

# **ESPAÇOS LIVRES PÚBLICOS: UTILIZAÇÃO DE INFRAESTRUTURA VERDE PARA OTIMIZAR A DRENAGEM URBANA NOS CENTROS HISTÓRICOS TOMBADOS**

**PUBLIC OPEN SPACES: UTILIZATION OF GREEN INFRASTRUCTURE TO OPTIMIZE URBAN DRAINAGE THE HISTORIC LISTED CENTERS**

**Claudione Fernandes de Medeiros\***

**Sônia Afonso\*\***

## **ABSTRACT**

The climate change affects a city life. Extreme events such as rising temperatures, droughts and floods also threaten cultural heritage. In listed historical centers, floods and spates have caused pathologies on houses and streets. The traditional urban drainage system has been shown to be inefficient, in addition to the difficulties of expanding this prerogative of respect for pre-existences. This study seeks to use public free spaces of listed cities as improvers of urban drainage, through the concepts of green infrastructure. In the first moment, a relation between climate changes and the disturbances to the cultural landscape is presented and how a green infrastructure can contribute to a resilience of the listed urban centers. Afterwards, the public space systems available for this application are analyzed, taking as a case study the city of Laguna / SC. As a result, it can be observed that the free spaces the workstations are transmissible for their merely scenic function for an infrastructural function and, in this way, they are vital for the urban centers, besides valuing a landscape, also to increase the effect of the drainage Without impacting or disregarding existing geomorphology and urban morphology.

Key-words: Free urban spaces, Green infrastructure, listed historical center.

## **INTRODUCTION**

The central theme of this article is related to the use of the green infrastructure concepts in public space systems under the public domain to potentiate the drainage of rainwater from the listed historical centers, taking as a case for this study the city of Laguna / SC. The main purpose is to contribute to the resilience of the national patrimony. Other benefits are attributed to the use of green infrastructure, such as landscape enhancement, microclimate creation and reduction of diffuse pollution (HERZOG, 2010).

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\* Architect and Urban Planner by the State University of Santa Catarina, master of the postgraduate program of the Federal University of Santa Catarina. Collaborating professor in the Course of Architecture and Urban Planning for UDESC and effective Architect and Urban planner of the City Hall of Laguna / SC. Senador Galotti Avenue, 329, Laguna, SC, Brazil.  
claudionearquiteta@gmail.com

\*\* Architect and Urban Planner, professor at the Federal University of Santa Catarina, PhD from College of São Paulo, School of Architecture and Urban Planning. Leader of the Research Group on Architecture, Landscape and Urban Spaces - CNPq, where coordinates the research Architecture and Landscape - Evaluation of the Urban Insertion in the Physical Environment. Post-Graduation Program in Architecture and Urban Planning of UFSC (PostARQ), Campus UFSC, Trindade, Florianópolis. SC, Brazil.  
soniaa@arq.ufsc.br

The city is a construction over time and space, a legacy with relevant historical and cultural value that must be preserved. The urban dynamics occurs differently depending on the actors involved in the process and the rules and laws that govern the planning. Social, economic, environmental and aesthetic concepts alternate and complete themselves in order to write their history. This history re-reading and our people's culture must be preserved and requalified so our cities do not lose the dynamics and quality, strengthening their cultural identity.

The National Historical and Artistic Heritage Institute (IPHAN) promotes the listing of urban settlements, giving them the status of national patrimony. The listing is an administrative act whose main objective is to preserve, through legal protection, the goods with historical, cultural, architectural and environmental value, preventing their destruction or decharacterization. The society references preservation must have interactive dimensions between space and time, contemplating and valuing each time.

Transformations in the cultural landscape and climate change are part of a series of recent issues related to urban waters. Cities need to adapt to become resilient to environmental impacts, that is, cities need to develop the capacity to return to form and original characteristics after going through processes that interfere with their dynamics. The green infrastructure has been applied with positive results in several cities, mainly in Europe and North America, as a complement or alternative to traditional urban drainage structures. However, this strategy has not yet been used nationally to mitigate the insufficient drainage of our listed and consolidated historical centers. In relation to this condition, the pre-existing free space systems are the dimensioners of this application, and should be analyzed and prepared for this function that contributes to an urban drainage efficiency, assisting in the conservation not only of natural resources, but also of the built patrimony.

The landscape involves a set of perceptions, ranging from the primitive original space, that is, the territory to the cultural and socioeconomic relations that generate changes, where the human being is one of the transforming agents of this environment. For Limberger and Santos (2000, p. 1) "... the landscape is a set of natural or artificial scenarios where man is, besides an observer, a transformer of these elements that compose the site." Macedo (1993, p.11) adopts the idea of landscape as "morphological expression of the different forms of occupation and, therefore, the transformation of the environment in a certain time." Landscape can be understood as a living system in constant actions and reactions, and this system composes the fabric of our existence (WATERMAN, 2010).

Architecture and urban planning are related to the landscape, since it is a continuous interpretation of the built and unbuilt. According to Magalhães (2001), it must be characterized with a critical eye seeking the respect for the ecology, the work and the knowledge acquired by the generations. For Ab'Saber:

The landscape is always an inheritance. In fact, it is an inheritance in every sense of the word: inheritance of physiographic and biological processes, and the collective patrimony of peoples who historically have inherited them as territory of action of their communities (AB'SABER, 2003, p.9)

The urban form constituted by a set of constructed volumes and a free space system is generated from the territory natural agents and the anthropic activities developed. Waterman (2010, p.15) speaks in this sense "although we shaped the landscape, we, at the same time, are products of places". From this conception, landscape is no longer a mere phenomenon and becomes a cultural production of a people. When the landscape is treated as a heritage property, aggregating several values, it receives a cultural landscape qualification. Ribeiro (2007) advocates the advantage of this term in its relational and integrative character of the material and the immaterial and the cultural and natural.

At the 1972 UNESCO General Conference in Paris, where the Guidelines for the Implementation of the World Heritage Convention were established (IPHAN, 2008), it was the first time the terminology of cultural heritage was cited officially. In 2008, at a meeting, the Committee decided to carry out new guidelines, it was studied and reflected about the cultural landscapes and their relation with the guarantee of biological diversity and improvement of the natural landscape values (ARAÚJO, 2009).

From the beginning, the landscape is a work that connects cultural and natural heritage, the term cultural landscape arises. After all, culture is the propellant of this landscape, which appears in an innate place. UNESCO thus defines the cultural landscape:

Cultural landscape: the cultural goods that represent the joint works of the human being and nature and illustrate the human society evolution and its settlements over time, conditioned by limitations and / or physical opportunities that presents its natural environment and by the successive social, economic and cultural forces, both external and internal. (UNESCO, 2010, p.03).

In Brazil, the listing of the entire architectural-landscape sets, which care about the entire urban site, worrying about its context and surroundings, inherent in the concept of cultural landscape. The concern is not in the preservation of an isolated good, but in the landscape preservation constituted as a whole. In this sense:

As regards the conservation of the urban site itself, it should be possible to maintain as much as peculiarities of its general configuration, such as accidents and other distinctive elements in the natural landscape, Existing on the grounds, such as a characteristic layout of streets, such as architectural local modalities and public and private vegetation. [...] On the other hand, it is necessary to aim to protect and benefit surrounding areas, endeavoring to ensure its a desirable panoramic frame, without new constructions with unusual prominence, nor earthworks nor any distressing endeavors (ANDRADE, 1987, Page 86).

Respect for the cultural landscape will not be achieved if for its conservation and protection we prune urban development. Therefore, the cultural landscape should not be imposed only on the past conditions, but on the integration of this past with the aspirations and needs of the present population. The cities are in constant transformation, they are dynamic and, according to Castriota (2009), it is a tangible real property, but modifications take place in layers throughout history, the pre-existing fabric is received as an inheritance and transformed through interventions representative of each time. Their functions must be maintained and diversified for its survival.

It is not about, therefore, freezing a life, nor transforming cities into museums, but thinking about the preservation and their life quality improvement, which covers both areas considered "historical" and those that are new. [...] Thinking about the city as an "environmental heritage" is thinking, first and foremost, about its historical and cultural meaning that has an urban landscape as a whole, valuing the vital process that informs the city and not just isolated "exceptional" monuments (CASTRIOTA, 2009, p.88).

