proportion of blacks and mulatto in the peripheral districts is also higher. The map of FIG.2-5 illustrates with recent data this phenomenon for the study area.
The IBGE adopts in its Ethnic-Racial Population Characteristics Research five categories of origin/race: white, yellow, brown, black, indigenous. As the results are based on self-declared answers and are referenced to people with 15 years old or older, there’s also a sixth category: Other. The ‘black’ and ‘brown’ categories are summed to compose the above map. It is clear that, despite all five districts presenting ratings in all categories, in the districts of Cidade Ademar and Pedreira, census tracts with greater presence of black population are more frequent.

Regarding the scholarisation of persons aged over 15, measured by average years of study, data from 2000 indicates that in all districts of the city, the black / mulatto population has an average number of years of schooling below the segment classified as white / yellow. "While white / yellow segment has, on average, 8.71 years of schooling, black / brown segment has 6.45 years" (SEPLA, 2007: p.42).

Still according to SEPLA, for both contingents the years of study increase as one moves from outlying areas to the more central regions. This data corroborates with the maps produced for the study area in FIG.2-6 and 2-7 that respectively bring, levels of
illiteracy for the 2010 census for the population over 5 years of age and demand for places in pre-school education per district for the year 2006.

Inequalities are also expressed by means of average income data for employed residents in the municipality. For white/yellow population, average income calculated in 2000 was 3.94 times the minimum wage, while the black/brown segment accounted for only 1.61 minimum wage. The differences are accentuated when crossed with the data of gender, seen below in FIG.2-7.
Assessing Urban Environmental Justice in Santo Amaro and Cidade Ademar subprefectures, São Paulo, Brazil

FIG. 2-7 - Average income of employed residents, by sex and race, 2000. Source: Adapted from SEMPLA, 2007: p. 44.
The Table 2-3 provides an overall comparison between the districts of the study area for two distinct indicators: monthly income and illiteracy.

Table 2-3 – Income and Illiteracy data for the study area.

<table>
<thead>
<tr>
<th>Subprefecture</th>
<th>District</th>
<th>Average Monthly Income (R$)</th>
<th>Illiteracy (%)</th>
<th>Black Population (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Santo Amaro</td>
<td>Campo Belo</td>
<td>5276.75</td>
<td>1.40</td>
<td>1.35</td>
</tr>
<tr>
<td></td>
<td>Campo Grande</td>
<td>2979.68</td>
<td>1.38</td>
<td>1.22</td>
</tr>
<tr>
<td></td>
<td>Santo Amaro</td>
<td>5581.01</td>
<td>1.13</td>
<td>1.01</td>
</tr>
<tr>
<td>Cidade Ademar</td>
<td>Cidade Ademar</td>
<td>1010.53</td>
<td>1.84</td>
<td>1.41</td>
</tr>
<tr>
<td></td>
<td>Pedreira</td>
<td>865.64</td>
<td>2.45</td>
<td>1.72</td>
</tr>
</tbody>
</table>

Source: IBGE Census, 2010 (IBGE, 2011)

1 Value of the average monthly income of the persons responsible for permanent households (with and without income). R$ 1,000.00 = US$ 420.58
2 Population over 5 years old

Note that the illiteracy rates presented by the census research reflect the entire population over the age of five, however it is not uncommon that literacy is offered only after the age of seven and normally illiteracy rates are counted from the age of 15. Nonetheless, it is appalling how the above selected data, together with the indicators presented earlier, reflects the discrepancy between the districts and, mainly, the subprefectures.

This discrepancy is not only reproduced upon the selected data, but also over most of the indicators that comprise the population social status and their exposure to the socioeconomic impacts of urban space production. No wonder, precarious occupations and settlements pop up concentrated in certain areas of the city (FIG.2-8).
Moreover, the study area is a symbolic region for the production of urban geographies in recent decades. The entire region is prominent in the metropolitan context for the development of urban apparatus that is towering valorised areas. This process is fostered by the implementation of formal urban operations which are promoting the outburst of real estate. At the same time, this process exerted significant pressure to mobilize populations to outlying districts defined as watershed protection areas in many cases. This strong contradiction of the space production is precisely the main reason for electing the area.

2.1.2 Relevant sites

As one might expect, an area spanning five populous districts, marked by multiple historical processes, shows no uniform characteristics. The result is the occurrence of a motley with notable patches. Spotting those places rally round tells(?) the story of the development of the study area. Moreover, the localities identified and described below are
noteworthy for being generators or receivers of social and environmental impacts, which then place a further understanding on the underlying trends and state of the environment of the selected research area.

The MAP.2-1 ahead previously locate the relevant sites as well as the key toponyms that will be frequently raised in the course of this thesis.
MAP.2-1 – Relevant sites and key toponymies of the study area.

Legend
- Limits of the Study Area
- Water Bodies
- Relevant sites
- Cidade Ademar
- Santo Amaro
- Municipal limit

Source: FBHAT, 2009; IBGE, 2010
• **Congonhas-São Paulo Airport**

The Congonhas Airport, located in the Campo Belo district, is the second busiest Brazilian airport, behind only the São Paulo-Guarulhos International airport. It operates flights only within the national territory and hosts 16.8 million passengers per year (140% of usage, almost 5 million above capacity) (Infraero, 2013). It opened in 1936 the site was 10 kilometers from the city centre outside the built-up urban area at the time (Saconi, 2013). Soon, the former smooth treeless hill where the aerodrome laid became one of the busiest air traffic centres and a strong pole of attraction of the population growth axis.

Due to the São Paulo's sheer urban growth, which has completely surrounded and engulfed the airport with dense clusters of residential and commercial skyscrapers, the airport has had its operations significantly altered since 2007, through the reduction of landing slots (rights allocated for scheduling landing and departure), and of operating times, presently from 6:00 to 22:30 hours (Infraero, 2013). As expected, even with the restrictions, the impacts of a busy airport within a dense urban area didn’t cease and today neighbouring populations suffer from air traffic noise and atmospheric emissions, in addition to intense daily traffic jams on the streets of residential neighbourhoods.

• **Pinheiros channel**

The Pinheiros channel was originated in the rectification of the Pinheiros River in the 1930s, the major tributary of the Tietê River, which in turn is the main river of the metropolitan region. The twentieth century has proved to be particularly harmful to the original conditions of the Pinheiros, its oppressed margins gave rise for urban development which ended up exhausting the ecological function of the river. The channel now is a major water pollution spillway of the metropolis, becoming a true open air sewer.

Although not officially receiving direct disposal of domestic and industrial effluents, the channel presents its quality immeasurably compromised. The costly efforts of dredging sediments contaminated with elevated loads of heavy metals are practically useless in the face of clandestine launches of effluents, of tributaries outflows with equal or worse quality and the runoff caused by rainfall on impermeable surfaces, impregnated with pollutants.

• **Billings Reservoir**

The Billings reservoir is the largest water supply source at the SPMR. Its 1.1 billion cubic meters (EMAE, 2013) along with the Guarapiranga reservoir provide drinking water to approximately one third of the São Paulo’s population (SABESP, 2011).

In addition to the public supply, the reservoir caters to a multipurpose conception of its waters that include power generation, sanitation, flood control, recreation, subsistence fishing and industrial and agricultural intake.
Located in the plateau region and covering areas of six municipalities, the dam was originally designed in the 1930s to generate electricity through a complex transposition between river basins. Although the reservoir is located upstream the Pinheiros channel, with the rectification of the river the waters were reversed with the objective of pouring water to supply the Billings reservoir so it could generate energy at the Henry Borden plant located at the foot of the plateau slopes, 750 meters below the water reservation (Santoro et al., 2009).

The quality of public water supply suffered significant decline from the 1950s and 1960s with the São Paulo’s second industrial wave which promoted huge population growth and the urban expansion towards the watershed areas. (Santoro et al., 2009). It also adds to the deterioration of the water the transposition of the Pinheiros channel, already exceedingly compromised.

Currently the watershed, even protected by legal provisions, is surrounded by dense districts invariably fruits of illegal occupation, which therefore are insufficiently served by sanitation.

- **Santo Amaro and Itatinga Sanitary Landfills**

  These areas are more properly wastelands, given that they operated for decades with scarce controlling measures, receiving solid residues from most of the districts in the southern zone of the municipality until the 1990’s.

  The Santo Amaro wasteland, exhausted since 1993, still percolates leachate (toxic liquid produced by the decomposition of waste) to the Pinheiros channel and aquifers that supply the Billings reservoir. It also serves nowadays as a health waste transhipment station (Moraes, 2006). After its deactivation, the landfill has been recovered to minimize the infiltration and consequent contamination of the watershed. The law states that after completion of the lifespan of the landfill, its area must be recovered for the purpose of environmental conservation and / or recreation and cannot be used as a built space.

  In the face of the predominantly industrial occupation of the surroundings, the direct risks to the population are minor but not negligible when one reflects upon the deterioration of public water supply.

  However, the most acute condition is evidenced at the Itatinga wasteland. Placed near one of the arms of the Billings reservoir, the site was conceived as a stone quarry (ISA, 2000) and with the closure of the Santo Amaro landfill it was prepared to collect inert civil construction residues. The site was officially terminated in 2004. However, organic waste was received clandestinely due to the proximity of illegal settlements in the surroundings. (Moraes, 2006)

- **Pedreira stone quarry and sand pit**

  This site seen ran a mining company. From the quarry and sand pit site, an average of 5.000m³ of stone and 6.000m³ of sand were removed. Today the area is used as
an inert material send-off, however, the stability conditions of the mining fronts were not properly investigated prior to the residue disposal. There was no installation of drainage systems or treatment of leachate. The geotechnical conditions are unknown (ISA, 2000). Recent illegal occupations are situated around it.

- **Piratininga Thermoelectric Power Plant**

  The Piratininga Plant is, nowadays, operated by EMAE (eng. Metropolitan Company of Water and Energy) which is a power generation concessionary that operates a hydraulic system and provides electric power in the metropolitan area of São Paulo, among other regions.

  The complex was built on the banks of the Pinheiros Channel, near the Billings Reservoir. It came into operation on November 15, 1954, with initial power of 200 MW. Due to the industrial expansion in the region, this power was later expanded, raising a total capacity of 472 MW in 1960. Aimed at improving air quality in the mid-80s, the fuel used was replaced by another cleaner (oil with low sulphur content). Since August 2000, the plant has been progressively using natural gas (EMAE, 2013).

2.2 **São Paulo: Geographical and Historical Contextualization**

The metropolis emerged, grew and developed on a diverse natural support, muffled by urban structures over 450 years of fast-paced city expansion. The emergence of capital reproduction starred significant and often irreparable changes to the environmental complexity: e.g. rectification of rivers; land filling and drainage of wetlands; flattening of the relief and vegetation suppression; among other human interferences. These anthropogenic manifestations ended up promoting a series of problems directly affecting everyday urban life.

In São Paulo this process is far from being chaotic. It was directly influenced by the mindset for urban policies undertaken throughout its history, being a mosaic of thousand of individual and collective actions from the generations that invested its projects and beliefs. “What seems like a rudderless vessel actually corresponds to the successive urban managements and city models adopted” (Rolnik, 2009: p.10).

2.2.1 **The colonial period**

“A place with cold and temperate airs as in Spain, with a healthy soil, fresh and fine water.” Jesuit priest of the Company of Jesus describing São Paulo’s original site in a letter to his superiors in Europe, 1554. (Souza, 2003)
The overwhelming urbanization did not leave many clues for understanding the current physiographic diversity of São Paulo’s urban site. The humid tropical climate and geographical position which situates São Paulo’s plateau between large forested areas of southeastern Brazil suggest that the Lusitanian colonizers found here an extension of the rain forests that covered the slopes and plains of the Atlantic coast. "At first it may be assumed that all areas involving the decomposed crystalline zone that forms the basin of São Paulo were covered by forests" (Ab'Sáber, 2004, p. 114).

Indications to understanding the landscape are more present in historical documents and the original toponymies of the early settlements. The fields of Piratininga, as were baptized the localities covering the plateau morphologies, indicated that the colonizers preferred the meadows. As they were not alone in this preference, in 1554 they founded a catechist settlement in an elevated treeless interfluve. Therefore they could protect themselves spotting from the above non hospitable acts of those who natively resided in the area (Prado Júnior, 1989).

This reading already indicates the urban vocation of the future site of São Paulo. It is a sedimentary basin with plateau compartments with topographic features likely to human occupation. From the high hills of the central interfluve, one can evidence soft levels and relatively lean river lowland terraces, which converge to a dense water network corresponding to the middle course of the Tietê river. It always obeys the soft altimetric variations and altitudes that do not exceed the range comprising 700 and 800 meters over the sea level, not far from coastal region (Ab'Sáber, 2004).

After nearly 300 years of ostracism, the city became a reference in the province, gaining protagonism in the early eight hundreds. This new status was accompanied by the penetration of coffee plantations that broadened over almost the entire map of the province.

Along with the coffee economy and the arrival of Brazilian independence from Portugal, São Paulo becomes an important junction of routes of eastern Brazil. All roads, inland waterways, land and rail, now cutting the state territory, will lead to São Paulo. In this period the population grew from 20,000 inhabitants to 240,000 in just 30 years as reported by Ramos (2001). Thus São Paulo truly begins to appear as a place of urban life itself, as a place from which to define a unit of social life, while opposing and integrating rural and urban areas. The city begins to harbour monetary circuits of a booming economy (Seabra, 1987), staging the Brazilian industrialization.

2.2.2 In the tracks of industrialization

"The largest industrial city in South America". Exhibited in tram signs that ran in the years 1910’s. (Ab'Sáber, 2004, p. 350)

Until the late nineteenth century the city occupied an area roughly similar to colonial times (Silva et al. 1955). At this point no major urban changes were not yet showed and the city grew from the shredding of smallholdings surrounding the reduced urban area, without obeying a strategic plan.
It was the First World War (1914-1918) that led the city to a spurt of industrialization conferring a pageantry status readily shown in tram signs. The arrival of industry drove substantial population growth and consequently the need for new infrastructure investments, especially in water supply, energy and transport.

This moment is when the study area was incorporated into the historical development of the city. The City Company\(^1\), had acquired land throughout the extent of the floodplain of the Pinheiros river up to Santo Amaro. At that time Santo Amaro was a small urban settlement distant from the capital perimeter, restricted to the function of supplying food and materials to São Paulo. The economic growth of São Paulo has generated new demands such as the need to link between the two urban nuclei - Santo Amaro and São Paulo - which became effective with the railway line that connected and enabled the transportation of cargo and passengers in 1913 (Mendes and Carvalho, 2000).

Ranchers and dairy farmers who settled in this portion were forced out of the boundaries of the urban area which progressed rapidly, giving way to new buildings. The creation of new neighbourhoods led to the conurbation of the urban centres of São Paulo and Santo Amaro (annexed as a district to São Paulo in 1935). To meet the new needs of the city, grand works of engineering translated the desire to appropriate the rivers' marginal terraces. Those areas were characterized as "marginal wetlands zones and oxbow lakes, with dark argillaceous soil and permanently waterlogged" (Ab'Sáber, 2004, p. 98).

In this process several interests were hidden when appropriating the floodplains. With the rectification of the rivers, properties acquired by large real estate groups gained area and perpetuity with the oppression of the meanders, flood control and political will. This transformed into valued spaces for urban use the so called 'useless' wetlands, considered dens of diseases and pests, although occupied in many cases by low social status population, (Seabra, 1987).

The same mentality has produced a plan of avenues that appropriated all the drains that seep over the plateau, channelling, submerging, narrowing and reducing their courses, to the point that today one of the world's most irrigated regions does not evidence a single river.

### 2.2.3 Urban sprawling and the appropriation of the watersheds

Between 1906 and 1927, the complex of water reservoirs was conceived in the southern region of the metropolis that emerged. These waters were reversed in order to feed these watersheds and allow the generation of electricity. Until the 1930s, the vegetation coverage of these portions, where the waters of the Guarapiranga and Billings reservoirs were barred, preserved original condition or were little altered by sparse human activities (Santoro et al, 2009). The quality of the water resource was preserved by a dense ombrophilous forest.