Landscape planning, then, should encompass urban public policies that involve as many natural factors as those constructed, valuing their set and their history. In the guidelines for factions implementation in central urban areas and historic cities (BRAZIL, 2011), it is clear that the cultural heritage preservation induces development. This development is necessary to overcome degradation scenarios and underutilization and to improve the cities urban and social quality, which must be productive and resilient.

## **CLIMATE CHANGE AND CULTURAL LANDSCAPE DISORDERS**

The climate changes are generated by innumerable natural factors, but mainly are responses of human intervention. They trigger the generation of different natural events in various parts of the

world, such as increasing or decreasing atmospheric temperature, high rainfall, changes in ocean temperature and humidity, disasters such as floods, tsunamis and cyclones are some examples.

In 1997, the Information Center for Environmental Resources and Hydrometeorology (CIRAM) was created in the state of Santa Catarina, linked to the Agricultural Research and Rural Extension Company (EPAGRI), with the responsibility of raising and monitoring natural resources and the State environment. It is responsible for hydro meteorological monitoring, for climate change management and its impacts on river basin dynamics, and for the monitoring and risk analysis of extreme hydrological events. In this year 2015, many cities in the state are on alert due to the rains. A study carried out by these agencies in conjunction with the National Institute of Meteorology (INMET) and the National Institute of Space Research (IMPE), with the Brazilian Meteorological Society (SBMET) support, points out the increase in the incidence of intense rainfall phenomena Santa Catarina, according to the transcript:

Reviews of the Fourth Report of the Intergovernmental Panel on Climate Change (IPCC) and the INPE Climate Report have shown that extreme precipitation events may become more frequent and may lead to more severe flooding and overflow (...). An intensification at the extremes of precipitation may be caused by the atmospheric humidity increase, which may increase its availability for precipitating systems associated with fronts, tropical and extra tropical storms and mesoscale convective complexes. Rainfall projections up to the end of the 21st century, derived from the IPCC and INPE global and regional models, for scenarios of high and low concentrations of greenhouse gases effect, show increases in extreme rainfall event trends, especially in the North and coast of Santa Catarina. (EPAGRI, 2008, p.57)

Overflow, inundations and flashflood cause many disorders to the public and private patrimony. The damages also reach the cultural landscape, destroying the listed property, dragging the street paving or even polluting the water bodies. Herzog (2013) points out that we need to think in a resilient way, that is, the city must be prepared to persist and absorb these changes while maintaining their functions and purposes.

In 2010, the city of São Luiz do Paraitinga, in São Paulo State, suffered from flooding from high rainfall levels and a precarious runoff system. Its patrimony integrity was threatened; the city had eight historic buildings, including the Main Church opened in the seventeenth century, devastated (Figure 01 and 02).



Figure 01: Main Church of São Luiz do Paraitinga / SP and cesário.

Source: Prefeitura Municipal de São Luiz do Paraitinga, 2009.



Figure 02: Main Church of São Luiz do Paraitinga deploration after the flood in 2010.

Source: Jornal Notícia na hora, 2010.

Laguna, a city on the Santa Catarina coast that in 1985 had a listed polygon delimited to protect its initial site, rich in architectural examples of the luso-brazilian, eclectic and *art deco* style, is also an example of national heritage that has been suffering with the rainfall increase. The central area is established in an alluvium plain between the chain of hills and the Lagoon Santo Antônio dos Anjos. The climate change influence in conjunction with the urbanization process and the soil impermeability increase contributed to the urban drainage inefficiency, causing problems in the flow and the water absorption. Figure 03 represents the flood at Tenente Bessa Street in the year of 2004, direct link of the hills with the lagoon. The floods have been still occurring and it is intensified each year, figures 04 and 05 show the same stretch of the city with floods in 1974 and 2014.



Figure 03: Flood at Tenente Bessa Street, Laguna / SC in September 2004.  
Source: Jornal de Laguna, 2004



Figure 04: Flood near Cine Mussi Theater, Laguna / SC in March 1974.  
Source: Photo Bacha, 2014.



Figure 05: Flood near Cine Mussi Theater, Laguna / SC in August 2014.  
Source: Grazielle Sitônio, 2014.

These natural events are increasingly frequent and threaten mainly the buildings. It can cause the total loss of a patrimony as in the case of São Luiz do Paraitinga or cause a slow death with the intensification of the ascending humidity in the house (figures 06 to 10). The pathologies generated may be superficial or structural, such as stains and mold on the walls, painting in the

process of peeling, plaster and parget displacement, cracks, weed vegetation at the base of the building, among others. What is possible to be observed in the details of the basement of the buildings through photographic survey, recorded in July 2015 after heavy rains and flood.



Figure 06: Duque de Caxias Street, Lagunense Congress Club, eclectic exemplary.  
Source: The author, 2015.



Figure 07: Raulino Horn Street, Centrão Lanches, *art deco* exemplary.  
Source: The author, 2015.





Figure 08: House in the República Juliana Square, a Portuguese-Brazilian exemplary.  
Source: Claudione Medeiros, 2015.



Figure 09: House of the intersection of Gustavo Richard Street with the XV de Novembro Boardwalk, an eclectic exemplary.  
Source: Claudione Medeiros, 2015.



Figure 10: Intersection House at Gustavo Richard Street and Tenente Bessa Street, *art deco* exemplary.  
Source: Claudione Medeiros, 2015.

The use of green infrastructure, according to Herzog (2010) may optimize the permeable areas, promoting a hydrological cycle balance, increasing infiltration, percolation and evapotranspiration. Also for Pellegrino (2014), besides improving urban drainage and water quality, this type of infrastructure contributes to the requalification of urban landscaping, constituting a new movement to create landscapes that can be perceived as such:

(...) as part of a strategy for open urban spaces implementation, landscaped treated to be more than mere urban beautification actions, but also to perform infrastructural functions related to urban water management, environmental comfort, biodiversity, circulation alternatives, accessibility and local image. (CORMIER, Pellegrino, 2008, p. 127).

So, the urban form composed by constructed volumes set and the free space systems, is no longer seen as a scenario to be treated as a living infrastructure.

## GREEN INFRASTRUCTURE AND URBAN RESILIENCE

Resilience is a new term for architects and urban planners. It was used in 2008 by the designer and philosopher John Thackara to transcribe much of his thoughts, he adopts the resilience definition as "the system ability to absorb disturbances and reorganize while undergoing some changes." (BALTAZAR, 2010) The resilience of a city then, is its ability to stay alive even exposed to climate, economic or social changes.

Pellegrino (2014) argues that climate change, coupled with urban developments and the waterproofing areas increase, contribute to disturbances acceleration and make cities more vulnerable. Landscape design and free space systems should contribute to increase the capacity to overcome, reorganize and recover consolidated areas.

Cities need to adapt to climate change to become resilient to environmental impacts. Environmental issues; such as green area conservation, proper use of soil and water, and improved air conditions, taking into account clean transport, are primordial points for sustainable urban planning. All must be brought together in an integrated green infrastructure plan - a way to restoring the urban environment and improving the life quality for the current population as well as of future generations without harming the natural environment. (BUENO and XIMENES, 2011, p.6)

It should be emphasized by interventions that increase the cities responsiveness capacity to the climatic events, promoting an increase in their degree of resilience. The green infrastructure is

inserted in this context as an instrument not only for the urban drainage, but also for sustainable urban planning. Where various aspects and issues are reviewed in search of a flexible and adaptable infrastructure system. The XXI century cities seek a qualitative expression of the place, with the premise of improving the life quality of its inhabitants. The balance between society and environment influences the production of this landscape and the new interventions proposition that connect environmental, social, economic and cultural compositions.

In order to support sustainable urban water systems, the green infrastructure is emerging. It has the role of connecting ecosystems within the urban environment, without neglecting the conditions of mobility and accessibility and the historical-cultural characteristics of place. Herzog reinforces this relevance:

The green infrastructure aims to mitigate the effects of urbanization on several scales and with multidisciplinary teams, so that the abiotic, biotic and socio-cultural aspects will be the focal points of integrated medium and long-term planning and projects. It is worth emphasizing that climate change, which is already taking place, must be considered in order to adapt the cities once their effects are mitigated or even avoided. Green infrastructure can make a significant contribution to this adaptation by reestablishing the ecological services eliminated during traditional urbanization. (HERZOG, 2010, p.3).

Green infrastructure has been applied in many international projects. Significant examples of this new way of managing rainwater are those applied in the states of Oregon and Washington, as well as in the province of British Columbia, cited by Cormier and Pellegrino (2008), who reiterate the importance of creating these urban landscapes seeking to reattach the natural ecosystems functions, this new creation movement of urban landscapes can be seen:

(...) as part of an implementation strategy of open urban spaces, landscaped treated to be more than mere actions of urban beautification, but also to perform infrastructural functions related to urban water management, environmental comfort, biodiversity, circulation alternatives, accessibility and local image. (CORMIER, Pellegrino, 2008, p. 127).

This infrastructure, according to Pellegrino (2014), can be divided into two groups, the first with the adoption of living systems, having the raw material the vegetation, the second depends on physical processes, and although it is also called green infrastructure, not necessarily it has to be constituted by living elements. The concept is based on the rainwater collection and retention and on the vegetation increase, reducing surface runoff, erosion and the amount of diffuse pollution transported by the first rains to the water bodies.

Various types of green infrastructures are considered, such as linear parks, rain ponds, biovalves, rain gardens, rainforest, ceilings and walls, detention basins, dry wells, sand filters, trenches or infiltration ditches, porous floors and cisterns for rainwater collection and reuse. The grouping of some typologies forms a grid or green network, which must be established according to contribution basin studies.

## **APPLICATION OF GREEN INFRASTRUCTURE IN PUBLIC FREE SPACE SYSTEMS: CASE OF STUDY THE CITY OF LAGUNA / SC**

To exemplify the possibility of applying green infrastructure in the systems of public open spaces on listed historical centers, we chose the city of Laguna / SC as a case of study (figure 11). Its urban center was listed in 1985, when a polygonal of listening was delimited with its inscription on the Book of the Archeological, Ethnographic and Landscape Listening of the Undersecretary of National Historical and Artistic Heritage. This polygonal consists in an imaginary line that coincides with the formation of a contribution basin, passing through the peaks of the hills and entering 200 m to the lagoon (figure 12). The enclosed area presents a great architectonic and landscaped collection, forming a great open-air museum.

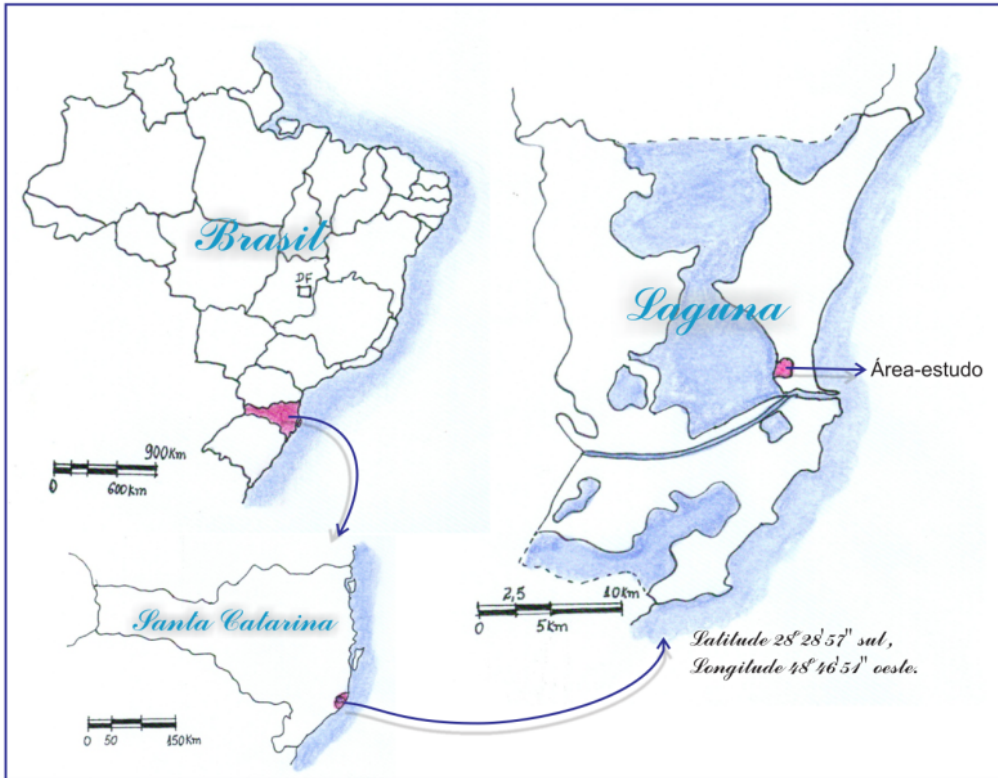


Figure 11: Location of Laguna / SC.  
Source: MEDEIROS, 2015.

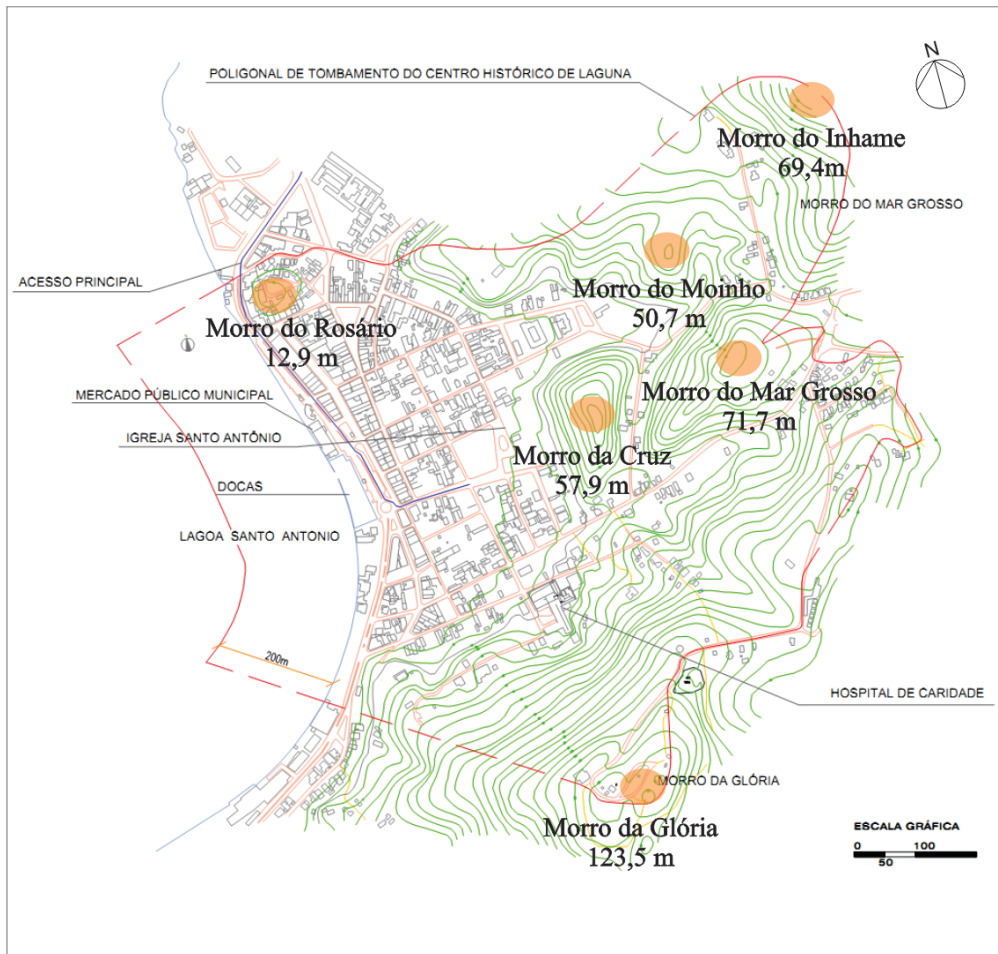


Figure 12: Planialtimetric map, indicating the imaginary line of the Polygonal of listening of the Lagoon Center.  
Source: IPHAN cartographic base, prepared by Claudione Medeiros, 2014.