\(^1\) Founded in London in 1911 with French, British and Brazilian investors, the company acquired over 15 million square meters in São Paulo perimeter. In 1912, the company settles permanently in the state capital with the name ‘City of Sao Paulo Improvements and Freehold Land Company Ltd.’ (Cia City, 2013).
The infrastructure development and the acceleration of the industrialization process in the region have enabled the incorporation of new territories to urban agglomeration. This phenomenon was backed up by migratory movements that were incorporated as new elements of the metropolitan urban structure.

In less than fifty years, fostered by waves of industrialization Brazil has experienced a structural transformation from agricultural to an urban country. The emerging metropolitan areas absorbed 30% of the country's population growth, receiving 8.3 million new residents just in the 1980's (IPEA, 1997: p.190-191).

Like other capitals and metropolitan regions, the city of São Paulo has become the pole of attraction for migratory contingent, growing exponentially in a short period, as seen on Table 2-4 and FIG.2-9.


<table>
<thead>
<tr>
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<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Brazil</td>
<td>51,944,397</td>
<td>70,992,343</td>
<td>94,508,583</td>
<td>119,002,706</td>
<td>146,825,475</td>
<td>169,799,170</td>
<td>190,755,799</td>
</tr>
<tr>
<td>SPMR</td>
<td>2,653,860</td>
<td>4,739,406</td>
<td>8,139,730</td>
<td>12,588,725</td>
<td>15,444,941</td>
<td>17,878,703</td>
<td>19,683,975</td>
</tr>
<tr>
<td>São Paulo</td>
<td>2,151,313</td>
<td>3,667,899</td>
<td>5,924,615</td>
<td>8,493,226</td>
<td>9,646,185</td>
<td>10,434,252</td>
<td>11,253,503</td>
</tr>
</tbody>
</table>


FIG. 2-9 - Population growth. SPMR and São Paulo. Source: Adapted from Infocidade, 2013.

São Paulo was growing between 43 and 66% per decade from 1950 until 1980, however the growth of Brazilian cities was not accompanied by the provision of infrastructure and urban services. According to Grostein (2001; p.14), the rapid urbanization pattern in Brazil imprinted on the metropolis, saving regional specificities, “at least two strong characteristics related to the predominant ‘city making’ manner”: the unsustainable aspects
associated to the processes of urban expansion and transformation/modernization of the intra-urban spaces; and low urban life quality to significant parcels of the population.

On the one hand, the construction of settlements for the elites, and on the other, the need to accommodate the working class, fostered a specific model of urbanization. In most of the metropolitan areas that were emerging, the expansion of the urban area assumed similar features materialized with a 'peripheral expansion pattern'. This process contributed to perpetuate "the illegal settlements, self-built homes and the distant housing projects of public production as its main thrusters." (Grostein, 2001: p. 14)

The state relinquished its control power over the production of urban space and proceeded to ignore the impressive expansion of the self-construction in irregular, illegal and precarious peripheral allotments, thus turning a blind eye in order to permit the necessity of labor power reproduction. Likewise, workers, even those employed in the formal sector, did not have their salaries regulated by the needs of their reproduction, which should include spending on housing (Maricato, 2001).

"The search for more affordable land for low-income population in contrast to the enhancement of core areas guided peripheral horizontal growth” (Santoro et al, 2009: p.37) and the region separating the historic centre from the water source areas, comprising the study area and surroundings, was a flagship part of the 'peripheral expansion pattern'. The second wave of industrialization in the 1950’s, the building of south-north axis avenues in the 1960’s and the metro line in the 1970’s promoted a huge population growth which then lead the urban area to double its size, fostering the occupations of the watersheds.

Unsurprisingly, the pollution worsens, especially after the transposition from the already polluted waters of the Pinheiros River to the reservoirs in the 1940’s and the advancement of the settlements deprived from sanitary infrastructure towards the banks of the reservoirs, which included the districts of Campo Grande, Cidade Ademar and Pedreira.

The answer to this situation is a reaction of the state through the creation of rules for occupancy. For the present context the main laws were the state laws for the watershed protection (State Laws N. 898/75 and 1.172/76) (Tagnin, 2001).

These laws considered urban occupation of the basin as the main factor for the poor water quality and intended to prevent encroachment and preserve the environment. The concept adopted for the new ventures was, briefly, to protect the watershed, permitting only low density occupation (Whately, Tagnin and Santoro, 2008). The laws instituted three categories of greater and less protection, according to the distance to the water body and establishing standards for use and occupation and several restrictions: for paving and sealing the soil; on allotments; on activities and; on urban infrastructure (Santoro et al, 2009).

The result: devaluation of property situated in the most restrictive categories, which increased the illegal allotments and the occupancy by low income population in the areas that should be first and foremost preserved. Also, the impediment to implement environmental sanitation due to legal prohibition led to a rapid degradation of the water quality. It took decades to clarify that the laws protecting the watershed could not annul the intense growth of urban population, and they certainly did not contribute to offer an alternative for housing. “The territory was more densely, irregularly and precariously
occupied, serving a population that did not fit into housing alternatives offered by the formal land market.” (Santoro et al., 2009: p.42)

Once again, in the 1980’s and early 1990’s, population growth in the south intensified with the creation of industrial allotments in the district of Santo Amaro and with the proximity to industrial centres in the ABCD region\(^2\).

After pressure from the civil society and public persecutors, positive steps were taken at that time with the recognition of the unavoidable circumstances of occupation. The administration of the mayor Luiza Erundina (1989-1992) represented a paradigmatic rupture in this sense while changing the way public management recognizes the right to land and housing. Projects conducted “surgical intervention in densely occupied areas, respecting its organizational and social space, ensuring (even if not yet legally) tenure security to occupiers” (Santoro et al, 2009). For the first time, a set of programs were aiming to guarantee the right to housing in order to reverse the environmental degradation through the urbanization of favelas.

This mindset lead to the revision in 1997 of the 1970’s watershed protection laws. The new watershed protection laws institutionalized categories for land use, establishing status for consolidation, restriction and recuperation. One important feature of the new institution was the decentralization of the decisions regarding the basin of a watershed, by establishing three party committees composed by the public realm, users and civil society. This was an important step for the creation of specific laws and the emergency plans which stated the possibility of performing ‘emergency repairs’ in cases where the environmental and sanitary conditions pose risks to life and health or impair the use of water sources.

\[2.2.4 \text{ Global city?} \]

"divided city, driven by visible and invisible walls that fray in ghettos and fortresses, besieged it and transforming its public spaces in war squares.” Rolnik (2009: p. 10)

The city spreads today and focuses public and private investment by the north-south axis, along the dried floodplain of the river. Brand new intelligent buildings rised in place of the meanders. At the Santo Amaro and Campo Belo districts, an overwhelming process replaced dense slums situated in floodable land. In less than ten years, they literally disappeared off the map along with their population, at least from these geographic coordinates.

\(^2\) The ABCD Region is a traditionally industrial region part of the SPMR composed by four municipalities: Santo André, São Bernardo (bordering the study area), São Caetano and Diadema (bordering the study area). It is the cradle of the automotive industry in Brazil and one of the most prominent economies in the country.
This new territory of productive outsourcing is built largely by international corporations, driven by the global need for better coordination between the central cities and the periphery of the capitalist system. This process consolidates the role of primatial city - overwhelmingly large city compared with other cities of the Nation/State, which holds the administrative and economic activities, exercises control over the political, economic and social fields (Sassen, 1993).

This new territoriality makes São Paulo the most expressive metropolis of the Mercosur, harbouring a series of peculiar services of the global economic centrality and a prominent status. The municipality hosts more than 20 billionaires (6th largest number in the world) and 60% of the Brazilian millionaires, the world’s 3rd largest stock exchange, it represents the world’s 10th richest economy (GDP = US$ 388 billion) and the largest helicopter fleet (Análise, 2011: p.189).

The business structures are accompanied by large real estate entrepreneurship that spread through the southern zone between Congonhas Airport and the Pinheiros channel. The worldwide trend for the re-development of ‘degraded’ areas in the city is pressuring the urban managers to bring improvements to the infrastructure sector, with emphasis on building avenues and road complexes and in the restructuring and expansion of airports, especially where it will cause great benefit for the real estate speculation.

Some urban operations conducted in the districts of Campo Belo and Santo Amaro are emblematic to highlight the promiscuous relationship of urban planning with the city’s business demand. These projects have been promoting a real redevelopment of neighbourhoods, transforming areas characterized by reminiscent hamlets from the period of smallholdings or occupied by low-income populations between Santo Amaro and the central districts.

The urbanist Mariana Fix studied in detail the removal of families who occupied the planned route for the construction of an avenue in the mid-1990s. To give place to the new avenue "more than 50,000 residents were driven out - many of them living in brick houses built in the last 10 or 20 years - and had little alternative but to go to other favelas in distant neighbourhoods (...). Much ended on the shores of Billings and Guarapiranga, a region that (...) has been intensively occupied by those who (...) have no other alternative" (Fix, 2001, p.134). The PHOTO.2-1 below illustrates a small segment of the transformation.
Assessing Urban Environmental Justice in Santo Amaro and Cidade Ademar subprefectures, São Paulo, Brazil

PHOTO 2-1 - Transformations of the Águas Espraiadas avenue (A) construction before (1995) and (B) after (1996), Campo Belo district. Source: adapted from Fix (2001)

Such projects have caused the frontiers of the built environment to be magnified over the last decade of the twentieth century. While the consolidated city lost 0.7 million inhabitants in the decade, the periphery and the consolidated periphery gained 2.7 million. From those, 2.1 million are in the urban frontier, including the watershed areas (Torres and Marques, 2005).

The region studied fits dichotomously in the current stage of urban production in São Paulo. The districts of Campo Belo and Santo Amaro assumed the role of the crib of the economic elite seeking new areas of real estate valuation, transforming their current territories in space of great urban boosting in the recent history of the metropolis, while the peripheral districts of Campo Grande, Cidade Ademar and Pedreira remain on the margins of financial spaces, absorbing the impact of the reproduction of centralities that mimic a mirage in global economic development, which make the city an engine of growth and exclusion.

This dominant logic extends over several problems present in today's society and is regularly treated as circumstantial, such as the invisibility of urban rivers, the scandalous waste generation and consequent degradation, deficient sanitation, or lack of minimum conditions for housing, all elements that imply lower quality of life. Above all, understanding if these aspects are manifested on specific areas and population profiles can reveal a trend that cannot be defended as punctual and aleatory, hence the great need to register this fact and the great effort to understand it by assessing environmental justice.
3 METHODOLOGY

This chapter contains the description of the applied methodical approaches for assessing urban environmental justice in two subprefectures of São Paulo while also presenting evidences of supporting materials, utilized data, procedures and techniques to assess it.

3.1 Environmental Quality and the Thresholds to Assess

Environmental Justice

There are at least two major scientific challenges in defining methods to build socio-environmental indicators and perform its integrated analysis. The first concerns the subjectivity of the choice of topics to be considered. As much as one tries to use scientific methods, decisions are often based on subjective judgments involving values, sensitivity, convictions and prejudices, as well as, of course, scientific truths. To minimize the subjectivity of the urban environmental quality assessment, a valuation that builds on broad consensus is required. This can be achieved by obtaining a statistical expression of the subjective opinions of a sample of experts, through resuming a plethora of specific publications (Gomes Orea, 1978 apud Nucci, 2008).

The second reflects on the ability of the indicators to study the space and taking into account all the variables and their interrelationships. When thinking about environmental planning, nowadays, one seeks a scientific approach aimed at the unity of knowledge and the transdisciplinarity of social, economic and natural aspects. However it is necessary to divide this space for a better understanding because the methodologies hitherto known yet were not able to study space by taking into account all the variables and their interrelationships (Nucci, 2008). So what actually happened in the broad consideration of socio-environmental quality aspects are studies in different spheres of planning with a subsequent attempt of partial synthesis, within each line of study, and then a more comprehensive synthesis in order to propose measures for space planning. Vargas (1999, apud Ribeiro & Vargas, 2004) enlightens on how to consider urban environmental quality (Table 3-1) by bringing the need to aggregate the dimensions that compose its meaning, not only from an ecological standpoint. Each dimension is composed by a range of identities reflecting the multiplicity that should be considered in such complex analysis.
### Table 3-1 - Dimensions of society that reflects on Urban Environmental Quality.

<table>
<thead>
<tr>
<th>Spatial</th>
<th>Biological</th>
<th>Social</th>
<th>Economic</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wellness</td>
<td>Physical health</td>
<td>Organization</td>
<td>Opportunities</td>
</tr>
<tr>
<td>vegetation, open spaces, tranquility</td>
<td>sanitation, insolation, noise levels, air quality</td>
<td>Community, social classes, associations</td>
<td>employment, labor, business</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Accessibility</th>
<th>Mental health</th>
<th>Personal achievement</th>
<th>Productivity</th>
</tr>
</thead>
<tbody>
<tr>
<td>road network system, transportation</td>
<td>stress, traffic congestion, queues, loneliness, complaints</td>
<td>friendship, affection, recognition</td>
<td>economics and diseconomies of agglomeration; traffic, cost of living, competition, complementarities</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Urban Design</th>
<th>Security</th>
<th>Contacts</th>
<th>Diversity</th>
</tr>
</thead>
<tbody>
<tr>
<td>visual elements, monotony, disorder, information</td>
<td>traffic, buildings, delinquency</td>
<td>meetings, privacy, solidarity</td>
<td>choices</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>References</th>
<th>Activities</th>
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<tbody>
<tr>
<td>orientation, history, landmarks</td>
<td>leisure, recreation, culture, shopping</td>
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<table>
<thead>
<tr>
<th>Land use</th>
<th>Professional fulfillment</th>
<th>Access and Options</th>
</tr>
</thead>
<tbody>
<tr>
<td>densities, conflicting uses, ease, permeability, segregation</td>
<td>mobility, opportunities</td>
<td>housing, work, urban services, social services, transportation</td>
</tr>
</tbody>
</table>

Source: translated from Vargas, 1999; apud Ribeiro and Vargas, 2004

Even an incomplete table, still according to Vargas’ understanding, can demonstrate the amplitude and subjectivity of the discussion, which is directly influenced by the stakeholders and their interests, objectives and expectations. "The subjective and collective frame changes with time as societies’ changes occur and individual and collective repertoires are magnified" (Vargas, 1999; apud Ribeiro and Vargas, 2004: p.19).

These dimensions include basic human needs, which in an urban context, are subject to the ecological characteristics of the city (Nucci, 2008). Sukopp and Werner (1991) drew such characteristics:

- High production and consumption of secondary energy;
- Large import and export of materials, huge amount of waste;
Assessing Urban Environmental Justice in Santo Amaro and Cidade Ademar subprefectures,
São Paulo, Brazil

- Elevation in several meters from the ground surface (verticalization);
- Strong contamination of air, soil and water;
- Decline of groundwater;
- Soil destruction;
- Development of a typically urban climate, with higher temperatures and low relative humidity (heat island effect);
- Tiled and heterogeneous space;
- Imbalance in favour of the consumer organisms, low primary productivity and weaker detritivorous bodies activity, and;
- Fundamental changes in plant and animal populations.

According to Nucci (2008) when combining these characteristics with the basic human needs, the most relevant aspects to urban environmental quality can be resumed: climate and atmospheric pollution; water–supply and flood risk; effluents; solid residues; visual and noise pollution; vegetation coverage; green areas and open spaces; recreational spaces; verticalization and population density.

The way those aspects manifest can be understood as environmental stressors or burdens, and as environmental benefits or disburdens. Hence, the movements who coined the term environmental injustice are concerned with indentifying instances when a specific community unduly bears the burden of environmentally detrimental practices (Čapek, 1993; Rodriguez, 1998; Cole and Foster, 2001; USCCR, 2003; Stephens, 2007; Neimanis, 2012).

“The environmental justice movement has since extended its scope to include research on, for example, poor air quality, hazardous waste sites, demographic representation in high-risk occupations, and exclusion from decision-making processes” (Neimanis, 2012: p.7).

Regarding urban environmental justice cartographic production, these aspects are usually condensed in major topics, e.g.: noise, air quality (Johnson and Kirk, 2004; Grineski et al., 2007; Bunge and Gebuhr, 2011), urban climate (Dugord, 2013) bioclimate, green space provision (Bunge and Gebuhr, 2011), sanitation, solid residues (USCCR, 2003).