The area of the study is consolidated (figure 13), so it is not possible the creation of new free areas that will de-characterize the national patrimony. However, when we rehabilitate existing areas, we create new public spaces. In this specific case, we need to identify the spaces as adaptable to the green infrastructure or not, in addition to following the IPHAN determinations regarding the historical gardens identification. For this systematic research process, exploratory visits with observation and photographic survey were used, a public spaces zoning was developed on the maps provided by the IPHAN technical office and maps were generated in the ArcGIS geospatial processing program, through data provided by the Secretariat Of the State of Santa Catarina using the geographic information system (GIS) as a tool for the water courses identification and the determination for best areas for the green infrastructure installation.



Figure 13: View of the Laguna Listed Historic Center from Santo Antônio Lagoon.  
Source: Ronaldo Amboni, 2015.

We start from the location of the free spaces already inserted on the city context, discarding areas of hills with remnants of Atlantic forest that must remain unchanged, either by force of law or by the understanding of the team (figure 14). The configuration of the contribution basin is the main link between a chain of hills and the Santo Antônio dos Anjos da Laguna Lagoon which can be observed through the generated hypsometric map (figure 15). These recreated spaces will serve as ecological trampolines that connected will contribute to the hydrological cycle restitution in the city and also with the landscape.

In a city it would be a great limitation to depend only on permanent preservation areas for the conservation of biodiversity, highlighting then the importance of a public and private open space project that presents a variety of situations, allowing in some way, its performance as ecological trampolines, in occupied areas by housing and other urban uses. Without facing this need for such connections, it becomes increasingly difficult to maintain meaningful native species in increasingly transformed landscapes. (PELLEGRINO, 2014, page 18)

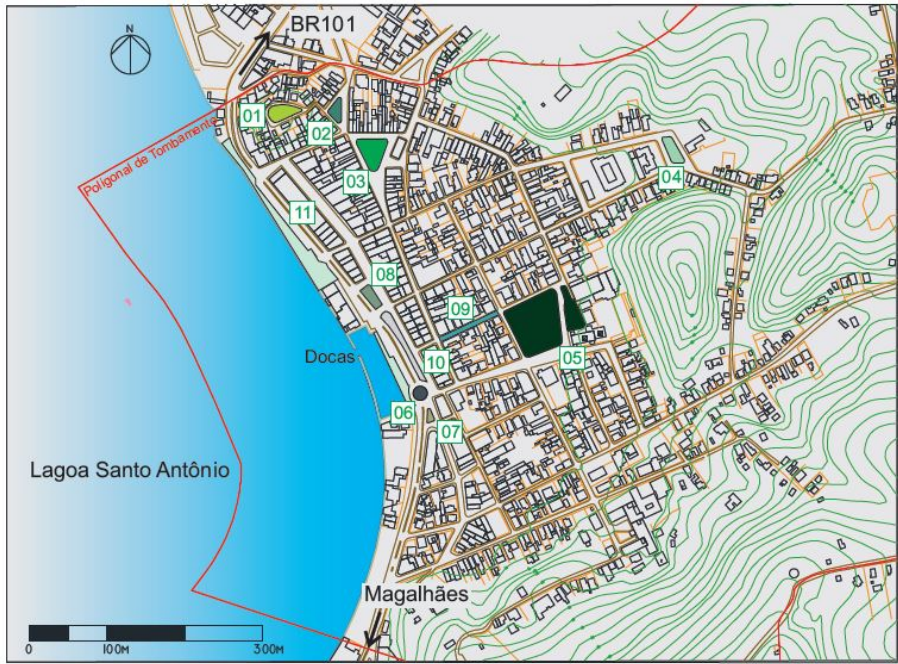


Figure 14: Index map of frame 01.  
 Source: IPHAN cartographic base, adapted by Claudione, 2014

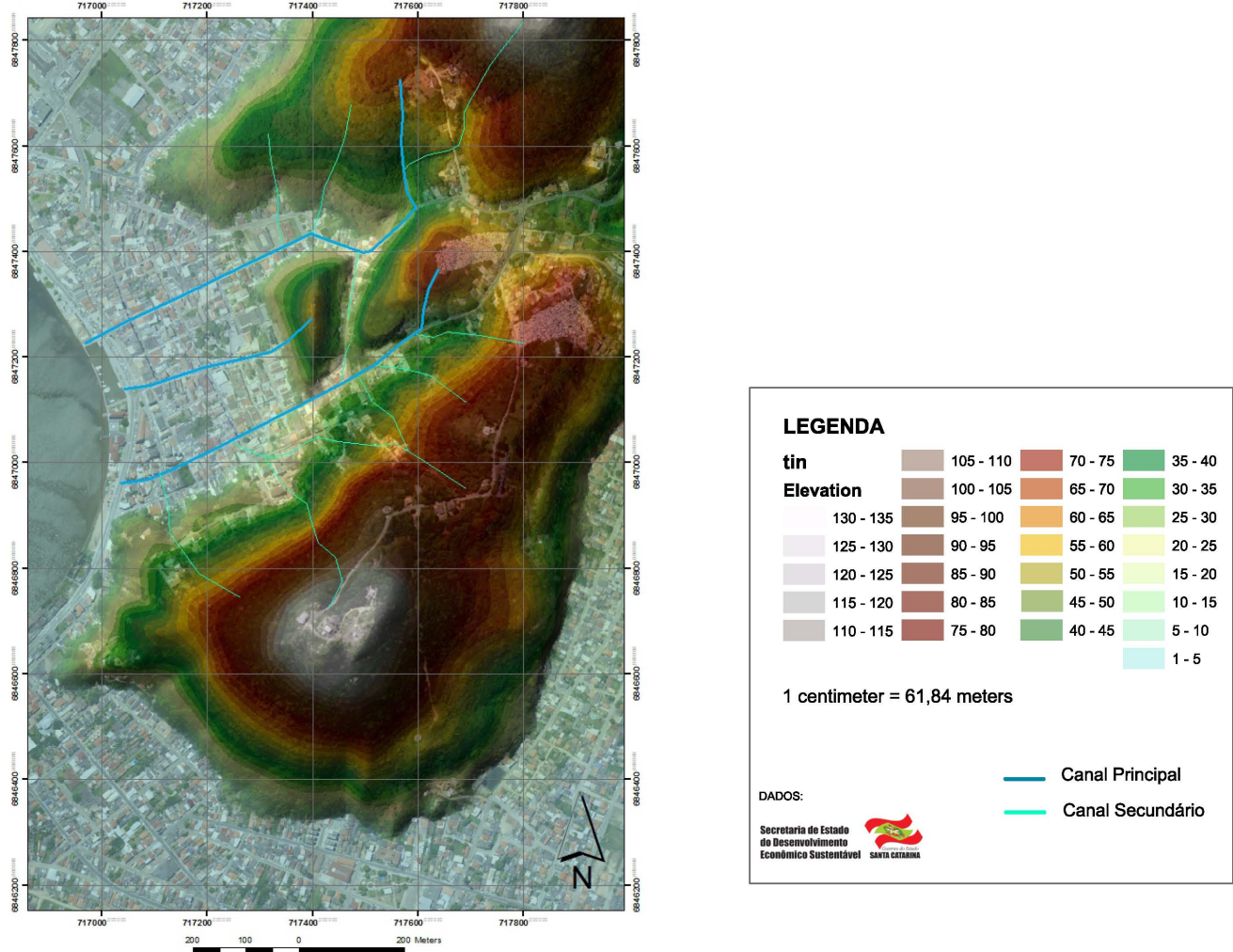


Figure 15: Hypsometric map generated with overlapping aerial photo images with local topography.  
 Source: State Secretariat of Santa Catarina, prepared by the author and civil engineer Rodolfo Godinho with the help of the ArcGIS geospatial processing program, 2014.

A summary table will be presented (table 01), where the free spaces identified were analyzed according to the quality type described by Macedo (1999): environmental, functional and aesthetic. The environmental design should encompass comfort and sustainability based on the triad: environment, social and economic. In the functional conception the demands are observed: the existing program, the accessibility, the infrastructure and the furniture and equipment, its conservation status and ergonomics. In the aesthetic conception, perhaps the most intriguing of all, by submitting to values that are changeable depending on time, space and society, the form and compositions were analyzed. We have included here the cultural / historical conception to determine which of these spaces should be considered as a historic garden and have its architectural typology preserved according to the notions of heritage following the Interventions in Historic Gardens Manual, published by IPHAN in 2005. This Manual describes the basic preservation concepts, including the values, integrity, authenticity, and the garden environment. The Florence Letter, reproduced in part below, describes how this intervention should be done:

Art. 1. A historical garden is an architectural and vegetal composition that, from the historical and artistic point of view, presents a public interest. Such it is considered a monument.