There’s a consensus among São Paulo’s urbanists that the subjects of sanitation, water supply, waste management, air quality and the provision of green recreational areas are crucial to analyze the city’s socio-environmental condition. This is especially a verity when considering São Paulo’s historical development and socio-environmental characteristics, but mostly when facing the strong demands for public investment in urban infrastructure, with considerable environmental impact for the city (Jacobi, 1994; Torres et al., 2007: Rolnik, 2009). Hence those are vital aspects for us to assess environmental justice.

Regarding the accessibility of information for each subject for the study area, the availability of public data and eased adaptability to the census tract level is determinant. Consequently the following topics at Table 3-2 were considered or discarded.
Table 3-2 – Considered and discarded subjects for the study area.

<table>
<thead>
<tr>
<th>Subjects</th>
<th>Access to data</th>
<th>Status</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Environmental data</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Air Quality</td>
<td>The State Environmental Agency (CETESB) annually publishes data for the metropolitan region for several parameters of air quality. However, there aren’t enough measurement stations resulting in a very sparse matrix for the working scale. There are no stations in the limits of the study area.</td>
<td>discarded</td>
</tr>
<tr>
<td>Noise Exposure</td>
<td>No consistently produced data on the subject for the study area.</td>
<td>discarded</td>
</tr>
<tr>
<td>climatic conditions</td>
<td>There aren’t enough measurement stations, resulting in a very sparse matrix for most of the parameters. However, near-ground temperature obtained from satellite image interpretation is available for the entire municipality.</td>
<td>partially considered</td>
</tr>
<tr>
<td>Provision of Urban Green (Provision of Trees, Tree-canopy Coverage and Access to Public Green Areas)</td>
<td>Municipal Land use map, satellite images, Population by census tracts, field surveillance, geo-database from previous research in the area.</td>
<td>considered</td>
</tr>
<tr>
<td>Water Supply, Waste and Sanitation</td>
<td>Through the IBGE census it is possible to access data by census tracts. The data provides information for collection and disposal of solid residues, water supply and sewage disposal.</td>
<td>considered</td>
</tr>
<tr>
<td><strong>Socio-economic data</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Social vulnerability</td>
<td>The social vulnerability index is a composition of demographic indicators and income and it is available at census tract level.</td>
<td>considered</td>
</tr>
<tr>
<td>Human Development Index</td>
<td>No available data in the level of census tracts.</td>
<td>discarded</td>
</tr>
</tbody>
</table>

3.2 Sources and materials

3.2.1 Methodological references

The synoptic analysis of a large number of variables necessarily incurs in the consideration, or at least in the consultation of an equally large number of methodological references. Integrate each one requires a complex exercise of synthesis and adaptation to the available data, the local reality and the desired product itself.

With this statement in mind, one must assume minimum premises in the search and consideration of references in order to avoid methodological confusion, the foray into unnecessary strain and distortion of the proposed results: methods close to the characteristics of the study area and the principles of environmental justice were prioritized; the decomplexation of methodologies and the use of standardized indicators and indices were prioritized in order to bring together with the initiative of building a replicable and updatable pilot model.
This means that in many instances there was no desire to follow the reference methods to the letter. The priority was the design of a simplified but cohesive and sufficient methodology, having the following cited publications as benchmarks for this proposal.

- **General aspects**

The **Berlin Pilot Project on Environmental Justice** (Bunge and Gebuhr, 2011) pursues a new methodological model for integrated reporting on environment, health, social issues and urban planning. The four major topics were noise, air quality, bioclimate and green space provision.

The effort contained by the individual topics of the project requested comprehensive geo-data which is as up-to-date as possible (Welsch et al., 2011). The socioeconomic data is originally provided within subdivisions of the city of Berlin which constitutes the “Living Environment Areas” (LEA) (german: “Lebensweltlich orientierte Räume”, LOR). For every LEA, available is small-scale information about changes in the socio-structural and socio-spatial development as a continuous city tracking system (Welsch et al, 2011). The combination of spatial environmental and social data was carried out on the level of LEA into the denominated Planning Areas.

Through the model proposed by the pilot project it is possible to understand which LEA’s of Berlin are affected by both high levels of social problems and health-related environmental pollution, moreover it allows the different information to be combined in a meaningfully manner that supports practical approaches and small–spatial-scale information on health-related environmental burdens to be integrated into Berlin’s planning system. All this questions were prior established to the investigation.

The abovementioned project underpins various aspects in the constitution of the model proposed by the current research:

- Establishes a coherent division of environmental issues to be analyzed and how to consider them in a multidimensional spectrum;
- Illuminates ways to use standardized social data and statistics especially in small-spatial-scale, and;
- Provides an overview of how to integrate different indicators into a single spatial unit.

- **Waste, water and sanitation**

The topics of waste and also water and sanitation bring a substantial amount of variables. All were taken from the results of the last census in 2010. As references for the integrated analysis of these variables, it is possible to cite the work of Miranda and Teixeira (2004) who built a systematic model of indicators for monitoring environmental sustainability in urban systems of water supply and sanitation, and Batista and Silva (2006) who created an Indicator of Environmental Health model for intra-urban analysis by census tract.
Both publications used a wide range of indicators in order to conduct an assessment of favourable or unfavourable trends to sustainability. The indicators ranged from the quality of the supplied water, natural system offer, percentage of the population served by the services, the number of service interruptions, economic performance in system productivity, existence of channels for participatory management, existence of monitoring systems, among many others.

In the case of Miranda and Teixeira (2004) all indicators were organized according to dimensions, namely environmental, social, cultural and political which grouped showed the same tendency in co-related problem analysis demonstrating general trends and gaps for optimal sustainability. Batista and Silva (2006) got similar results organized in a single index per census tract.

- **Public Green**

  **Trees provision and Tree-canopy coverage:** There are countless methods for characterizing the provision of urban arboreous vegetation in tropical and subtropical cities and the queried researches range from a morphological characterization of tree canopies corridors layout (Jim, 1989; Assis, 2009; Salvi et al., 2011; King and Locke, 2013) to a more amplified portrayal of the measured benefits of urban green, including street canopies and natural areas (Nucci & Cavalheiro, 1998; Alvarez, 2004; Cruz, 2013; Poe et al., 2013).

  The universe results for the census tracts from the research conducted by the IBGE in 2010 are sufficient, given the need to produce an index that reflects only the provision of trees in urban areas, without necessarily performing a characterization of size, species, among others.

  Regarding the quality of tree-canopy coverage the data used is supported by the previous research conducted in the same study area by Cruz (2013) whose work was based on the methodology created by Jim (1989) for the build-up areas of Hong Kong.

  **Access to public green areas:** Although the present study does not require a typification of urban green areas as proposed by some of the assessed studies (Vieira and Biondi, 2008; Malek et al., 2010; Bargos and Matias, 2012), a good use has been made of these methodologies in the appliance of basis criteria for the production of georeferenced databases, namely the analysis of official maps land use and the information refining through satellite image.

  The provision of green spaces analysis by the State of Berlin (SenStadt, 2013a) and its socio-spatial distribution (Kleinschmit et al., 2011) were fundamental reference basis to the selection of the areas to be considered setting guidelines for size, shape, accessibility and minimum space requirement per citizen. Other indicators were considered in the mentioned publications such as noise and air pollution. However, this kind of data is not available for São Paulo region.
• Surface Temperature

The systematic and dense data production on the urban climate characteristics in São Paulo is still a future point. The few attempts to build a climatological model are based on geographically scattered measurements on isolated stations and sporadic interpretation of satellite image scenes. This last resource is often cited as good reference in the understanding of urban climatic patterns as predicted by Dugord (2013), who uses near-ground temperature together with other indicators to demonstrate and classify phenomena like urban heat islands.

3.2.2 Geodatabase

Maps throughout this dissertation were created using ArcGIS® 9.3 software (Esri Inc, 2008). ArcGIS® and ArcMap™ are the intellectual property of Esri and are used herein under license. All images used in the present thesis were obtained through the software Google Earth Pro, version 7.0.2.8415 (Google Inc, 2012). The Tables 3-3, 3-4 and 3-5 below, respectively, describe the data sources utilized for obtaining the shapefiles, images and digitalized maps.

Table 3-3 – Data source for the original shapefiles utilized.

<table>
<thead>
<tr>
<th>Description/Content</th>
<th>Data Source</th>
<th>Original datum</th>
<th>Type of Shapefile</th>
<th>Available online</th>
</tr>
</thead>
<tbody>
<tr>
<td>São Paulo Metropolitan Region Build-up Area</td>
<td>Fundação SOS Mata Atlântica; INPE, 2005</td>
<td>GCS Córrego Alegre</td>
<td>Polygon</td>
<td>*<a href="http://mapas.sosma.org.br/">http://mapas.sosma.org.br/</a></td>
</tr>
<tr>
<td>Political Division - South America</td>
<td>FABHAT, 2009</td>
<td>GCS Córrego Alegre</td>
<td>Polygon</td>
<td><a href="http://www.fabhat.org.br/site/index.php?option=com_content">http://www.fabhat.org.br/site/index.php?option=com_content</a></td>
</tr>
<tr>
<td>Political Division, Brazil</td>
<td>FABHAT, 2009</td>
<td>GCS Córrego Alegre</td>
<td>Polygon</td>
<td><a href="http://www.fabhat.org.br/site/index.php?option=com_content">http://www.fabhat.org.br/site/index.php?option=com_content</a></td>
</tr>
</tbody>
</table>
Assessing Urban Environmental Justice in Santo Amaro and Cidade Ademar subprefectures, São Paulo, Brazil

<table>
<thead>
<tr>
<th>Description/Content</th>
<th>Data Source</th>
<th>Original datum</th>
<th>Type of Shapefile</th>
<th>Available online</th>
</tr>
</thead>
<tbody>
<tr>
<td>Favelas and substandard housing in the São Paulo municipality</td>
<td>CEM, 2013b</td>
<td>GCS SIRGAS 2000</td>
<td>Polygon</td>
<td><a href="http://www.fflch.usp.br/centrodametropole/631">http://www.fflch.usp.br/centrodametropole/631</a></td>
</tr>
<tr>
<td>Tree-canopy coverage for Santo Amaro and Cidade Ademar subprefectures, São Paulo</td>
<td>Cruz, 2013</td>
<td>GCS WGS 1984</td>
<td>Polygon</td>
<td>Not available online</td>
</tr>
</tbody>
</table>

* Access upon registration and online request: Data can only be downloaded for research, teaching and scientific purpose. It is prohibited the commercial use of the data.

Table 3-4 – Data source for the used Google Earth images.

<table>
<thead>
<tr>
<th>Description</th>
<th>Image coordinates (UTM – WGS 1984)</th>
<th>Date of image</th>
<th>Accessed on</th>
</tr>
</thead>
<tbody>
<tr>
<td>Segment of the Pinheiros channel</td>
<td>23K 325.393 E and 7.385.196 S</td>
<td>July 16th, 2013</td>
<td>October 3rd, 2013</td>
</tr>
<tr>
<td>Billings reservoir</td>
<td>23K 331.946 E and 7.376.466 S</td>
<td>July 16th, 2013</td>
<td>October 3rd, 2013</td>
</tr>
<tr>
<td>Congonhas Airport and surroundings</td>
<td>23K 330.132 E and 7.386.018 S</td>
<td>December 14th, 2008</td>
<td>October 24th, 2013</td>
</tr>
</tbody>
</table>
Table 3-5 – Data source for the digitalized maps

<table>
<thead>
<tr>
<th>Description</th>
<th>Map Title</th>
<th>Map original scale</th>
<th>Data Source</th>
<th>Publication Title</th>
<th>Available online</th>
</tr>
</thead>
</table>
3.2.3 The IBGE Census tracts

Census tracts are the smallest territorial units of the IBGE Censuses\(^3\). They are also the chosen territorial unit comprising all indicators and indices obtained, directly or indirectly used in the present research.

Formed by a continuous area, the tracts are fully contained in urban or rural area, exhausting the entire national territory. Its territorial demarcation is designed to meet the operational aspects of the census, containing, in urban areas the average of 230 households and 700 inhabitants per tract (IBGE, 2011). Its limits are allocated on elements of easy identification for the census taker, such as roads, streets or rivers. The data available by census tract comprise characteristics of private households and residents that have been surveyed for the totality of the population and are called, by convention, results of the universe.

The information on tract level is distributed in spreadsheets with about 3,000 variables, covering various characteristics of the population: gender; age; skin colour or race; household condition; persons responsible for the household; literacy; income of individuals and households; typology of the census tract; characteristics of the surroundings of urban households; public services and infrastructure, etc.

In order to compose the indicators and indices, the current research extracted from the variables relevant information for the districts of the study area: Permanent households or persons responsible for permanent households; residents in permanent private households or population living in permanent private households; nominal value of the average monthly income of the person responsible for the permanent household (with and without income); water supply information for residents in permanent households; sanitary sewage information for residents in permanent households; residues collection and disposal information for residents in permanent households; existence of arborisation in the plot or in front of it; existence of garbage in the plot or in front of it; existence of open sewer in the plot or in front of it; adequacy of housing for permanent household, and; social vulnerability.

Beside all the variables, every census tract contains a geocode that is the key to its spatialization. The code is composed by 15 digits which sequentially represent the territorial divisions to locate the census tract. The geocode of the census tract is the link between the data available in the spreadsheets and the census tract shapefile.

The Table 3-6 and 3-7 informs some of the details that can be derived from the spreadsheets and consequent spatialization of the data.

---

\(^3\) The demographic census is carried out in Brazil with certain regularity every 10 years since 1872 and conducted by the Brazilian Institute of Geography and Statistics (IBGE) since 1936. In the 2010 census, 191,000 census takers visited 67.6 million households in all 5,565 Brazilian municipalities (IBGE, 2013).
Table 3-6 – IBGE census tracts – demographic data.

<table>
<thead>
<tr>
<th>District</th>
<th>Number of census tracts</th>
<th>Permanent households or persons responsible for permanent households</th>
<th>Population living in permanent private households</th>
<th>Average population per household</th>
</tr>
</thead>
<tbody>
<tr>
<td>Campo Belo</td>
<td>148</td>
<td>24415</td>
<td>65349</td>
<td>2.68</td>
</tr>
<tr>
<td>Santo Amaro</td>
<td>134</td>
<td>25374</td>
<td>70822</td>
<td>2.79</td>
</tr>
<tr>
<td>Campo Grande</td>
<td>173</td>
<td>33758</td>
<td>101137</td>
<td>3.00</td>
</tr>
<tr>
<td>Cidade Ademar</td>
<td>380</td>
<td>80858</td>
<td>266542</td>
<td>3.30</td>
</tr>
<tr>
<td>Pedreira</td>
<td>262</td>
<td>42056</td>
<td>144194</td>
<td>3.43</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>1097</strong></td>
<td><strong>206461</strong></td>
<td><strong>648044</strong></td>
<td><strong>3.04</strong></td>
</tr>
</tbody>
</table>

Table 3-7 – IBGE census tracts – spatial data

<table>
<thead>
<tr>
<th>District</th>
<th>Biggest census tract (sqm)</th>
<th>Smallest census tract (sqm)</th>
<th>Census tracts with no data</th>
<th>Census tracts with inconsistent data</th>
</tr>
</thead>
<tbody>
<tr>
<td>Campo Belo</td>
<td>1776532</td>
<td>1598</td>
<td>4</td>
<td>0</td>
</tr>
<tr>
<td>Santo Amaro</td>
<td>985975</td>
<td>1497</td>
<td>5</td>
<td>2</td>
</tr>
<tr>
<td>Campo Grande</td>
<td>1124059</td>
<td>1035</td>
<td>4</td>
<td>0</td>
</tr>
<tr>
<td>Cidade Ademar</td>
<td>140205</td>
<td>528</td>
<td>2</td>
<td>3</td>
</tr>
<tr>
<td>Pedreira</td>
<td>1988482</td>
<td>2132</td>
<td>5</td>
<td>4</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>20</strong></td>
<td></td>
<td></td>
<td><strong>9</strong></td>
</tr>
</tbody>
</table>

As evidenced above, from the 1,097 census tracts under analysis 29 could not be taken under consideration due to lack of information at the spreadsheets or insufficient number of households.

It is remarkable the significant difference between the sizes of the census tracts areas that a district can have. This discrepancy is explained by the existence of notable areas highlighted in Chapter 2.1.1, e.g. areas such as the Congonhas Airport and the Pedreira Quarry, that are fully embedded in a tract, but also by the type of predominant land use in certain regions. Less densely regions, for instance predominantly industrial areas, have larger census tracts as they require a larger area to achieve an average of 230 households that comprise a tract. The airport example is illustrated below on the FIG.3-1.
Another important detail in relation to the size of the census tracts concerns the direct relation to the population density of each feature. Despite the average residents per household being similar in all districts (around three) census tracts located in areas where lots are big are as a result larger. Likewise, census tracts located in verticalized regions presents greater concentration of residents over the same area, reducing the size of the tract.

Notwithstanding, such census tracts contain data for the same variables and are therefore subject to classification in the production of indicators and indices of this research. The collected data constitute refined information and an accurate reflection of a specific place and its differences with other places. Hence they represent a fundamental source for the application of the method.

3.3 Method description

To understand the conditions of environmental justice in a particular location requires a systematic mapping effort. The final result depends on the aggregation of initial parameters which contribute to the construction of partial cartographic synthesis, and finally to the composition of a synoptic map.
3.3.1 General index composition

As already emphasized, this research relied on the indicators available for the study area, which enable analysis in detailed scale of census tracts. Nine initial parameters were chosen:

- Means of waste collection per residents;
- Exposure to waste in the vicinity of households;
- Water supply per resident;
- Sanitation indicators per resident;
- Exposure to open air sewer in the vicinity of households;
- Existence of trees in vicinity of households;
- Configuration of tree-canopy coverage;
- Access to public green areas per residents;
- Near ground temperature

From a thematic analysis, these parameters comprise four partial indices:

- Waste Index – W-I
- Water and Sanitation Index – WS-I
- Public Green Index – PG-I
- Low-Surface Temperature Index – LST-I

In turn, these partial indices comprise a synoptic index of Urban Environmental Quality. The last stage in obtaining the map of Environmental Justice is the integrated analysis of Urban Environmental Quality and São Paulo’s Social Vulnerability Index. The steps are summarized in the diagram shown in FIG. 3-2 below.

![FIG. 3-2 - Creation scheme of partial indices for the Environmental Justice synoptic map.](image-url)
Each stage requires the correct geostatistical treatment of the available indicators and relies on specific methods for the composition of partial and synoptic indices. The particulars will be described from the subtopic 3.3.2.

Generally each indicator is transformed into a percentage rate or different categories and subsequently reclassified into four classes so they can be crossed in a matrix analysis. Each class receives different grades which represent the exposure to more or less environmental stressors and as a final point to the subjection to higher or lower rate of environmental justice.

In total 16 maps were produced and analyzed in an integrated basis in order to assess Environmental Justice for Santo Amaro and Cidade Ademar, São Paulo.

### 3.3.2 Waste Index – W-I

The map corresponding to the **Waste Index – W-I** is a result of the overlaying of two corresponding parameters. The indicators that comprise each parameter were obtained from the interpretation of the 2010 census variables for the tracts in the study area. An index was generated from each indicator, corresponding to the percentage of residents, or in some cases households, under the condition of environmental burden or disburden. The **FIG.3-3** below illustrates the steps to the creation of the final index, which are detailed in the sequence.

![FIG. 3-3 - Depicting the map keys.](image)

As demonstrated, the two corresponding parameters were analyzed from the spreadsheets of the 2010 census results of the universe, each of them generated a partial index:
i. residues collection and disposal information for residents in permanent households;

The following indicators of the 2010 census were considered for this parameter:

- Residents in permanent private households with periodical garbage collection by the public service;
- Residents in permanent private households with garbage collected in containers by the public service;
- Residents in permanent private households with garbage burned on the property;
- Residents in permanent private households with garbage buried on the property;
- Residents in permanent private households with garbage dumped in a vacant lot or street;
- Residents in permanent private households with garbage thrown into river, lake or sea;
- Residents in permanent private households with another garbage disposal.

The abovementioned indicators correspond to the means of garbage collection and disposal, and the result in the spreadsheet is represented in absolute numbers for each census tract.

In Brazil, the service of garbage collection is performed by the municipal government through public companies or concessionaries. Those enterprises have the responsibility for proper disposal of the garbage.

In remote areas or of difficult access, the public collection is carried out through containers that store the residues for a period longer than the regular collection. In any case, the final disposal of waste if collected by the public service is the same, and therefore considered adequate for the effects of this research.

For each indicator carried out was a percentage apportioning compared to the total population of the census tract. The final Adequate Waste Collection Index is the percentage of resident in a condition of environmental disburden (or adequate waste disposal: result of the percentage of residents in permanent private households with residues collected periodically or in containers by the public service). As a result, the opposite situation represents an environmental burden (or inadequate waste collection: result of the percentage of residents in permanent private households without public service collection).

The obtained percentages were entered into the census tracts original shapefile according to each feature geocode, thus enabling the spatialization of the index. The symbology of the legend was classified according to the Natural Breaks (Jenks) method in 17 classes varying from 35% (the lowest percentage of adequate waste collection for a census tract) to 100% (the highest percentage).
ii. **Existence or absence of accumulated waste in the plot or in front of it;**

The following indicators retrieved from the 2010 census were considered for this topic:

- Permanent households - There is accumulated waste in the plot or in front of it;
- Permanent households - There is no accumulated waste in the plot or in front of it;

These indicators correspond to the observation of accumulated waste in the plot of the households or in the vicinity and the result in the spreadsheet is represented in absolute numbers for each census tract. The aforesaid indicator points to a deficiency in the public waste collection, regardless of whether the lots under such circumstances are served by the system or not. Also it demonstrates a probable impairment in the cleaning service of public places such as streets, avenues, squares and other public areas.

Some inconsistencies were observed when crossing the variables for this indicator. On occasion some census tracts showed absolute zero as a result both for the existence of accumulated waste, and for the absence. Since this circumstance was observed in a small number of tracts, it was understood that the inconsistencies were not significant for the indicator to be discarded. The most restrictive condition was considered for those cases, namely the existence of accumulated waste.

A percentage apportioning compared to the total population of the census tract was carried out. The final **Accumulated Waste Index** is the percentage of households in a condition of environmental disburden (or absence of accumulated waste in the plot or in front of it). The opposite situation represents an environmental burden (or the presence of accumulated waste in the plot or in front of it).

The obtained percentages were entered into the census tracts original shapefile according to each feature geocode, thus enabling the spatialization of the index. The symbology of the legend was classified according to the Natural Breaks (Jenks) method in 32 classes varying from 100% (the highest percentage of residents without accumulated waste for a census tract) to 0% (the lowest percentage).

After the creation of the partial indices, they are summed in order to obtain the final **Waste Index**. The sum operation is performed by of ArcMap 9.3 for each parameter's percent values. In order to be summed, all partial indices shapefiles have to be converted into images. The ArcToolbox is used with the aim of converting the polygons into raster files.

The second step is the overlaying of the converted raster files in order to generate a single raster file which comprises the sum of both partial indices. Once again the ArcToolbox performs the geostatistical operation. The new summed raster file is reconverted into a shapefile so it can be reclassified.
The new polygon is then reclassified according to the Natural Breaks (Jenks) method into four categories varying from the total sum of 35 (the lowest summed value) to 200 (the highest summed value).

The lowest values represent the summed percentage of residents per census tract with less favourable environmental situation and consequently higher exposure to environmental stressors related to waste pollution and collection parameters. The Table 3-8 below demonstrates the breaks considered for each class, which compose the final index.

Table 3-8 – Waste Index map key.

<table>
<thead>
<tr>
<th>Exposure to environmental stressors</th>
<th>Intervals</th>
<th>Category</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Very high</td>
<td>≤ 35 - 121</td>
<td>4</td>
<td>Most of the residents have no access to waste collection and/or are exposed to accumulated garbage</td>
</tr>
<tr>
<td>High</td>
<td>≤ 122 - 165</td>
<td>3</td>
<td>A significant parcel of the residents have no access to waste collection and/or are exposed to accumulated garbage</td>
</tr>
<tr>
<td>Medium</td>
<td>≤ 166 - 189</td>
<td>2</td>
<td>Few residents have no access to waste collection and/or are exposed to accumulated garbage</td>
</tr>
<tr>
<td>Low</td>
<td>≤ 190 - 200</td>
<td>1</td>
<td>Most of the population have access to waste collection and is not exposed to accumulated garbage</td>
</tr>
</tbody>
</table>

3.3.3 Water and Sanitation Index – WS-I

The map corresponding to the Water and Sanitation Index – WS-I is a result of the overlaying of three corresponding parameters. The indicators that comprise each parameter were obtained from the interpretation of the 2010 census variables for the tracts in the study area. From each indicator generated was an index corresponding to the percentage of residents, or in some cases households, under the condition of environmental burden or disburden. The FIG.3-4 below illustrates the steps to the creation of the final index, which are detailed in the sequence.
Assessing Urban Environmental Justice in Santo Amaro and Cidade Ademar subprefectures, São Paulo, Brazil

The three related parameters were analyzed from the spreadsheets of the 2010 census results of the universe, each of them generated a partial index:

i. water supply information for residents in permanent households;

The subsequent indicators were considered for this parameter:

- Residents in permanent private households with water supply from the public network system;
- Residents in permanent private households with water supply from well or spring at the property;
- Residents in permanent private households with supply from rainwater stored in tanks;
- Residents in permanent private households with other forms of water supply

The aforementioned indicators not necessarily correspond to the only source of water supply per household, but to the main one, and the result in the spreadsheet is represented in absolute numbers for each census tract.

Subsequently, for each indicator carried out was a percentage apportioning compared to the total population of the census tract.

It is necessary to craft a caveat comment to this specific topic. It is not possible to state categorically that the water quality provided by the public system is superior than the water obtained from other sources, especially when considering the quality of the watersheds in the south of the municipality. Although the public water supply company demonstrates the offered water potability, there is a great expenditure in the treatment for the water to reach these standards, increasing the presence of products used in purification. Corroborates to this assertion is the fact that many high and medium standard condominiums adopted alternative sources for water intake such
as wells and springs on the property, providing proper and less expensive treatment to achieve potable water.

Parallel to the situation described above there are households that still use alternative intake due to lack of access to the public system, giving them a likely condition of inadequate water supply.

As it is not possible to assess the quality of the water from the census questionnaire, it has adopted a more restrictive analysis that considers inadequate all the sources that are not connected to the public network.

This means that the final **Adequate Water Supply Index** is the percentage of residents in a condition of environmental disburden (or adequate water supply: result of the percentage of residents in permanent private households with water supply from the public network system). Consequently, the opposite situation represents the environmental burden (or inadequate water supply: result of the percentage of residents in permanent private households without supply from the public network system, which comprises all other water intake sources).

The obtained percentages were entered into the census tracts original shapefile according to each feature geocode, thus enabling the spatialization of the index. The symbology of the legend was classified according to the Natural Breaks (Jenks) method in 16 classes varying from 12% (the lowest percentage of adequate water supply for a census tract) to 100% (the highest percentage).

**ii. sanitary sewage information for residents in permanent households;**

The following indicators were considered for this topic:

- Residents in permanent private households with bathroom or toilet for the exclusive use of residents and sanitation through the sewage or rainwater network system;
- Residents in permanent private households with bathroom or toilet for the exclusive use of residents and sanitation via septic tank;
- Residents in permanent private households with bathroom or toilet for the exclusive use of residents and sanitation via rudimentary cesspool;
- Residents in permanent private households with bathroom or toilet for the exclusive use of residents with sanitary effluent into ditch;
- Residents in permanent private households with bathroom or toilet for the exclusive use of residents with sanitary effluent into river, lake or sea;
- Residents in permanent private households with bathroom or toilet for the exclusive use of residents with sanitary effluent into another sinkhole;
- Residents in permanent private households with no bathroom or toilet for the exclusive use of residents.
The abovementioned indicators correspond to the means of effluent disposal and the result in the spreadsheet is represented in absolute numbers for each census tract.

Subsequently, for each question carried out was a percentage apportioning compared to the total population of the census tract. The final index for this topic is the percentage of resident in a condition of environmental disburden (or adequate sanitation: result of the percentage of residents in permanent private households with bathroom or toilet for the exclusive use of residents and sanitation through the sewage or rainwater network system). As a result, the opposite situation represents an environmental burden (or inadequate sanitation: result of the percentage of residents in permanent private households with sanitary effluent into septic tank, rudimentary cesspool, ditch, water body and other sinkholes, or without bathroom or toilet for the exclusive use of residents).

It is worth noting that the release of effluent in septic tanks is restrictively considered as inadequate sanitation in the urban context. Such units consist of a primary form of treatment of wastewater while simply performing the separation of the solids contained in the sewage. It is indicated especially for rural or isolated residences. However, the treatment is not complete and therefore cannot be considered sufficient to areas of higher population density.

The obtained percentages were entered into the census tracts original shapefile according to each feature geocode, thus enabling the spatialization of the Adequate Sanitation Index. The symbology of the legend was classified according to the Natural Breaks (Jenks) method in 32 classes varying from 0% (the lowest percentage of adequate sanitation for a census tract) to 100% (the highest percentage).

iii. Existence or absence of open sewage in the plot or in front of it.

The following indicators were considered for this topic:

- Permanent households - There is open air sewage in the plot or in front of it;
- Permanent households - There is no open air sewage in the plot or in front of it;

These indicators correspond to the observation of open air sewage in the plot of the households or in front of it and the result in the spreadsheet is represented in absolute numbers for each census tract.

This indicator is a result of the observation of polluted waters by the presence of liquid effluents in the vicinity of lots, e.g. streams, rivers, lakes and other drainage channels visually identifiable as polluted.

Some inconsistencies were observed when crossing the variables for this indicator. Occasionally some census tracts showed absolute zero as a result both for
the existence of open air sewage, and for its absence. Since this condition was observed in a small number of tracts, it was understood that the inconsistencies were not significant for the indicator to be discarded. The most restrictive condition was considered for those cases, namely the existence of open air sewage.

A percentage apportioning compared to the total population of the census tract was carried out. The final Open Air Sewage Exposure Index is the percentage of households in a condition of environmental disburden (or absence of exposure to open air sewage in the plot or in front of it). The opposite situation represents an environmental burden (or the exposure to open air sewage in the plot or in front of it).

The obtained percentages were entered into the census tracts original shapefile according to each feature geocode, thus enabling the spatialization of the index. The symbology of the legend was classified according to the Natural Breaks (Jenks) method in 32 classes varying from 100% (the highest percentage of residents without exposure to open air sewage for a census tract) to 0% (the lowest percentage).

After the creation of the partial indices, they are summed in order to obtain the final WS-I. The sum operation is performed by of ArcMap 9.3 for each parameter’s percent values. With the purpose of summing, all partial indices shapefiles have to be converted into images. The ArcToolbox is used with the aim of converting the polygons into raster files. The second step is the overlaying of the converted raster files in order to generate a single raster file which comprises the sum of all partial indices. Once again the ArcToolbox performs the geostatistical operation. The new summed raster file is reconverted into a shapefile so it can be reclassified.

The new polygon is then reclassified according to the Natural Breaks (Jenks) method into four categories varying from the total sum of 13 (the lowest summed value) to 300 (the highest summed value). The lowest values represent the summed percentage of residents per census tract with a less favorable environmental situation and consequently higher exposure to environmental stressors related to water and sanitation parameters. The Table 3-9 below demonstrates the breaks considered for each class, which compose the final index.
Table 3-9 – Water and Sanitation Index map key

<table>
<thead>
<tr>
<th>Map Key</th>
<th>Intervals</th>
<th>Category</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Very high</td>
<td>≤ 13 - 156</td>
<td>4</td>
<td>Most of the residents have no access to safe water supply and sanitation and/or are exposed to open air sewage</td>
</tr>
<tr>
<td>High</td>
<td>≤ 157 - 229</td>
<td>3</td>
<td>A significant parcel of the population have no access to safe water supply and sanitation and/or are exposed to open air sewage</td>
</tr>
<tr>
<td>Medium</td>
<td>≤ 230 - 276</td>
<td>2</td>
<td>Few residents have no access to safe water supply and sanitation and/or are exposed to open air sewage</td>
</tr>
<tr>
<td>Low</td>
<td>≤ 277 - 300</td>
<td>1</td>
<td>The majority of the residents are supplied with safe water and sanitation and are not exposed to open air sewage</td>
</tr>
</tbody>
</table>

3.3.4 Public Green Index – PG-I

The map corresponding to the Public Green Index – PG-I is a product of the overlaying of three corresponding parameters.