Art 9. The historical gardens protection requires it to be identified and inventoried. It imposes differentiated interventions, which are maintenance, conservation, restoration. It possibly may recommend restitution. Authenticity concerns both the design and volume of parts as well as their setting or plants or minerals choices that constitute it.

Art. 10. Any maintenance operation, conservation, restoration or restitution of a historic garden or of one of its parties shall simultaneously consider all its elements. Separating the treatments would alter the bonds that bind them together.

Art. 15. Any restoration and, with greater reason, any restitution of a historic garden shall only be undertaken after one of the documents referring to the respective garden and analogous gardens, which is capable of ensuring the scientific character of the intervention. Before any execution, this study should result in a project that will undergo a collegiate examination and approval.

Art. 16. The restoration intervention must respect the respective garden evolution. In principle, it should not privilege one period at the expense of another, unless the deterioration or loss of certain parts may exceptionally give rise to a refund founded on traces or irrefutable documentation. More particularly, the parts of a garden closer to the building may be subject to restitution in order to emphasize its coherence.

Art. 17. When a garden has totally disappeared or only possesses conjectural elements of its successive states, it shall not undertake a relevant restitution of the historical garden notion. The works which in this case are inspired by traditional forms on the ground of an ancient garden, or in a place where no garden previously existed, would then constitute notions of evocation or creation, excluding any qualification of historical garden. Florence Letter, 1981 (CURY, 2004).

The modifications that must be avoided are those that can deteriorate the garden and its surroundings quality. IPHAN always supports interventions that contribute to integrity and preservation, while respecting landscape aesthetics and space functionality.

PUBLIC FREE SPACES	ENVIRONMENTAL CONCEPTION	FUNCTIONAL CONCEPTION	AESTHETIC CONCEPTION	CULTURAL CONCEPTION / HISTORICAL
According to the exploratory visits, photographic survey and analysis of the Geographic Information System.	Comfort Criteria of sustainability. Soil permeability and native or relevant vegetation.	Accessibility, infrastructure, existing furniture and equipment criteria, their conservation status and ergonomics	Form and composition criteria. IPHAN technicians were refused for the outstanding elements considered by the institute.	We analyzed the place history, and values, integrity, authenticity and its surroundings. The space integrity and representativeness of its time were decisive for the analysis and the position of this as a historical garden or not. Meetings were also held at the IPHAN technical office for these analyzes.

PUBLIC FREE SPACES	ENVIRONMENTAL CONCEPTION	FUNCTIONAL CONCEPTION	AESTHETIC CONCEPTION	CULTURAL CONCEPTION / HISTORICAL
<p><b>Rosário Hill</b></p> 	<p>It does not have any outstanding vegetation however, hill the permeability is guaranteed by the public area, a central and sloping wasteland.</p>	<p>The space does not have any furniture nor equipment, has no accessibility and no trace to be preserved. Place unused inserted from centrality.</p>	<p>Lack of elements to evaluate aesthetic quality.</p>	<p>1845 - It had on its summit the Chapel Nossa Senhora do Rosário dos Homens Pretos, built by slaves. Until 1996 still had the chapel ruins, today only vestiges. It does not represent a historic garden.</p>
<p><b>Largo do Rosário</b></p> 	<p>It has a fig tree and flower beds with grass. Near the Rosário Hill.</p>	<p>It has street furniture: 02 benches and a table, but much damaged. It has no trashcans. Its surroundings are occupied by houses in the majority with commercial use.</p>	<p>It has a triangular layout. There is a monument in honor of Jerônimo Coelho.</p>	<p>It was formed from the house demolition existed on that area. It does not represent a historic garden.</p>
<p><b>República Juliana Square</b></p> 	<p>Its original vegetation was subtracted in interventions to turn it into a square for events. It has some almond trees that provide shade.</p>	<p>It has an underground distribution network and bench still in good condition. Its design is triangular.</p>	<p>It has a monument in honor of Anita Garibaldi. It has in its surroundings the House and Chain building, in addition some Luso-Brazilian and eclectic houses.</p>	<p>It was once Chain Square, Conde D'Eu, Mafra Counselor and Praça da Bandeira. Stage of historical events like the Proclamation of the Republic in 1839. It does not represent a historic garden.</p>
<p><b>Lauro Muller Square</b></p> 	<p>It does not have significant vegetation elements, besides an aroeira in the center. Close to the foothills of the Mill and Carioca water source.</p>	<p>It has two benches and a set of trashcans. Its shape is triangular.</p>	<p>From the square, it is possible to see the Carioca water source and Pinto D'Ullysséa House.</p>	<p>It emerged along with the Jerônimo Coelho School and the Health Post construction in 1911. Before the place was configured as a flooding for the washerwomen. It does not represent a historic garden.</p>
<p><b>Vidal Ramos Square</b></p> 	<p>It has pairs of palm trees in the foursquare. An abundant vegetation, with varied species.</p>	<p>Very used until the 90's as a meeting point to the city young people. With the cinema closure, the square lost its movement on weekends. Close to trades, it represents a quiet place for resting and contemplation.</p>	<p>Significant element the central fountain, with paving in hydraulic floor at the edge.</p>	<p>Built between 1910 and 1915, where it used to be the Management Field. It is the square of the Mother Church and has a geometric trace. Since the interventions always respected the initial course. This is a historic garden.</p>
<p><b>Roundabout</b></p> 	<p>It does not have any type of vegetation. Near the lagoon. Exposed to strong winds, mainly northeast and south.</p>	<p>It has a central post. It serves to direct the transit of the neighborhoods Progresso and Magalhães to the</p>	<p>It is located in front of the Santo Antônio dos Anjos Lagoon. Circle shape.</p>	<p>It does not represent a historic garden.</p>








		Center.		
<b>Domingos de B. Peixoto Square</b> 	It has an almond tree and is a shelter for birds.	It has two benches.	It is located between the Roundabout and the Cine Mussi Theater. It has a monument in honor of Domingos de Brito Peixoto, founder of the city. Its format constitutes the completion of the court.	It has hydraulic tile floor, which would be a condition for a future intervention. It represents in part a historic garden.
<b>Paulo Carneiro Square</b> 	It has two almond trees, close to the Lagoon.	It has benches, trashcan and a natural products traveling fair every Friday.	It is located in front of the Municipal Public Market. Urban waste generated after the deactivation of the railway line.	It has been through many interventions, it was used to be a gas station. It does not represent a historic garden.
<b>Boardwalk XV of November</b> 	Dry public space, with no vegetation.	It has benches and trashcans, little used. It is a great commercial and service corridor.	It has drawings in Portuguese stone on the floor. Commercial street, which connects the Plaza de la Matriz to the Santo Antônio lagoon.	XV of November Street was the scene of the city's carnival rehearsals for many years. In the 90's the boardwalk was built. It does not represent a historic garden.
<b>Boardwalk Avenida</b> 	Dry public space, with no vegetation. Near the edge of the lagoon, exposed to winds.	It has some broken benches and serves as a trash deposit for merchants.	It has no aesthetic appeal. It is located in front of the docks of the Santo Antônio dos Anjos Lagoon. It came after the old Highway was demolished and an old Gas Station.	It was until the early 80's location of the Municipal Bus Station.
<b>North Shore</b> 	It has almond trees and a few grass. It has a beautiful sunset. South and northeast wind.	Its main users are the anglers, and the people who are waiting for public transportation.	It is located in the extension of the Lagoon Santo Antônio dos Anjos and is divided in north and south by the municipal public market.	It has already undergone several interventions. Today it has kiosks of imported products and natural products. Does not represent a historic garden.
<b>South Shore</b> 	It has some flowerbeds with grass. South and northeast wind.	It is the dock, used as a berth for small boats.	It represents the border of the southern part of the Public Market. It has a monument of the Rotary Club of Laguna.	It has already undergone several interventions. Already had some types of fish stalls, which today have been extinct. It does not represent a historic garden.