The indicators were partly obtained from the 2010 census, but also with information from the Regional Strategic Plan from Santo Amaro and Cidade Ademar subprefectures, satellite images, field surveillance and previously obtained geodatabase. The FIG.3-5 below illustrates the steps to the creation of the final index, which are detailed in the sequence.

**FIG. 3-5 - Creation scheme of indicators and partial indices for the Public Green Index.**
For the consolidation of all partial indices different analytical methods already discussed in this chapter were used. They are particularized in the sequence.

i. **Provision of public green spaces**

Some criteria are fundamental to assess the provision of green spaces for the study area and the reference methods (Kleinschmit et al., 2011; SenStadt, 2013a) sets the cornerstones for its assertion:

- **The area must be at least 0.5 ha large.**

Recreational open spaces must have a minimum size of 0.5 ha in order to make type-specific use possible. Small areas can be considered if they are located in the context of a larger green network structure.

- **The accessibility must be barrier free.**

Unhindered accessibility to open green space must be guaranteed. Obstacles include railway tracks, water bodies, motorways and fences.

Such characteristics nullify the possibility of considering the environmental protection areas and other native vegetation fragments. In Brazil, these sites, when within urban areas, are invariably fenced in order to prevent invasions and deforestation. The below Table 3-9 describes the considered areas.

<table>
<thead>
<tr>
<th>Considered</th>
<th>Not considered</th>
</tr>
</thead>
<tbody>
<tr>
<td>Public and open access parks, squares, beaches and other recreational areas with more than 0.5 ha</td>
<td>Non accessible public environmental preservation areas</td>
</tr>
<tr>
<td>Private areas</td>
<td>Traffic routes’ medians and roundabouts</td>
</tr>
<tr>
<td>Traffic routes’ medians and roundabouts</td>
<td>Non accessible grassy areas (airport, channel margins, railway tracks, transmission lines, etc.)</td>
</tr>
<tr>
<td>Non accessible vegetation fragments</td>
<td></td>
</tr>
</tbody>
</table>

In order to obtain the previous cited areas, the present research assessed the Regional Strategic Plan for Santo Amaro (SEPLSA, 2004a) and Cidade Ademar (SEPLSA, 2004b) which brings a set of maps that illustrates ‘parks and municipal areas’ corresponding to the available green spaces according to the land use.
However, a significant disparity in terms of area size, characteristics and availability was evidenced when comparing the existing cartography and the actual situation. To refine the information, the ‘parks and municipal areas’ were projected over satellite image (Google Earth Pro, 2013). This step enabled the redesign and superficial analysis of the characteristics of each area. The information was supplemented by field surveys to the areas.

- **The area must be located within a radius of approximately 500 metres from a residence;**

Determining the minimum acceptable walking distance is a complex task since one must consider a number of physical factors such as topography, road geometry, sidewalk condition, climate, land use, public security, lighting, as well as individual dimensions such as mobility and psychological limitations, people’s needs and motivations, among others.

It is not part of this study to conduct an investigation over the individual urban mobility determination, however it is necessary to obtain an average mark that can appraise the minimum distance that a household needs to locate from a public green space to benefit from it.

In order to restrict the randomness in determining a minimum acceptable walking distance, it adopted the standard given by the studies of circulation from the publications over public transports. In the case of Porto Alegre, a minimum of 500 meters walking distance was specified to an urban bus stop in relatively flat and densely populated neighbourhoods (Ladeira et al, 2006). The value is compatible with the average distance predicted by the reference method (SenStadt, 2013). This radius of 500m is the **intake area** and sets a predetermined buffer zone around the considered green spaces.

- **The availability degree is set in 6 sq. m. of green space per inhabitant.**

The reference methods consider the availability of 6 sq. m. of open green space per inhabitant sufficient. After determining the 500 metres buffer zone, the census tracts that have at least half of their polygon encompassed by the intake area are considered for the calculation. As it is not possible to split the census tracts to consider just the population encompassed by the intake area, those border polygons with its areas partially subsumed had the entire population considered for the calculus. Situations in which a census tract is included in two or more intake areas demands a sum of the green space sizes.

The degree of availability of public green space per inhabitant is obtained by the division of the size, or the summed sizes of the green spaces considered, and the summed population of the census tracts encompassed by the intake area. This
degree is divided into four levels to generate the **Public Green Space Provision Index** as presented in the Table 3-11.

### Table 3-11 - Public Green Space Provision Index map key

<table>
<thead>
<tr>
<th>Map Key</th>
<th>Green space provision (sq. meter/resident)</th>
<th>Category</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>High/Very High</td>
<td>&gt; 6.0</td>
<td>4</td>
<td>provided/well provided</td>
</tr>
<tr>
<td>Medium</td>
<td>≤ 6.0 - 3.1</td>
<td>3</td>
<td>underprovided</td>
</tr>
<tr>
<td>Low</td>
<td>3.0 - 0.1</td>
<td>2</td>
<td>poorly provided</td>
</tr>
<tr>
<td>Very Low</td>
<td>&lt; 0.1</td>
<td>1</td>
<td>not provided/strongly underprovided</td>
</tr>
</tbody>
</table>

Source: Adapted from SenStadt, 2009; Kleinschmit et al., 2011.

### ii. Provision of trees

The following indicators obtained from the 2010 census were considered for this topic:

- Permanent households - there are trees;
- Permanent households - there is no tree;

These indicators correspond to the observation of trees in the plot or in front of it. The result in the spreadsheet is the absolute number of households with or without trees in the vicinity, regardless of the amount of trees evidenced, for each census tract. Some inconsistencies were observed when crossing the variables for this indicator. Occasionally, some census tracts showed absolute zero as a result both for the existence of trees, and for its absence. Since this condition was observed in a small number of tracts it was understood that the inconsistencies were not significant for the indicator to be discarded. The most restrictive condition was considered for those cases, namely the absence of trees.

A percentage apportioning compared to the total population of the census tract was carried out. The final **Trees Provision Index** is the percentage of households in a condition of environmental disburden (or provided by trees in the plot or in front of it). The opposite situation represents an environmental burden (or the absence of trees in the plot or in front of it). The obtained percentages were entered into the census tracts original shapefile according to each feature geocode, thus enabling the spatialization of the index. The symbology of the legend was classified according to the Natural Breaks (Jenks) method in 4 classes or categories varying from 100% (the highest percentage of households provided with trees in the plot or in front of it) to 0% (the lowest percentage) as seen on the map key at the Table 3-12 below.
Table 3-12 - Trees Provision Index map key.

<table>
<thead>
<tr>
<th>Map Key</th>
<th>Provision of Trees Index (% of households)</th>
<th>Category</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>High/Very High</td>
<td>≤ 84 – 100</td>
<td>4</td>
<td>provided/well provided</td>
</tr>
<tr>
<td>Medium</td>
<td>≤ 54 – 83</td>
<td>3</td>
<td>underprovided</td>
</tr>
<tr>
<td>Low</td>
<td>≤ 20 – 53</td>
<td>2</td>
<td>poorly provided</td>
</tr>
<tr>
<td>Very Low</td>
<td>≤ 19</td>
<td>1</td>
<td>not provided/strongly underprovided</td>
</tr>
</tbody>
</table>

iii. Urban tree-canopy coverage

An additional noteworthy approach of assessing the quality of urban green is through the classification of the tree-canopy distribution (Jim, 1989; Furlan, 2004; Assis, 2009; Cruz, 2013; King and Locke, 2013).

Jim (1989) proposes comprehensive classification criteria for urban tree cover using its inherent geometric attributes. The shape of canopies corridors and fragments are used as cardinal differentia, identifying three major groups: isolated, linear and connected. Three variants per each group are then divided according to coverage, connectivity and contiguity. The FIG.3-6 illustrates the nine categories for urban tree canopy configuration in a continuum of spatial changes.
According to Jim (1989: p. 217) “the isolated types are dominated by artificial covers of buildings, roads, and other nonplantable impermeable materials”. The linear type presents characteristics of “juxtaposition of trees in one dominant direction in response to regimentation by elongated artificial habits” (Jim, 1989: p. 217). The connected types have a higher degree of connectivity and contiguity and are normally established before the inroad of urbanization, although they are present in the urban fabric.

In his master thesis, Cruz (2013) produced an analysis of the tree-canopy connectivity for the subprefectures of Santo Amaro and Cidade Ademar according to Jim’s abovementioned methodology. The present research had access to the results and the digital database produced.
From the obtained shapefile, the nine variants were reclassified according to the emoluments to city life propitiated by the quality of canopy coverage as following (Table 3-13).

### Table 3-13 – Environmental emoluments of tree-canopies configuration

<table>
<thead>
<tr>
<th>Tree-canopy emoluments</th>
<th>Map Key</th>
<th>Tree-canopy configuration</th>
<th>Category</th>
<th>Vegetation description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Very High</td>
<td>3.c</td>
<td>4</td>
<td>natural areas only</td>
<td></td>
</tr>
<tr>
<td>High</td>
<td>2.a; 2.b; 2.c; 3.a; 3.b</td>
<td>3</td>
<td>environmental excellence when mixed with urban equipment</td>
<td></td>
</tr>
<tr>
<td>Average</td>
<td>1.b; 1.c</td>
<td>2</td>
<td>clustered within urban fabric and clumped in green areas</td>
<td></td>
</tr>
<tr>
<td>Low</td>
<td>1.a</td>
<td>1</td>
<td>absence or semi-absence</td>
<td></td>
</tr>
</tbody>
</table>

Subsequently each census tract is associated with a category of predominant environmental emolument in order to generate the Quality of Tree-Canopy Coverage Index map.

After the creation of the partial indices, they are summed so that one can get the final PG-I. The sum operation is performed by of ArcMap 9.3 for each parameter’s ‘Category’ values. In order to be summed, all partial indices shapefiles have to be converted into images. The ArcToolbox is used with the aim of converting the polygons into raster files. The second step is the overlaying of the converted raster files in order to generate a single raster file which comprises the sum of the three partial indices. Once again the ArcToolbox performs the geostatistical operation. The new summed raster file is reconverted into a shapefile so it can be reclassified.

The new polygon is then reclassified according to the Tables 3-14 and 3-15 into four classes varying from the total sum of 3 (the lowest summed ‘Category’ value) to 12 (the highest summed value). The lowest values represent the sum of the high provision of Trees and Public Green Spaces per census tract and consequently low exposure to environmental stressors.

### Table 3-14 – Public Green Index matrix analysis.

<table>
<thead>
<tr>
<th>Environmental benefit</th>
<th>PG-I: Possible sums</th>
</tr>
</thead>
<tbody>
<tr>
<td>4</td>
<td>Low/Very low</td>
</tr>
<tr>
<td>3</td>
<td>Average/Low</td>
</tr>
<tr>
<td>2</td>
<td>Medium/High</td>
</tr>
<tr>
<td>1</td>
<td>Very high/High</td>
</tr>
</tbody>
</table>

QTCC-I – Quality of Tree-Canopy Coverage Index; TP-I – Trees Provision Index; Public Green Space Provision Index; PG-I – Public Green Index;
Table 3-15 – Public Green Index map key

<table>
<thead>
<tr>
<th>Exposure to environmental stressors</th>
<th>Map Key</th>
<th>Possible Sums</th>
<th>Category</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Very high</td>
<td></td>
<td>8-12</td>
<td>4</td>
<td>Most residents have no access to public green spaces and are not benefited by urban trees.</td>
</tr>
<tr>
<td>High</td>
<td></td>
<td>6 - 7</td>
<td>3</td>
<td>A significant parcel of the population have no access to public green spaces and/or are not benefited by urban trees.</td>
</tr>
<tr>
<td>Medium</td>
<td></td>
<td>5</td>
<td>2</td>
<td>Few residents have no access to public green spaces and/or are not benefited by urban trees.</td>
</tr>
<tr>
<td>Low</td>
<td></td>
<td>3 - 4</td>
<td>1</td>
<td>The majority of the residents have access to public green spaces and are benefited by urban trees.</td>
</tr>
</tbody>
</table>

3.3.5 Low-Surface Temperature Index – LST-I

Climatic stress is considered as a phenomenon induced by hot atmospheric conditions negatively affecting the energy balance of the human body (Kovats and Hajat, 2008 apud Dugord, 2013).

As Dugord examined, recent studies have proved that urban structures and especially Urban Heat Islands - UHI’s – “affect directly (e.g. through increased local temperatures) and indirectly (e.g. through air pollution) the thermal comfort and health of the cities’ dwellers (Harlan et al., 2006; Schwarz et al., 2012)” (Dugord, 2013: p.22).

Analysis of climatic factors influencing thermal comfort in urban areas is based on a series of indicators that rely on a dense monitoring array. Unfortunately, these indicators are not available for the study area. However, near-ground temperature is a convenient indicator for air temperatures and is being widely used in UHI’s phenomenon studies (Dugord, 2013).

The present analysis is based on the modelled near-ground air temperature presented by the São Paulo Environmental Atlas (SVMA, 2013). It is the only reliable indicator available for the study area. Through this single data it is possible to identify relevant climatic patterns and possible environmental stressors.

The referenced map draws the apparent surface temperature from Landsat-7 ETM+ Satellite Image, Thermal Band (TM6+), scene from September 3rd 1999 at 09:57 AM.

The temperature ranges from 25.5°C to 30.5°C and were reclassified into four classes as exemplified below on Table 3-16.
Table 3-16 – Low-Surface Temperature Index map key

<table>
<thead>
<tr>
<th>Map Key</th>
<th>Interval (°C)</th>
<th>Category</th>
<th>Land use characteristics</th>
</tr>
</thead>
<tbody>
<tr>
<td>Very high</td>
<td>&gt; 30</td>
<td>4</td>
<td>Densely populated areas with no vegetation coverage and high albedo</td>
</tr>
<tr>
<td>High</td>
<td>29 – 30</td>
<td>3</td>
<td>Predominantly impervious surfaces and increased albedo</td>
</tr>
<tr>
<td>Medium</td>
<td>28 - 29</td>
<td>2</td>
<td>Urban fabric intermingled with arboreal corridors and vegetation clusters</td>
</tr>
<tr>
<td>Low</td>
<td>&lt; 28</td>
<td>1</td>
<td>Areas under influence of water bodies and dense vegetation fragments</td>
</tr>
</tbody>
</table>

3.3.6 Urban Environmental Quality Index – UEQ-I

As a repetition of the previous steps that led to the creation of the partial indices, those are summed in order to generate the final Urban Environmental Quality Index – UEQ-I.

Every census tract of the new polygon is then reclassified according to an additive approach method associated with the number of exposures to environmental stressors. This method ensures that the final composition can emphasize exposure to environmental impacts by multiplying the sum of the categories by a factor indicating the number of exposures to environmental stressors.

This technique is performed in order to avoid the masking of burdens when simple summing the categories. The UEQ is therefore the result of a calculation that obeys the following equation:

$$UEQ \cdot \text{factor} = [(W-I + WS-I + PG-I + LST-I) \times \text{ES}] + (W-I + WS-I + PG-I + LST-I)$$

The variable ES represents the number of exposures to environmental stressors regarding all partial indices as detailed below (Table 3-17). It is important to highlight that, in order to limit the influence of the LST-I in the composition of the final UEQ-I the exposure to environmental stressor for the aforementioned index was multiplied by 0.5. Knowing that the LST-I is insufficient to explain the urban climate conditions, the measure is established to offset the index’s weight in face of the other eight parameters that compose more relevant indices regarding urban environmental quality.
Table 3-17 – ES variable composition.

<table>
<thead>
<tr>
<th>Exposure to environmental stressor?</th>
<th>Individual index ES value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Categories 3 and 4 – YES</td>
<td>1.0 (for W-I, WS-I, PG-I) or 0.5 (for LST-I)</td>
</tr>
<tr>
<td>Categories 1 and 2 – NO</td>
<td>0.0</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>W-I / WS-I / PG-I</th>
<th>LST-I</th>
<th>ES</th>
</tr>
</thead>
<tbody>
<tr>
<td>YES for all indices</td>
<td>YES</td>
<td>3.5</td>
</tr>
<tr>
<td>YES for all indices</td>
<td>NO</td>
<td>3.0</td>
</tr>
<tr>
<td>YES for two indices</td>
<td>YES</td>
<td>2.5</td>
</tr>
<tr>
<td>YES for two indices</td>
<td>NO</td>
<td>2.0</td>
</tr>
<tr>
<td>YES for one index</td>
<td>YES</td>
<td>1.5</td>
</tr>
<tr>
<td>YES for one index</td>
<td>NO</td>
<td>1.0</td>
</tr>
<tr>
<td>No for all indices</td>
<td>YES</td>
<td>0.5</td>
</tr>
<tr>
<td>No for all indices</td>
<td>NO</td>
<td>0.0</td>
</tr>
</tbody>
</table>

The **UEQ**-factor is then reclassified according to Natural Breaks (Jenks) into four classes representing the **UEQ-I** categories (Table 3-18).

Table 3-18 - Urban Environmental Quality Index map key.

<table>
<thead>
<tr>
<th>Map Key</th>
<th>UEQ-factor</th>
<th>Category</th>
</tr>
</thead>
<tbody>
<tr>
<td>Least Favourable</td>
<td>≥ 54</td>
<td>4</td>
</tr>
<tr>
<td>Unfavourable</td>
<td>33 - 52</td>
<td>3</td>
</tr>
<tr>
<td>Favourable</td>
<td>18 – 30</td>
<td>2</td>
</tr>
<tr>
<td>Very Favourable</td>
<td>≤ 16</td>
<td>1</td>
</tr>
</tbody>
</table>

### 3.3.7 São Paulo’s Social Vulnerability Index – IPVS

The social vulnerability map for the study area was elaborated based on the **São Paulo’s Social Vulnerability Index 2010** (Portuguese: Índice Paulista de Vulnerabilidade Social - IPVS). The IPVS was created by the Seade Foundation[^4] - State System for Data Analysis - for all State of São Paulo, with the intention of offering the public manager and the general public a more detailed overview of the intra-urban living conditions, identifying the spatial location of areas that concentrate the population segments most vulnerable to poverty (Fundação Seade, 2013). The index is a combination between the socioeconomic and demographic dimensions (Table 3-19) obtained from the inquiry applied by the 2010 Census on its basic questionnaire.

[^4]: The Fundação Seade is a foundation linked to the Department of Planning and Regional Development of the State of São Paulo dedicated to the production and dissemination of socioeconomic and demographic statistics and analysis.
Assessing Urban Environmental Justice in Santo Amaro and Cidade Ademar subprefectures, São Paulo, Brazil

Table 3-19 - IPVS variable composition.

<table>
<thead>
<tr>
<th>Variables - 2010 census</th>
<th>Socioeconomic dimension</th>
<th>Demographic dimension</th>
</tr>
</thead>
<tbody>
<tr>
<td>average income of women responsible for the household</td>
<td>% Of heads of household aged 10 to 29 years old</td>
<td></td>
</tr>
<tr>
<td>% Of households with household income per capita up to half a minimum wage</td>
<td>% Of women heads of household aged 10 to 29 years old</td>
<td></td>
</tr>
<tr>
<td>% Of households with household income per capita of up to one quarter a minimum wage</td>
<td>average age of people heads of household</td>
<td></td>
</tr>
<tr>
<td>% Of heads of household alphabetized household income per capita</td>
<td>% Of children 0-5 years old</td>
<td></td>
</tr>
</tbody>
</table>


The final index was obtained from a cluster analysis using a factorial calculation which compared the socioeconomic and demographic results of the last census with the results from the year 2000. The cross-comparison of the clusters factorial scores with information on the type of the census tract (subnormal or not special) and its location in the municipality (urban or rural) generated seven social vulnerability groups (Table 3-20) that classified all the census tracts with more than 50 households.

Table 3-20 – Vulnerability groups for the IPVS 2010.

<table>
<thead>
<tr>
<th>IPVS 2010</th>
<th>Groups</th>
<th>Dimensions</th>
<th>Situation and type of tracts per group</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lowest vulnerability</td>
<td>1</td>
<td>Very high</td>
<td>Young, adult and elderly families</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Urban and rural non-special and subnormal</td>
</tr>
<tr>
<td>Very low vulnerability</td>
<td>2</td>
<td>Average</td>
<td>Adult and elderly families</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Urban and rural non-special and subnormal</td>
</tr>
<tr>
<td>Low vulnerability</td>
<td>3</td>
<td>Average</td>
<td>Young families</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Urban and rural non-special and subnormal</td>
</tr>
<tr>
<td>Average vulnerability</td>
<td>4</td>
<td>Low</td>
<td>Adult and elderly families</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Urban and rural non-special and subnormal</td>
</tr>
<tr>
<td>High vulnerability</td>
<td>5</td>
<td>Low</td>
<td>Young families in urban tracts</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Urban non-special</td>
</tr>
<tr>
<td>Very high vulnerability</td>
<td>6</td>
<td>Low</td>
<td>Young families in urban subnormal tracts</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Urban subnormal</td>
</tr>
<tr>
<td>High vulnerability (not applicable to the study area)</td>
<td>7</td>
<td>Low</td>
<td>Young, adult and elderly families in rural tracts</td>
</tr>
</tbody>
</table>


5 Due to specificities of spatial occupation, census tracts can be defined as subnormal. This is the case of the favelas, whose standard includes high density, narrow and nameless alleys (CEM, 2013a).
The obtained data was entered into the census tracts original shapefile according to each feature geocode, thus enabling the spatialization of the index. The Group 7 does not apply to the study area.

3.3.8 Environmental Justice Index – EJ-I

The Environmental Justice Index – EJ-I is generated from a matrix analysis between UEQ-I and IPVS. The technical procedures which allow the sum of both indices are repeated in the same manner of the creation of partial indices, namely conversion into raster files, the sum of the raster files, conversion to polygons and reclassification in accordance with Tables 3-21 and 3-22 below.

Table 3-21 – Environmental Justice matrix analysis.

<table>
<thead>
<tr>
<th>IPVS</th>
<th>Very Favourable</th>
<th>Favourable</th>
<th>Unfavourable</th>
<th>Least Favourable</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lowest</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Very Low</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Low</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Average</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>High</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Very High</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

UEQ-I – Urban Environmental Quality Index; IPVS – São Paulo’s Social Vulnerability Index
### Table 3-22 – Environmental Justice Index map key

<table>
<thead>
<tr>
<th>Environmental Justice: Integrated Environmental Quality and Social Vulnerability Index</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Very low</td>
<td>Multiple exposure to environmental stressors and high, very high or average social vulnerability</td>
</tr>
<tr>
<td>Low</td>
<td>Multiple exposure to environmental stressors and average, low or very low social vulnerability</td>
</tr>
<tr>
<td>Medium</td>
<td>Few exposure to environmental stressors and low, average, high or very high social vulnerability; multiple exposure to environmental stressors and very low or lowest vulnerability</td>
</tr>
<tr>
<td>High</td>
<td>No exposures to environmental stressors; unfavourable exposure to environmental stressors and the lowest vulnerability</td>
</tr>
</tbody>
</table>
4 RESULTS AND DISCUSSION

This chapter displays the cartographic results and performs a related discussion of the main evident data in order to reflect on the difficulties and gains pertinent to the pursuing of the research’s intent.

4.1 Contrasting areas: results presentation

The sixteen maps presented below appear in different scales according to the stage of development of each. The first partial indexes, in all eight maps are shown at scale 1:65,000. The second partial indices, totalling six maps, are shown in greater detail scale of 1:40,000. In turn, the final index for Environmental Justice is presented in scale 1:15,000. The FIG.4-1 presents an overview of all maps developed.

4.1.1 Waste

The FIG.4-2 and FIG.4-3 are set out in the sequence and comprise the partial index contained within the MAP.4-1 - Waste Index.
Assessing Urban Environmental Justice in Santo Amaro and Cidade Ademar subprefectures, São Paulo, Brazil

FIG. 4-1 - Low resolution overview of the 16 maps developed.
Assessing Urban Environmental Justice in Santo Amaro and Cidade Ademar subprefectures, São Paulo, Brazil

FIG. 4-2 - Waste Collection Index Map
Assessing Urban Environmental Justice in Santo Amaro and Cidade Ademar subprefectures, São Paulo, Brazil

FIG. 4-3 – Accumulated Waste Index Map.
Legend

- Municipal limit
- Districts
- Limits of the Study Area
- Census Tracts
- Water Bodies

Waste Index

- No data
- Exposure to Environmental Stressors:
  - Very High
  - High
  - Medium
  - Low

Source: FBHAT, 2009; IBGE, 2010

MAP.4-1 – Waste Index Map

Transverse Mercator
SIRGAS 2000
UTM Zone 23 South

0 0.5 1 2 3 4 Km
1:40,000

Source: FBHAT, 2009; IBGE, 2010
In São Paulo the household solid waste collection is divided into two different systems with alternating days of service: the collection of recyclables, which are not taken into account by the present research because it is not surveyed by the IBGE Census; and the regular collection of solid waste which are disposed in sanitary landfills.

Population growth and increasing consumer choices undoubtedly produce direct impact on waste generation per capita. The regular collection of solid waste reaches 9.9 thousand tons daily, which represents more than 300 kg of waste per inhabitant yearly, however currently only 1.5% of this amount is recovered or reused by proper sorting and composting (São Paulo, 2012).

Garbage collection is seemingly universalized within the city. The last census shows that less than 1% of the population is not served by adequate collection. The data analyzed for the study area corroborates this statement. As FIG.4-4 shows, a total of 99.4% of the population has adequate solid waste collection and there are no significant discrepancies between districts.

However, a detailed analysis reveals that, despite the vast majority of the areas are 100% served, some census tracts presented rates significantly below the universality.

The exceptional cases (when less than 70% of residents receive collection) totalling 5 census tracts are all found in the districts of Cidade Ademar and Pedreira, visible in the above MAP.4-1. As shown in Table 4-1 below just one of the census tracts analyzed presents an average monthly income substantially higher than the average of the respective district. The others have only a fraction of these.
Table 4-1 – Lowest waste collection indices vs. income per census tract

<table>
<thead>
<tr>
<th>District</th>
<th>% of collection</th>
<th>Pop.</th>
<th>Average monthly income – tract (R$)</th>
<th>Average monthly income – district (R$)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cidade Ademar</td>
<td>34</td>
<td>1062</td>
<td>2676,00</td>
<td>1010,53</td>
</tr>
<tr>
<td>Pedreira</td>
<td>48</td>
<td>616</td>
<td>869,00</td>
<td>865,64</td>
</tr>
<tr>
<td>Cidade Ademar</td>
<td>56</td>
<td>373</td>
<td>556,00</td>
<td>1010,53</td>
</tr>
<tr>
<td>Cidade Ademar</td>
<td>67</td>
<td>43</td>
<td>492,00</td>
<td></td>
</tr>
<tr>
<td>Cidade Ademar</td>
<td>69</td>
<td>409</td>
<td>370,00</td>
<td></td>
</tr>
</tbody>
</table>

Source: IBGE Census, 2010 (IBGE, 2011)

Regarding the accumulation of garbage in the vicinity of lots, substantially higher rates were observed in the subprefecture of Cidade Ademar (FIG. 4-5).

FIG. 4-5 - Percentage of residents exposed/not exposed to accumulated waste.

The rates demonstrate that, despite the universalized residential collection, in the most deprived districts there is a considerable gap in the services of street cleaning. Still, the quantities that do not have the correct destination are irregularly disposed in common ground (PHOTO 4-1) invariably located in areas of lower social status.
In addition to the discrepancies between districts is also observed that there are intra-districts inequalities. With the exception of Santo Amaro, all other districts presents at least one census tract that identify 100% of the residents with exposure to waste accumulation, quite clear in the correspondent Map 4-2.

The final index for the topic (Fig. 4-6) largely reflects the circumstances shown by the accumulated waste index and thus reveals a difference between the districts that comprise both subprefectures.
Assessing Urban Environmental Justice in Santo Amaro and Cidade Ademar subprefectures, São Paulo, Brazil

4.1.2 Water and Sanitation

The FIG.4-7, FIG.4-8 and FIG.4-9, presented below, comprise the partial index contained within the MAP.4-2 – Water and Sanitation Index.
Assessing Urban Environmental Justice in Santo Amaro and Cidade Ademar subprefectures, São Paulo, Brazil

FIG. 4-7 - Water Supply Index Map.
Assessing Urban Environmental Justice in Santo Amaro and Cidade Ademar subprefectures, São Paulo, Brazil

FIG. 4-8 – Sanitation Index Map.
Assessing Urban Environmental Justice in Santo Amaro and Cidade Ademar subprefectures, São Paulo, Brazil

FIG. 4-9 – Open Air Sewer Index Map.
Assessing Urban Environmental Justice in Santo Amaro and Cidade Ademar subprefectures, São Paulo, Brazil
The evolution of water and sewage systems followed the SPMR’s development evolving from isolated solutions to its interconnection through integrated systems. The service provision is currently entrusted to the State of São Paulo, with the exception of urban drainage when it comes to micro-drainage, which is treated by the municipality.

In the same way as the waste collection, the treated water distribution in São Paulo is practically universalized. Just near 1% of the population do not have access to adequate water supply. The situation is also replicated in the studied area being apparently irrelevant the percentage differences (FIG.4-10).

![Water Supply Adequacy](image)

**FIG. 4-10 - Percentage of residents with/without adequate water supply.**

Again the differences are best understood when observing cases in each district. Three cases stand out in the districts of Pedreira, Cidade Ademar and Campo Grande (Table 4-2). Campo Belo and Santo Amaro in turn have no rates inferior than 92% and 97% respectively.

**Table 4-2 – Lowest water supply indices vs. income per census tract.**

<table>
<thead>
<tr>
<th>District</th>
<th>supplied pop.</th>
<th>Pop.</th>
<th>Average monthly income - tract</th>
<th>Average monthly income - district</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pedreira</td>
<td>11%</td>
<td>568</td>
<td>R$ 630,00</td>
<td>R$ 865,64</td>
</tr>
<tr>
<td>Cidade Ademar</td>
<td>14%</td>
<td>409</td>
<td>R$ 370,00</td>
<td>R$ 1010,53</td>
</tr>
<tr>
<td>Campo Grande</td>
<td>70%</td>
<td>627</td>
<td>R$ 1156,00</td>
<td>R$ 2979,68</td>
</tr>
</tbody>
</table>

Source: IBGE Census, 2010 (IBGE, 2011)
The census universe result includes a total of nearly 20 thousand households without access to the water supply network in the municipality. These are concentrated in peripheral areas, including the southern districts of the study area.

As for sanitation, according to the 2010 census (IBGE, 2011) in São Paulo more than 13% of residents are not served by the public sanitation system, and many of these households that possess environmentally harmful forms of disposal (9% of the municipality) are located in areas of watershed protection.

This is the case of Pedreira district which has the worst rates as evidenced in the FIG. 4-11 chart. The fact that the census tracts with the lowest rates are located on the margins of the Billings reservoir and its tributaries is a major aggravating factor.

![FIG. 4-11 - Percentage of residents with/without adequate sanitation.](image)

Due to this scenario, it is not by chance that 9.1% of the Pedreira's residents are exposed to contaminated drainage channels as shown in the FIG.4-12 graph and illustrated in the PHOTOS 4-2 and 4-3.
The results for the index regarding the topic Water and Sanitation (FIG.4-13) reflect the conditions highlighted, particularly in the final disposal of domestic effluents. The districts within the subprefecture of Cidade Ademar, which is located in an area environmentally sensitive and crucial to the quality of water supply, bear the highest sanitation precariousness. Consequently, the aforementioned districts contribute to the overall rate of the study area to be less stringent than those of the municipality, while the subprefecture of Santo Amaro presents a comparatively eased scenario with low exposure to environmental burdens.
FIG. 4-13 - Percentage of residents with/without exposure to environmental stressors related to water and sanitation.

4.1.3 Public Green

The FIG.4-14, FIG.4-15 and FIG.4-16, on hand underneath, comprise the partial index contained within the MAP.4-3 – Public Green Index Map.
Assessing Urban Environmental Justice in Santo Amaro and Cidade Ademar subprefectures, São Paulo, Brazil

FIG. 4-14 - Public Green Spaces Provision Index Map.
Assessing Urban Environmental Justice in Santo Amaro and Cidade Ademar subprefectures, São Paulo, Brazil

FIG. 4-15 – Provision of Trees Index Map.