Table 01: Synthesis of the Analysis of Public Free Spaces of Laguna / SC.

Source: MEDEIROS, 2015. (Images: the author, 2014 and text based on MORAIS, 2006)

From the analyzes above, and as a way of proving the applicability of the green infrastructure in the public spaces of the center of Laguna, an application of the green infrastructure concept map was produced (figure 16) and some schematic images related to it in figures 17 to 28. The concept of green infrastructure was incorporated into these drawings to optimize urban drainage and avoid

occasional floods, especially near the listed housing. The map was structured in four axes, three of which have a structurally clear space and coincide with the main thalweg formed within the micro-basin of Laguna center. The fourth axis is the water receiver, located on the edge of the lagoon.

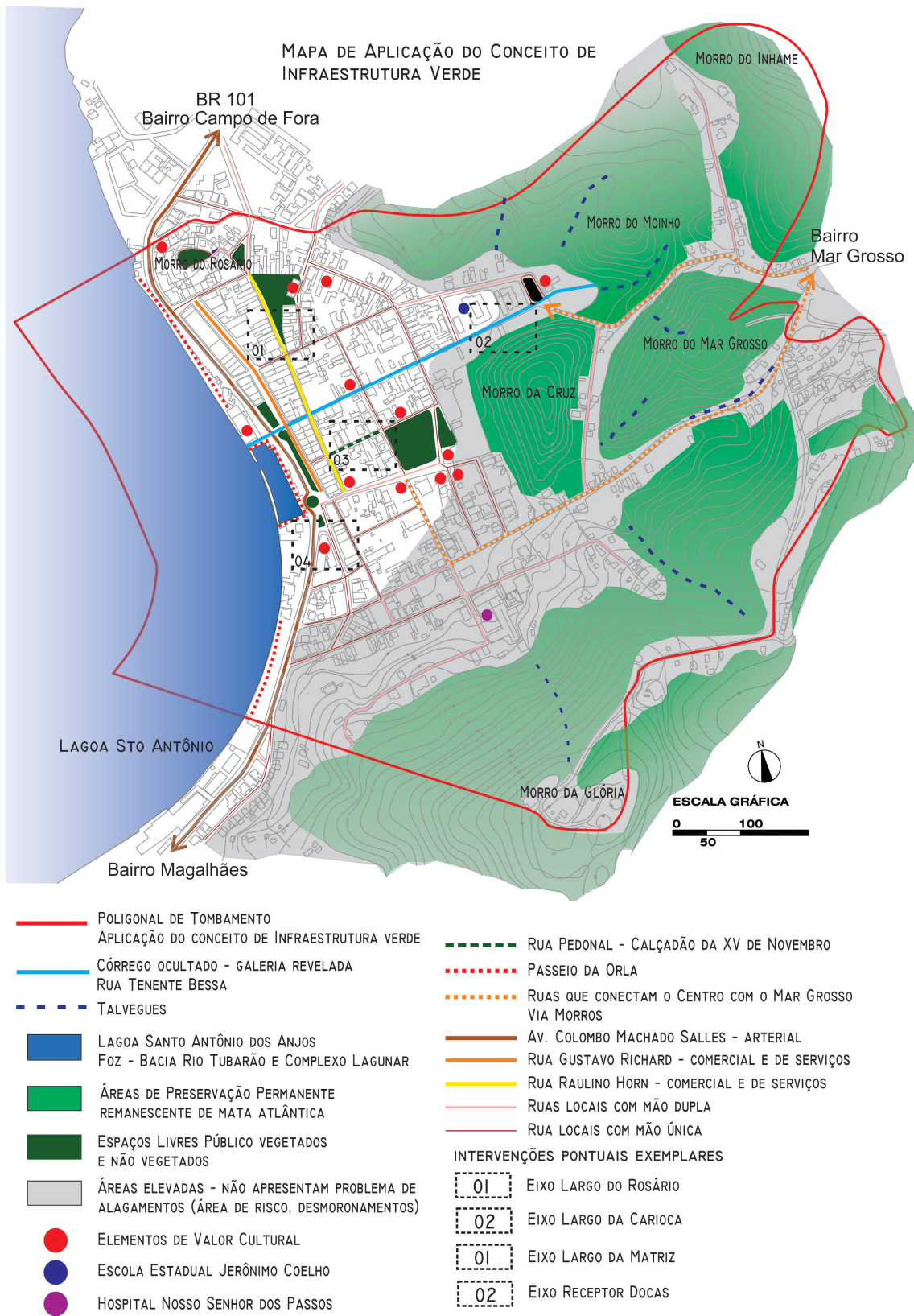


Figure 16: Application map of the green infrastructure concept.  
Source: IPHAN cartographic base, adapted by Claudione, 2015.

The Largo do Rosário axis (Figure 17) has as its structuring element the Rosário Hill and República Juliana Square. Civic tributes and cultural events are held in this square, so the interventions must respect this place vocation. Rain gardens, rainforest beds and a cistern that collects water from the roof of the Anita Garibaldi Museum to be used to maintain the square itself are inserted (Figure 18). The points with greater flooding are at the foot of the hill, where a rain garden was inserted to assist the traditional drainage already existing. Rain plains assist in the rainwater accumulating absorption between the track and the guides, leaving the way for pedestrians clear (Figure 19).

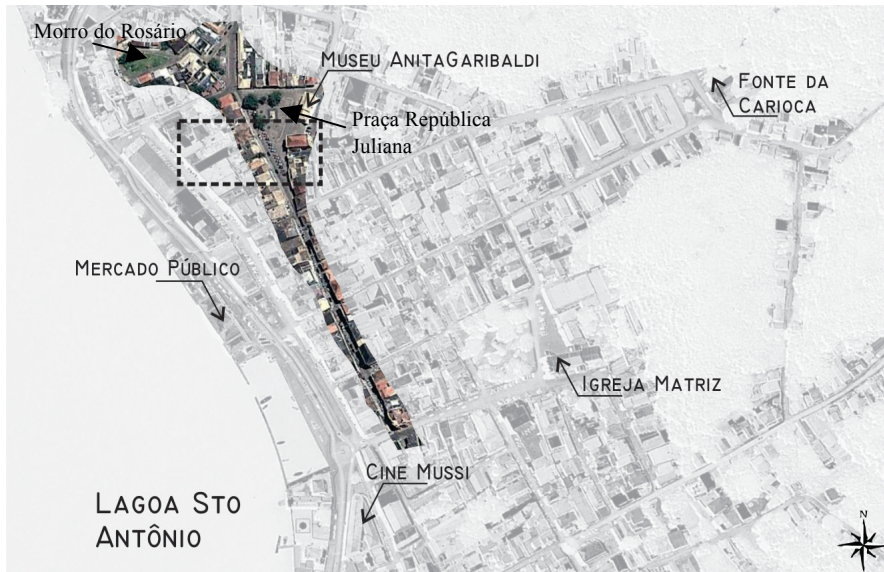


Figure 17: Application map of the location of the Largo do Rosário axis.  
Source: Google Earth image, adapted by Claudione, 2015.



Figure 18: Exemplary point interventions on the Largo do Rosário axis.  
Source: Google Earth image, adapted by Claudione, 2015.