Provision of Trees Assessment

Legend

- **Districts**
- **Water Bodies**

- **1:65,000**
- **0 1,000 2,000 4,000 6,000 8,000 Meters**

- **Transverse Mercator**
- **SIRGAS 2000**
- **UTM - Zone 23 South**

**Source:**

- **FBHAT, 2009**
- **IBGE, 2010**
Assessing Urban Environmental Justice in Santo Amaro and Cidade Ademar subprefectures, São Paulo, Brazil

FIG. 4-16- Map of the Quality of Tree-canopy Coverage
Assessing Urban Environmental Justice in Santo Amaro and Cidade Ademar subprefectures, São Paulo, Brazil
The expansion of São Paulo has significantly altered the vegetation engulfing its original site. The original dense ombrophilous rainforest is a tropical forest formation characterized by a high degree of flora endemism. This process transformed, in a definitive manner, the pre-colonial landscape which led not only to an ecological loss but to the erosion of an extensive list of benefits and amenities that the attributes of the natural landscape provides to urban life.

Still in the 1990s, a period when the city experienced a major population expansion in its peripheral districts, the area of the municipality was occupied in just 5.9% by green areas and parks (Furlan, 2004). Precisely in the outlying districts where forest fragments remain, urban expansion occurred in an overwhelming way producing true built-up "deserts".

According to the research of the households surroundings characteristics conducted by the last census and which surveyed the existence of arboreous individuals near the lots, nearly half of the Pedreira district population (47.9%) is completely devoid of the services of urban vegetation, a deprivation which is shared with the district of Cidade Ademar (41.8%) as shown by FIG.4-17.

FIG. 4-17 - Percentage of residents exposed to the existence/absence of trees in the vicinity.

The above result separately does not allow an accurate assessment of the lack of urban green, due to the fact that the index parses every isolated canopy and arboreous individuals of all sizes. In this sense, the spatial qualification of tree-canopies connectivity and coverage is used complementarily. The quality of the vegetation coverage can be better understood for the study area in the MAP.4-3 which produced the results shown in FIG.4-18 below.
The characteristics of urban occupation and subsequent configuration of the lots influence the uptake of remnant vegetation to the built environment and the support of roadway green. Wider lots with lower constructive coefficient, characterized by nobler and less verticalized areas, favour the existence of arboreous clusters and corridors. In turn, twinned or vertical lots with high constructive coefficient allied with restricted space of the public walkways featuring the most deprived neighbourhoods are hurdles to the existence of tree corridors.

The PHOTO 4-4 and 4-5 displayed below represent typical canopy configurations in the studied districts. The first reflects environmental excellence when mixed with urban equipment, common particularly in parts of Campo Belo and Campo Grande, but especially in Santo Amaro, where 42.4% of the population enjoy this condition. The second illustrates a landscape of absence or semi-absence of canopies, quite common in Cidade Ademar, where almost 90% of the population is subject to this burden. This is inflected also to a significant part of Pedreira and Campo Grande.
The analysis of the spatial distribution of canopies enlightens the understanding on the provision of ecological benefits. It is however necessary to be alert to the fact that when adding green areas that do not represent spaces for human use, the data can alleviate, not to say mask, a worrying socioenvironmental context, as global vegetation coverage rates do not always refer to spaces where people can enjoy leisure.

The provision of public green spaces is used in order to distinguish the reminiscent fragments and private green from open green areas with social and cultural purposes in urban life.

According to the method used, the collected results show that the study area has a substantial deficit in the provision of public open spaces with rare exceptions in an intra-urban analysis. None of the five districts the population provided with sufficient public green spaces exceeds 7% of the total (FIG.4-19).
By extending this analysis to a comparison with the average income of the census tracts (Table 4-3) it is possible to notice that the privileges of access to green areas and a higher social status are not necessarily mutual, with the exception perhaps of Pedreira.

Table 4-3 – Provision of Public Green Spaces vs. income per census tract.

<table>
<thead>
<tr>
<th>District</th>
<th>Average monthly income (R$) – best census tracts</th>
<th>Average monthly income (R$) – district</th>
</tr>
</thead>
<tbody>
<tr>
<td>Campo Belo</td>
<td>5734,48</td>
<td>R$ 5276,75</td>
</tr>
<tr>
<td>Campo Grande</td>
<td>2926,09</td>
<td>R$ 2979,68</td>
</tr>
<tr>
<td>Santo Amaro</td>
<td>5352,58</td>
<td>R$ 5581,01</td>
</tr>
<tr>
<td>Cidade Ademar</td>
<td>1036,80</td>
<td>R$ 1010,53</td>
</tr>
<tr>
<td>Pedreira*</td>
<td>1364,10</td>
<td>R$ 865,64</td>
</tr>
</tbody>
</table>

* The average for Pedreira was calculated for the class ‘underprovided’, which is the best result for that district. Source: IBGE Census, 2010 (IBGE, 2011)

Indeed, with such a significant deficit is not surprising that all social strata suffer deprivation. However, although it is not the intent of this study to perform an assessment of the quality of the public spaces considered, it worth mentioning that some important distinctions were denoted in field surveys. Even if the observations are not sufficient to provide a statistical evaluation, at least they endow some evidence of where those who bears greater socioenvironmental burden are. Two symptomatic examples are shown in PHOTOS 4-6 and 4-7 below.
The examples corroborate with the reality of the other areas visited. While the districts of Santo Amaro and Campo Belo present public green areas gifted with statured vegetation and equipment in superior state of conservation, the same is not repeated, with rare exceptions, in the other districts, where desertish leisure areas predominate, consisting largely in dirt football fields and equipments in fading conditions.

The integrated result of the three indices reflects a city that sacrifices its vegetation and does not take advantage of it in the design of urban landscapes. Still, even all districts being highly exposed to environmental stress factors fomented by the lack of public urban green at all scales, the peripheral districts sense the deprived conditions more intensely (reaching 96.1% of the entire population of Cidade Ademar), and enjoy the sporadic beneficial circumstances much less (FIG.4-20).
4.1.4 Low-Surface Temperature

The LST-I comprise a single index which is mapped in the MAP.4-4 – Low-Surface Temperature Index Map.
Low Surface Temperature (°C)*

- Low - <28°C
- Medium - 28-29°C
- High - 29-30°C
- Very High - >30°C

*As obtained from Landsat 7 ETM+ Satellite Image, Thermal Band (TM6+). Scene from Sep. 3rd 1999 at 09:57 AM. Apparent surface temperature map.
According to the climatic classification of the IBGE (2002) the dominant subclima in São Paulo region is the humid subtropical with intense rainfall in the period between December and February.

The static and dynamic climate conditions in SPMR are regulated by several factors such as the high levels of the plateau where the city lies relative to the surrounding relief, the influences of air masses movement mainly from the South Atlantic, the biogeographical characteristics of a massive wet tropical vegetation in the surroundings and more recently the urban expansion and the bioclimatic local scale phenomena arising from anthropogenic influences, especially the increasing temperature observed in different areas of the urban perimeter.

The analysis utilized a near-ground or low-surface air temperature map which allowed the identification of relevant climatic patterns and potential environmental stressors characterized by UHIs. Variations of up to 5°C were observed in the study area, within the SPMR the variations reach up to 10°C (SVMA, 2013).

The low-surface temperature is strongly regulated by the characteristics of land use and occupation. The areas where the predominant surfaces are composed by materials that effectively store short-wave radiation, like asphalt and impermeable rooftops normally subsumed to higher temperatures, are mostly seen in dense areas such as Cidade Ademar and Campo Belo and the industrial sites of Campo Grande and Santo Amaro.

According to the obtained results (FIG.4-21), the studied districts present similar conditions. However, a great part of the study area is benefited by its peripheral location where important forest patches are preserved, besides the presence of large bodies of water. Both surfaces have a low albedo that significantly eases the rise of temperatures in the early hours of the day, vide the district of Pedreira, where more than 80% of the population enjoy a mild climate condition and some areas of dense tree-canopy corridors between Campo Belo and Santo Amaro.
4.1.5 Urban Environmental Quality

The environmental analysis carried out in census tracts level at the subprefectures of Santo Amaro and Cidade Ademar grouped four subjects in order to compose an integrated Urban Environmental Quality Index (UEQ-I). The large-scale results gathered for each environmental subject were spatially depicted and combined to create a synoptic index. The results of the environmental favourability analysis are illustrated at the MAP.4-5.
As FIG.4-22 shows, most of the study area population (82.7%) bear fewer exposure to the considered environmental stressors. However, some disparities between districts are patent. Inevitably the census tracts subject to greater amount of environmental burdens are in the subprefecture of Cidade Ademar.

FIG. 4-22 - Percentage of residents subsumed to favourable/unfavourable Urban Environmental Quality

In order to better understand the characteristics of the dwellers that inhabit the census tracts qualified with the highest rates of environmental quality and also with those who have the worst conditions encountered, they were grouped according to the indices’ categories and compared to the respective indicators of income, literacy and ethnic-racial characteristics.

All census tracts in which the four environmental indices did not exceed the categories 1 and 2 (best environmental condition) were grouped to characterize the absence of environmental stressors (class 3 was tolerated in the case of LST-I). Likewise the categories 3 and 4 (worst environmental condition) concomitantly were considered for all indices characterizing census tracts with complete absence of environmental benefits (for LST-I it was tolerated class 2). Tables 4-4 and 4-5 below respectively represent the best and worst environmental conditions along with a comparison of the social status, the Table 4-6 is set for comparison.
Table 4-4 - Absence of environmental stressors vs. social status.

<table>
<thead>
<tr>
<th>District</th>
<th>Pop.</th>
<th>% of the total</th>
<th>Average Income</th>
<th>Illiterates</th>
<th>Black pop.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Campo Belo</td>
<td>3.565</td>
<td>5.4</td>
<td>R$ 5.771,43</td>
<td>1.01 %</td>
<td>1.07 %</td>
</tr>
<tr>
<td>Campo Grande</td>
<td>501</td>
<td>0.5</td>
<td>R$ 8.552,00</td>
<td>1.20 %</td>
<td>1.40 %</td>
</tr>
<tr>
<td>Santo Amaro</td>
<td>4.400</td>
<td>6.1</td>
<td>R$ 5.352,58</td>
<td>0.91 %</td>
<td>0.86 %</td>
</tr>
<tr>
<td>Pedreira</td>
<td>5.056</td>
<td>3.5</td>
<td>R$ 1.216,18</td>
<td>2.00 %</td>
<td>1.68 %</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td>13.522</td>
<td>2.1</td>
<td>R$ 4.034,91</td>
<td>1.35 %</td>
<td>1.21 %</td>
</tr>
</tbody>
</table>

Note: The green cells represent indicators that are better than the districts average; the blue cells represent a percentage of black population higher than the average; Cidade Ademar district was not considered because it does not evidence this scenario.

Table 4-5 - Absence of environmental benefits vs. social status.

<table>
<thead>
<tr>
<th>District</th>
<th>Pop.</th>
<th>% of the total</th>
<th>Average Income</th>
<th>Illiterates</th>
<th>Black pop.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Campo Belo</td>
<td>2.507</td>
<td>3.8</td>
<td>R$ 1.290,59</td>
<td>2.83 %</td>
<td>2.23 %</td>
</tr>
<tr>
<td>Campo Grande</td>
<td>3.736</td>
<td>3.7</td>
<td>R$ 925,13</td>
<td>1.95 %</td>
<td>1.26 %</td>
</tr>
<tr>
<td>Cidade Ademar</td>
<td>13.180</td>
<td>4.9</td>
<td>R$ 610,02</td>
<td>1.22 %</td>
<td>1.38 %</td>
</tr>
<tr>
<td>Pedreira</td>
<td>3.988</td>
<td>2.8</td>
<td>R$ 707,85</td>
<td>3.28 %</td>
<td>1.87 %</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td>23.411</td>
<td>3.6</td>
<td>R$ 749,85</td>
<td>2.13 %</td>
<td>1.45 %</td>
</tr>
</tbody>
</table>

Note: The red cells represent indicators that are lower than the districts average; the blue cells represent a percentage of black population higher than the average; Santo Amaro district was not considered because it does not evidence this scenario.

Table 4-6 - Social status - comparison table.

<table>
<thead>
<tr>
<th>District</th>
<th>Pop.</th>
<th>Average Income</th>
<th>Illiterates</th>
<th>Black pop.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Campo Belo</td>
<td>65.752</td>
<td>R$ 5.276,75</td>
<td>1.40 %</td>
<td>1.35 %</td>
</tr>
<tr>
<td>Campo Grande</td>
<td>100.713</td>
<td>R$ 2.979,68</td>
<td>1.38 %</td>
<td>1.22 %</td>
</tr>
<tr>
<td>Santo Amaro</td>
<td>71.560</td>
<td>R$ 5.581,01</td>
<td>1.13 %</td>
<td>1.01 %</td>
</tr>
<tr>
<td>Cidade Ademar</td>
<td>266.681</td>
<td>R$ 1.010,53</td>
<td>1.84 %</td>
<td>1.41 %</td>
</tr>
<tr>
<td>Pedreira</td>
<td>144.317</td>
<td>R$ 865,64</td>
<td>2.45 %</td>
<td>1.72 %</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td>649.023</td>
<td>R$ 2.082,17</td>
<td>1.78 %</td>
<td>1.40 %</td>
</tr>
</tbody>
</table>

Source for all tables: IBGE Census, 2010 (IBGE, 2011)

Only 26 census tracts in 1,102 or 2.1% of the study area’s total population are classified with total absence of environmental stressors, meaning that all other census tracts have at least one index defined as an environmental burden. As shown, almost all social indicators are above the average of the respective districts, revealing

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6 Value of the average monthly income of the persons responsible for permanent households (with and without income). R$ 1,000.00 = US$ 420.58
7 Population over 5 years old.
8 Categories ‘black’ and ‘brown’. Self-declared answers from people with 15 years old or older.
that families with better social condition are as well privileged with better environmental quality.

The opposite also corroborates with the evidence of environmental injustice that the study area presents. Almost all social indicators pointed to lower district averages when a high load of environmental impacts is evident.

With the aim of performing a spatial analysis of these evidences the UEQ-I is superimposed to social vulnerability data, described next.

### 4.1.6 Social Vulnerability

As already detailed in the methodology, the social vulnerability map for the study area (MAP.4-6) was elaborated based on the *São Paulo’s Social Vulnerability Index 2010* or IPVS. The index offers detailed overview of the intra-urban living conditions while combining socioeconomic and demographic dimensions. The FIG.4-23 below presents the results of the cartographic product.

![Social Vulnerability Map](image)

**FIG. 4-23 - Percentage of residents subsumed to high/low Social Vulnerability**

The areas that concentrate the population segments most vulnerable to poverty are mainly located at the Cidade Ademar subprefecture, reaching a total of 24.8% of Pedreira’s district population and 25.1% of Cidade Ademar when considering ‘Very High’ and ‘High’ social vulnerability.

One notes that although the district of Campo Belo presents low rates of vulnerability in an overall result, a significant portion of the population (5.9%) lives in conditions of very high social vulnerability, meaning that there are subnormal census
tracts within the district where young families with low socioeconomic status live engulfed by census tracts mainly composed by families with very high social status. This will be further explored.
4.1.7 Environmental Justice

The results provided by the UEQ-I and IPVS are jointly analyzed in order to verify if there is a pattern in the distribution of social and environmental characteristics. Before generating the EJ-I, an initial integrated analysis of the socio-spatial distribution of environmental burdens and amenities offers insight of the spatial overlap of concurrent classes.

The FIG.4-24 and FIG.4-25 below are graphics that integrate UEQ-I and IPVS respectively for Santo Amaro and Cidade Ademar subprefectures.

![Social Vulnerability vs. Urban Environmental Quality](image)

**FIG. 4-24 - Social Vulnerability vs. Urban Environmental Quality: Percentage of residents per class – Santo Amaro subprefecture**

From the group of people living in census tracts classified as 'Lowest' IPVS, comprising the best social strata, more than 53,300 inhabitants (45.5% of the vulnerability class) enjoy very favourable UEQ condition while only 502 inhabitants (less than 0.5%) of the same group are subsumed under least favourable environmental quality. The opposite is evidenced when analyzing the class of 'Very High' social vulnerability. Over 61% live in the least favourable environmental circumstances. It is noteworthy that as there are few census tracts classified as ‘High’ and ‘Average’ social vulnerability in Santo Amaro subprefecture, its intersection with the UEQ-I led to a monographic result.
FIG. 4-25 - Social Vulnerability vs. Urban Environmental Quality: Percentage of residents per class – Cidade Ademar subprefecture

And again it is remarkable that, in the subprefecture of Cidade Ademar, the census tracts with less social vulnerability enjoy more favourable condition from the point of view of UEQ. However, this distinction is not so glaring among the least favourable UEQ classes.

The MAP.4-7 highlights the cases where social vulnerability indices occur as 'Very High' superimposed on census tracts classified as 'Unfavourable' and 'Least Favourable' for UEQ-I. This offers insight of where the most glaring environmental injustice cases may be located.

By superimposing the number of environmental burdens on the social vulnerability data, it is clear that the classes of less favourable and unfavourable environmental quality often overlap the class of very high social vulnerability.

With the purpose of exploring the relationship between low social status and the exposure to contemporary environmental impacts, the created UEQ-I and its respective map are crossed with the IPVS map, thus generating the EJ-I map (MAP.4-8).
Assessing Urban Environmental Justice in two subprefectures, São Paulo, Brazil submitted by Guilherme Henrique Bego Klauzar supervised by Prof. Dr. Sigal Kischitz

December, 2013

Environmental Justice Index
for Santo Amaro and Cidade Ademar Subprefectures, São Paulo

UEQ-I - Urban Environmental Quality Index
IPVS - São Paulo's Social Vulnerability Index

SENAME's Social Vulnerability Index, December 2013, Brazil

Legend
- Districts
- Municipal limit
- Census Tracts
- Relevant sites

Environmental Justice Index
- No data
- High
- Medium
- Low
- Very Low

December, 2013
The final mapping clearly identifies a well-defined mosaic of same class groupings, slightly intermixed. The worst rates of environmental justice are clustered in the central part of Cidade Ademar district spreading across the boundaries with Pedreira and Campo Grande. One also sees census tracts with very low rates of environmental justice clustered in portions of the Campo Belo and southern Pedreira.

It is noticeable a spreading pattern of the worst qualified census tracts. They huddle up in the shallows carved by the hydrographic system. The explanation lies in the historical occupancy by low income populations on floodplain areas. Those areas are mainly public domain since they are much sought by public authorities to expand the road network, as already discussed in Chapter 2, before becoming the target of land speculation. For being off the record occupations those areas are subject to all kinds of deprivations in the supply of environmental services by the state, such as sanitation, water and waste collection, resulting in twofold social and environmental impacts. The results are illustrated in the FIG.4-26 below.

![FIG. 4-26 - Percentage of residents per class of environmental justice.](image)

As a result of the diagnosis the following considerations can be woven concerning the districts of the study area.

**Campo Belo:** Few of the census tracts, precisely those with the highest social vulnerability (PHOTO 4-8) bear most of the environmental burdens. A group of just over 5% of the residents is largely deprived of essential environmental services while living along the main water stream that divides the district in half. While the vast majority of inhabitants living in the district’s upper town interfluves enjoy a natural condition of low social vulnerability and environmental benefits such the dense mesh of arboreal corridors (PHOTO 4-9) and full compliance of municipal services. This singularity characterizes a high intra-urban environmental injustice.
Assessing Urban Environmental Justice in Santo Amaro and Cidade Ademar subprefectures, São Paulo, Brazil

**Campo Grande:** The district is not characterized by low social status, but bears most of the environmental stressors and social vulnerability of the subprefecture. Consequently, the area is subjected with high intra-urban and inter-urban environmental injustice.

**Santo Amaro:** The entire population benefits from very little environmental burdens and does not present social vulnerability.

**Cidade Ademar:** It is the counterpoint of its neighbour Santo Amaro. A great part of the district simultaneously bears very low social status and a vast amount of environmental stressors which is the reason why 24,4% of the population is subject to low and very low environmental justice, the lowest rate among the five districts of the study area.

**Pedreira:** Although the district being subjected to high levels of social vulnerability and also the hardships of many of the identified environmental impacts (PHOTO 4-10), both are not necessarily concomitant. The district encompasses 54,6% of the residents in the condition of ‘High’ environmental justice. Such realization is due to the fact that the census tracts located on the margins of the Billings Reservoir benefit from two important environmental amenities: the lowest heat stress and access to patches of native vegetation (PHOTO 4-11). Nonetheless 17% of the population abides low or very low environmental justice.
Santo Amaro vs. Cidade Ademar subprefectures: At least 42% of the population of the study area is subject to some environmental injustice and of these the largest portion is concentrated in the districts of Cidade Ademar and Pedreira. Comparatively the two subprefectures showed significantly different results, with undeniable environmental and social lag between one site and another, confirming the suspicions of very high environmental injustice for this emblematic case.

4.2 Discussion on the Findings

The techniques and methods used for constructing the Urban Environmental Quality and Environmental Justice indices demonstrated a starkly synthesis potential of the socio-environmental context in the study area. Numerous results have been collected and all corroborate with the hypothesis supporting the relationship between low social status and the exposure to contemporary environmental stressors for Cidade Ademar and Santo Amaro subprefectures. The integrated results also showed a tendency in the somatisation of environmental burdens in socially deprived districts. Many of the existing census tracts showed low levels of environmental quality for all analyzed parameters. The range of maps enabled the identification of patterns in the distribution of social and environmental characteristics within the districts and between the subprefectures, thereby fulfilling the primary empirical purpose.

The experimental indices were sufficient to respond to the heterogeneity and complexity of the spatial distribution of the variables, thus expressing clearly where social and environmental pressure areas lie. It is thereby impossible to reject the relevance of Environmental Justice as a subject to be highly considered for future research in the field of urban management. It is worth emphasizing the need to include in future research the parameters related to air quality and noise as primary environmental impacts and necessary to compose an integrated trustworthy environmental quality index.
Also, as a derivative study, it is necessary to acknowledge the contribution of the techniques that nourish this research. Several different studies were consulted in order to set sufficient ballast for the simulation of the index, from key landmarks guiding the methodological development and inserting the topic of EJ into the context of GIS, to applied methodical approaches for each of the chosen parameters. Thus it was possible to achieve the desired secondary objectives. Heading these triggering resources the Berlin Pilot Project on Environmental Justice (Bunge and Gebuhr, 2011) established for the first time an integrated and multidisciplinary approach that is a vital aspect of the present research. The cited reference opened “a new perspective on the multi-dimensional nature of the socio-spatial distribution of environmental burdens and resources in an urban area.” (Lakes and Klimeczek, 2011: p.43). The Berlin’s pilot model also provides the starting point for developing an index which can measure environmental justice synthesizing all variables as one single value at large scale, without neglecting small territories. In the terms of São Paulo and its metropolitan region this is an undeniable virtue.

Thus, the significant contribution of the territory in Planning Support Systems – PSS, refers to the possibility of understanding urban problems in its totality and in its fractions and therefore discriminating the intra-urban inequalities (Genovez et al, 2007). “The place that people occupy in the territory reflects the position of individuals in society, so if we want to transform the living conditions of the poorest population we must intensify the transformation of their habitat.” (SEMPIA, 2007: p.51) The evidenced environmental impactssignals the fragmentation in the urban territory, and indirectly underline a spatial expression of the social processes that occur in the study area. The fixity of the built environment requires continuing actions and a long-term plan-making process as to overcome the challenge of reducing social and environmental inequalities. This necessarily involves the transformation of the territory. Every action of government transforms the territory directly or indirectly, positively or negatively. Public policies gain in effectiveness and efficiency when they adopt a territorial approach, with appropriate scale and scope (Emplasa, 2007). No policy proposal can become strategic and effective if the territorial dynamics are ignored (Santos, 2001).

It becomes crucial to know the size of the actions, about every little piece of the territory whether planned or not,. This way, future actions gain volume based on precise cartographic information. In order to cope with the plan-making process, the development of PSS, and the growing demands for better urban management, the current outcomes of the research offer a valid decision support tool. It is expected that similar techniques can be incorporated to provide better technical basis to planners involved in the actions of intervention in urban space, hence forwarding discussions regarding just and sustainable urban areas.

However, similar techniques cannot perform without improvement and in isolation. In order to identify how the combination of factors matter and which levers to push, one confronts how and why segregation plays such an important role in reproducing the poverty and urban inequality. There’s a latent need to collect, treat and produce data that offers a different and clearer picture of where disparate outcomes persist and what the relation is with the overall city-making process.
Also, only with the proper articulation of democratic movements and the use of the constitutional paradigm it is possible to reorient the vocation of exclusion and segmentation of the city, eventually turning it into the space of citizenship.

4.3 Reflections on the constraints

During the application of the research’s method, or even during the conception of it, some difficulties were faced. Those are inherent to studies of transdisciplinary nature browsing into social, economic and environmental aspects of multiple dimensions. Due to these circumstances, the present effort should be content to meet the challenges of subjectivity, scale, data accessibility and reality simplification. Some of them are mitigated, others minimized, while others are circumvented, however not every aspect can be avoided.

A work of cartographic synthesis considering environmental and social dimensions requires a broad conceptual debate and can only be completely fulfilled by a multidisciplinary team that is able to raise and work with all environmental variables. This is an important limit of an individual’s work especially for a researcher with no vertical training thus imposing restrictions on research issues related to the extension of technical and theoretical capacity and feasibility aspects. Working with methods that consider multiple elements at the same time in a systemic way requires almost all available research time to be consumed in the collection and treatment of specific data (Nucci, 2008). This feasibility aspect was addressed by prioritizing the decomplexation of methodologies and the use of standardized indicators and indices while using available methods close to the characteristics of the study area.

As already discussed previously, a major challenge was to avoid the pitfalls of subjective judgments which could affect not only the definition of topics but also the way they are grouped and their weighting for a final classification. This can only be achieved by pursuing a statistical expression of a large number of scientific methods. Integrating each one demands an effort of synthesis and adaptation to the accessible statistics.

It had adopted a consistent process for the classification of categories using natural breaks (Jenks method) for percentage indices, thus looking for the minimization of each class’s standard deviation from the class mean and maximizing each class's deviation from the means of the other groups. This is consistent with the notion of cognitive mapping, hence diminishing the discrepancy within classes and maximizing the difference between classes. For the indices already defined by previous categories, a matrix analysis was performed to define the ranges of classes through the sum of the environmental stressors due to the fact that the technique was frequently used in cross sector analysis.

The analysis transits through many specific variables in order to describe relations with the regional reality. This generates a twofold difficulty of scale and reality simplification.
The thematic mapping seeks for an integrated approach since ever, on the other hand there is still the insistence in comprehensive analytical solution that produces ambitious maps. This attempt to exhaust the proposed theme, expressing all at the same time, superimposing or juxtaposing attributes or variables ends up blurring an overall integrated picture (Martinelli, 1994).

What we intent is a passage from heterogeneity to uniformity and not merely a separate description of the reality elements. The choice of the scale used in data collection reflects this intent since the scale appears as a filter that impoverishes reality but actually preserves what is relevant in relation to a given intention (Nucci, 2008). The physical size of the study area and the desired level of understanding of the environment were two important premises. However, the seminal notion was the availability of data for intra-urban analysis, determined by the censustracts. Four levels of geographic information were produced from individual indicators to a synoptic model, including thematic groupings.

We are aware of the limitations of the method. What is sought is a consistency in the discussion and in the method construction, thus providing a way to understand and explain reality. Given the constraints and the chosen paths to mitigate them, every step of this research aimed at providing elements so that, at the end, the original questions are answered and progress is conquered towards reducing inequalities and improving the urban life.
5 CONCLUSION

“[...] the present, imminent, uncompleted, not only project and not quite finished reality [...] contains the appetite for a future unrealized” (Santos, 2002, p.121).

The lines meticulously drawn above wittingly denote that the conclusion of that scientific research should not only be aimed at what was produced, but also at what is to come.

As seen, a significant socio-spatial distribution of environmental burdens in the city can be clearly identified. On that basis, it is justifiable to affirm that the topic of environmental justice is undoubtedly relevant and needs to be addressed. The outcomes were able to summarize and highlight the compromised conditions of urban environmental quality inherent to low-income populations in the studied districts. This achievement was backed by a multidisciplinary methodological approach which made it possible to process an integrated and geographically referenced database into useful knowledge.

While adapting the general principles of representation and simulation to a specific context and applications, the set of maps produced in this research is a practicable starting point to the subject of Environmental Justice, especially considering that this concept is a relatively unexplored topic and a novelty to scientific research in Brazil.

As stated by Batty (2009), the development of PSS, with a focus on sustainability and the need for in situ tools useful for local municipalities are key to the application of GIS in Latin America. These tools have to be coupled with techniques capable of scrutinizing the hiatus between the virtual and the real urban territory. This is a major leap that urban planning seeks to address, and the plans and policies that represent the outcomes of such planning need to embrace techniques capable of revealing the process that produces the evidenced patterns of inequalities.

Putting aside the difficulties faced in obtaining and processing the data, not to mention the feasibility issues among other constraints, it is possible to raise some questions about limiting factors concerning the obtained outcomes. How much does it reveal about reality? How much of the processes setting these scenarios can be translated into this kind of outcome?

In conclusion, the computational representation of urban space reveals trends for grasping the complexities of the urban sphere in digital media. However, the trends in the exclusion patterns are a subject still to be revisited. These aspects can only be fully understood with the modeling of spatial dynamics of the territory, an effort that requires long-term observation of statistically significant variables with a resourceful and proficient manipulation.

Moreover, it is necessary to encourage surveys related to the urban environment that aim at proposing improved methods and discuss environmental quality parameters. However, the scientific work done in universities does not take
effect unless citizens have access to the debate. GIS can further the all-important purpose of this discussion. For the first time georeferenced information became accessible in social platforms, hence opening the possibility for users to consult, feed and create spatial information. This is a glaring breakthrough to inform and arouse a spirit of community responsibility and resistance, among other spheres, against projects sapping urban environmental quality. Likewise, it can be a platform for a new model of participation and city-making.

We are facing a major opportunity to break with the inertia largely caused by the unwillingness to reflect on the transformation processes governed by the global city model, a model that imposes drastic impacts on the social and cultural relations, as well as on the environment. In this sense, lethargy is often the foe of progressive action that confronts inequity and injustice. We need to not only embrace the reactions to address our failures, but most importantly reaffirm our commitment to defy injustice in whatever form it takes.
6 REFERENCES


Assessing Urban Environmental Justice in Santo Amaro and Cidade Ademar subprefectures, São Paulo, Brazil


Assessing Urban Environmental Justice in Santo Amaro and Cidade Ademar subprefectures, São Paulo, Brazil


Assessing Urban Environmental Justice in Santo Amaro and Cidade Ademar subprefectures, São Paulo, Brazil


http://www.prefeitura.sp.gov.br/cidade/secretarias/meio_ambiente/publicacoes_s

SVMA - São Paulo: Prefeitura do Município de São Paulo. Secretaria Municipal do
Verde e do Meio Ambiente; SEMPLA - São Paulo: Secretaria Municipal do
Oct 2013.

Tagnin, Renato Arnaldo; Magalhães, Edmundo de Wema (2001). O tratamento da
expansão urbana na proteção aos mananciais. In: Boletim Técnico da Escola
Politécnica da USP, Departamento de Engenharia de Construção Civil,
BT/PCC/278 EPUSP: São Paulo.

Torres, Haroldo (orgs). São Paulo: segregação, pobreza e desigualdades

Torres, Haroldo; Humberto Alves; Maria Aparecida De Oliveira (2007). São Paulo peri-
urban dynamics: some social causes and environmental

2007. Nairobi: UNEP

the preparation of GEO Cities Reports. 3rd version. Panama City: United Nations


USCCR – United States Commission on Civil Rights. (2003). Not in My Backyard:
Executive Order 12,898 and Title VI as Tools for Achieving Environmental

Vieira, Carolina Haddad Souza Dias and Daniela Biondi. (2008). Analysis of Land
Cover Change in the Municipality of Curitiba, Brazil, from 1986 to 2004, Using

Welsch, Jörn; Hartmut Bömermann; Heidrun Nagel (2011) Data sources of the Berlin
pilot project: the Berlin Environmental Atlas and Social Urban Development
Monitoring In: Bunge, Christiane; Kerstin Gebuhr. UMID: Umwelt und Mensch –
Informationsdienst: Special Issue II - Environmental Justice. Berlin: Federal