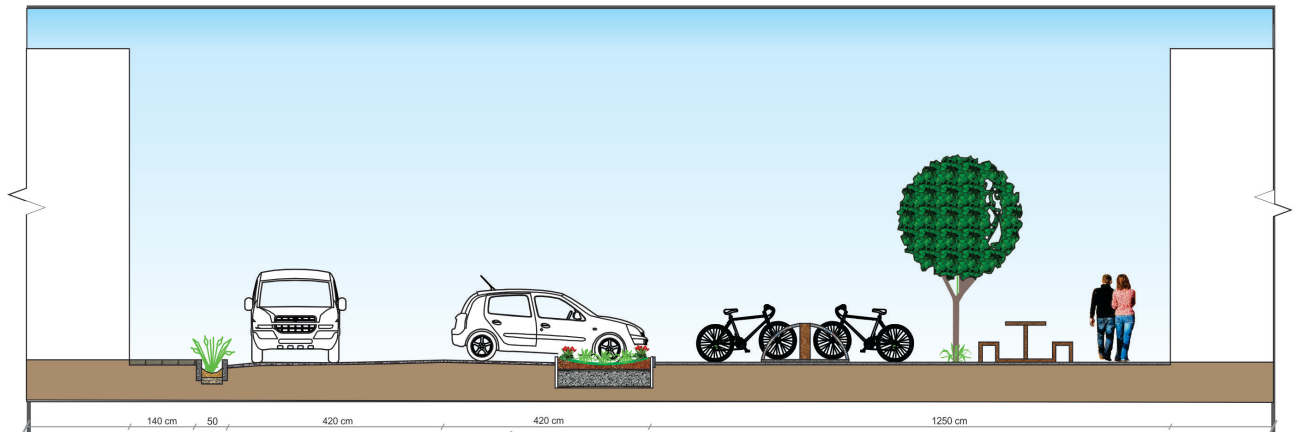


Figure 19: Schematic section of the Largo do Rosário axis.  
Source: Claudione Medeiros, 2015.

The second axis is Largo da Carioca, it represents the main thalweg identified in the map analysis (figure 20), with Lauro Muller Square and Carioca Water Source, being the free spaces that structure this axis. In the area in question, there is explicit evidence when Ulysséa (1943) describes the city in 1880, of the existence of a creek in this place, which was channeled in 1911, due to the Jerônimo Coelho School construction. In this way, the proposal is to retake this natural path of water through a trench and a system of gutters or biovallets connecting the rain garden and the rainforest (Figures 21 and 22). The playground inserted in the shaft represents new possibilities of use and permanence. Protected from the winds, it is located in Tv. Clito Araújo and next to the Jerônimo Coelho School.

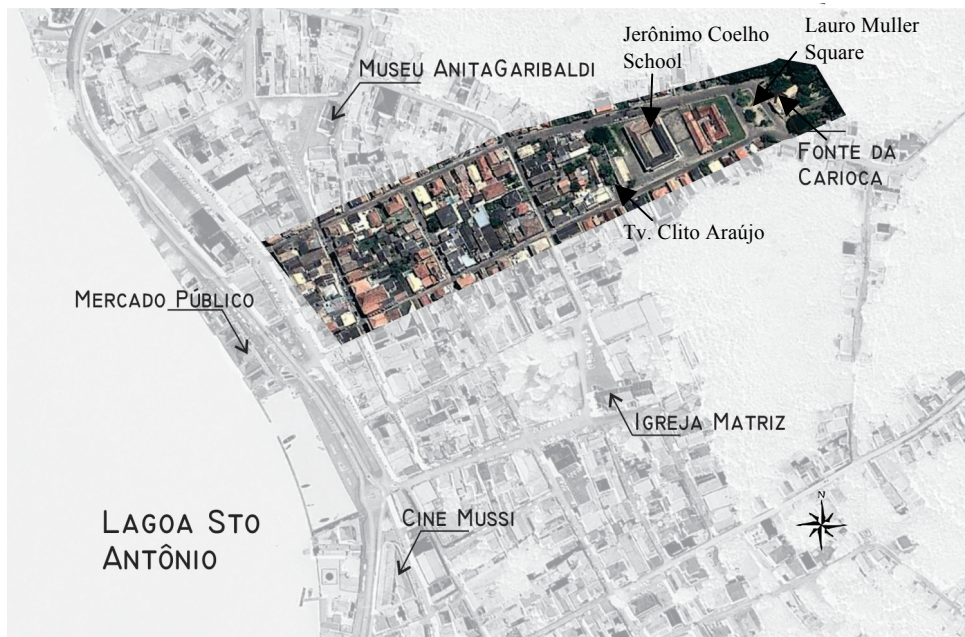


Figure 20: Application map of the location of the Largo da Carioca axis.  
Source: Google Earth image, adapted by Claudione, 2015.



Figure 21: Exemplary point interventions on the Largo da Carioca axis.  
 Source: Google Earth image, adapted by Claudione, 2015.

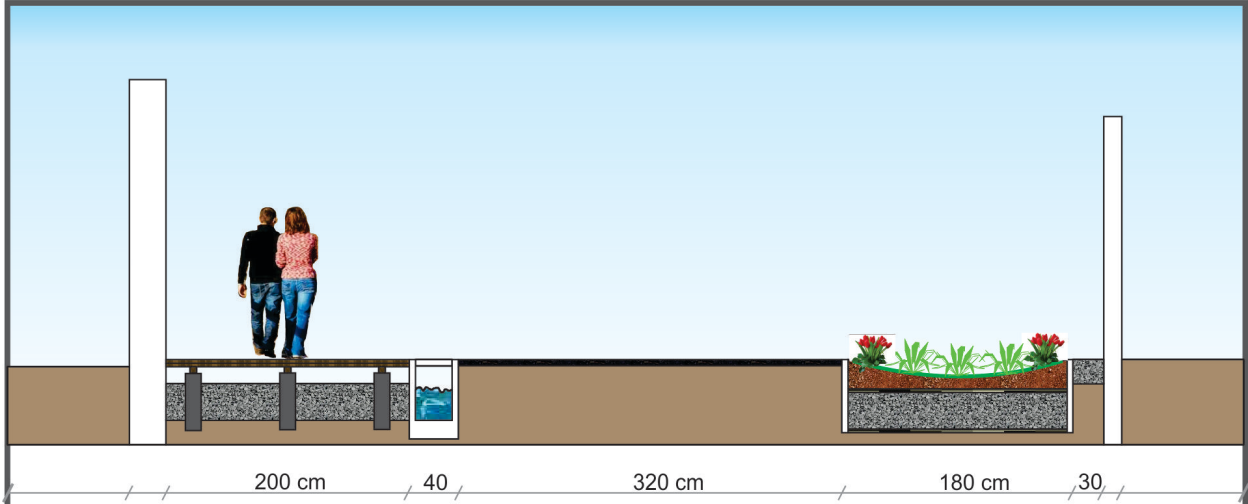


Figure 22: Schematic section of the Largo da Carioca axis.  
 Source: Claudione Medeiros, 2015.

The Broad Axis of the Matriz is formed by Vidal Ramos Square and the streets that connect it to the Santo Antônio dos Anjos Lagoon (figure 23). The street with the highest number of floods is XV of November Street, used as a boardwalk, it will receive rainforest beds to keep out rainwater from the house and allow pedestrians to pass (Figure 24 and 25). The system of gutters and trenches will also serve to potentiate beyond the direction of the water to the lagoon, the percolation capacity. The structuring square of this axis is the one identified as historic garden and, in this case, the interventions must respect the pertinent guidelines and legislation. As several public buildings, such as the cultural center, the Matriz and the music conservatory, the cistern will receive the rainwater from these roofs, and will serve to maintain the square, as well as a resource for the central fountain.



Figure 23: Location of application map of the axis of the Matrix Largo.  
Source: Google Earth image, adapted by Claudione, 2015.



Figure 24: Exemplary point interventions on the axis of the Matrix Largo.  
Source: Google Earth image, adapted by Claudione, 2015.

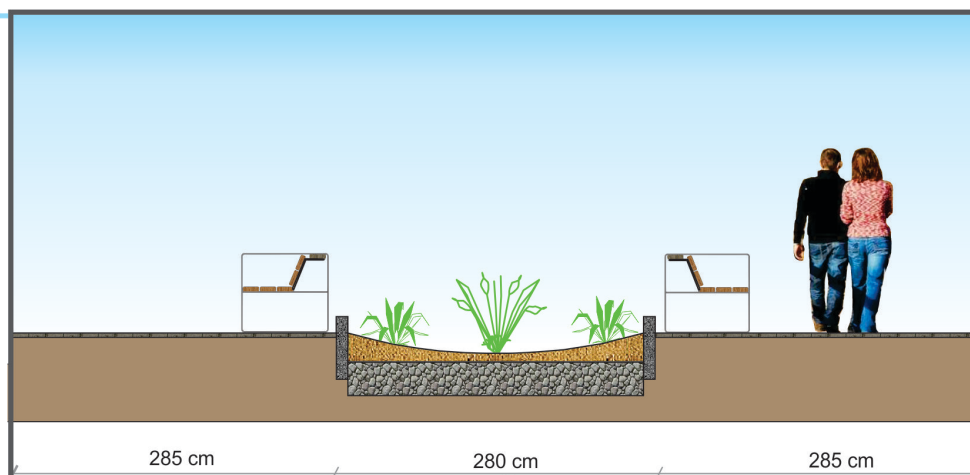


Figure 25: Schematic cut of the axis of the Matrix Largo.  
Source: Claudione Medeiros, 2015.

The fourth axis, which we call the Docks Receiver Axis, is formed by the border of the Santo Antônio dos Anjos Lagoon extension in the Center (figure 26). It is the main forming axis of the proposed infrastructure, since it is the destination of the others. In it, a cycle way is proposed for increasing urban mobility at Colombo Machado Salles Avenue, which cuts through the center and links it to the other districts of the city (Figures 27 and 28). At this receiver axis, several flooding problems have been detected throughout, although the lagoon is only a few meters away. The green infrastructure system will connect the other axes to the water body and increase the absorption capacity of rainwater.

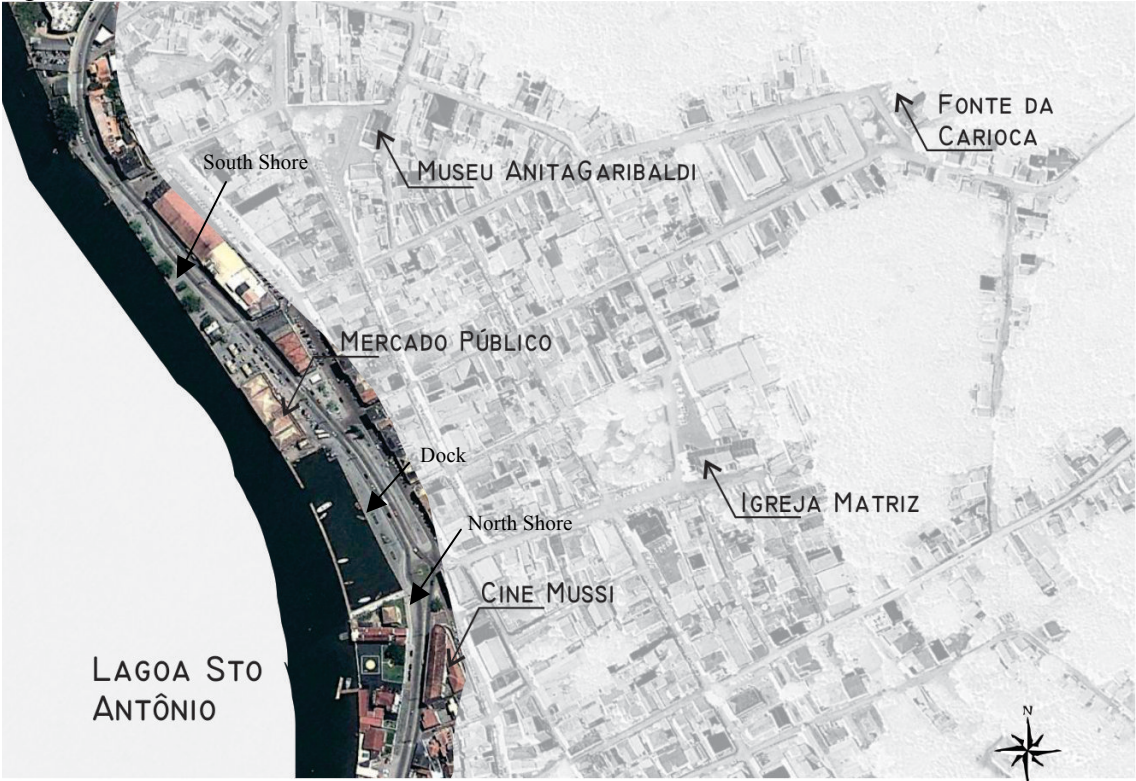


Figure 26: Application map of location of the Receptor Docks axis.  
Source: Google Earth image, adapted by Claudione, 2015.



Figure 27: Exemplary point interventions in the Receptor docks axis.  
Source: Google Earth image, adapted by Claudione, 2015.

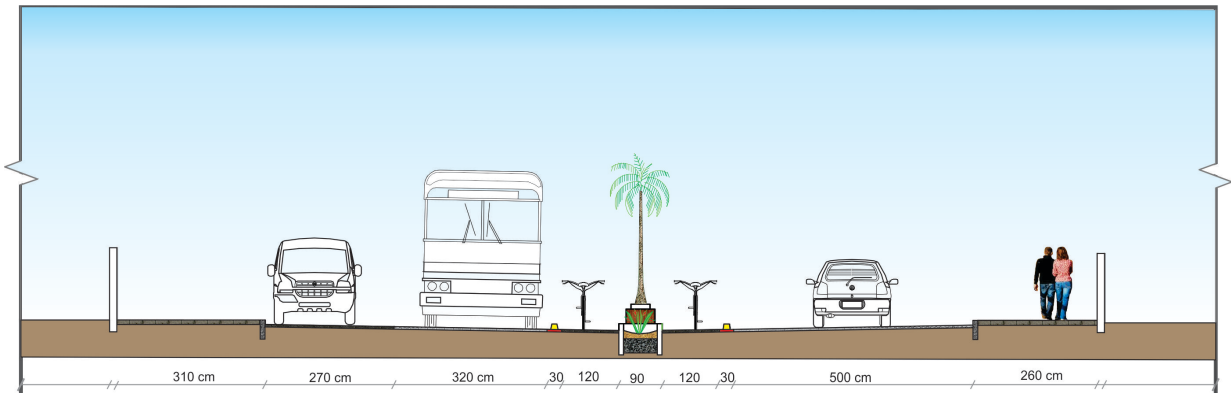


Figure 28: Schematic section of the Receiver Docks axis.  
Source: Claudione Medeiros, 2015.

## FINAL CONSIDERATIONS

The historical centers listed need some techniques that promote their development through low impact strategies, given their already consolidated situation and remarkable cultural landscape with its houses and streets. The traditional drainage systems' inefficiency and damage caused to heritage due to climate change are evident. The green infrastructure can contribute considerably to promote the revitalization of these centers, enhancing their landscape and increasing the effectiveness of urban drainage as a system that takes advantage of existing public spaces; its shape is flexible and rescues the already inherent functions of the site, without impacting or disregarding the preexisting urban form.

The consequences of the use of green infrastructure will be the landscaping value of the Center and the possibilities of permanence in this area, besides the main benefit that, by decreasing the flow of the floods and increasing the infiltration of rainwater will protect the built and natural heritage. Landscaping adds values and sensations that attract people, making the public place safer and cozier and improving the population's life quality.

Urban planning should seek to make cities resilient to climate change, with a capacity for response and recovery to the events of intense rains more and more frequent. This search for the balance between the built and the natural adds to the longings of consolidated patrimony preservation, prerogatives of the Institute of National Historical and Artistic Heritage in the implementation of actions to preserve listed buildings, transforming the cities' centers into accessible places, with social and functional diversity and generators of the strengthening of cultural identity.

The free public spaces identification that can be applied to the green infrastructure within the historical center of Laguna, pointed out, among all, only the Vidal Ramos Square as an example of a Historic Garden, since it has architectural and vegetal composition characteristics that must be preserved from the point of view of historical sight. This space, which has been analyzed according to the recommendations of the Florence Letter of 1981 (CURY, 2004), is subject to restoration, maintenance and conservation, however, any modification must be justified and approved by the competent agencies, respecting the evolution of the garden and all times.

The other spaces identified as capable of receiving the green infrastructure, may increase and enhance permeable areas and promote the balance of the water cycle, increasing infiltration, percolation and evapotranspiration. The location of these ecological strategies should coincide with the main flooding points, observed in the field after intense rains and overflows.

Studying the public spaces of listed historic centers is only a starting point for future revitalization projects using a green infrastructure. Disseminate these strategies and promote a globalization of this knowledge, joining scientific studies with existing applications in other countries, motivate a sustainable and malleable model creation for these cities. The studies are contributions to a constitution of Urban Planning, through actions and guidelines produced by an interdisciplinary team, formed to explore the methods and strategies of green infrastructure. The



green infrastructure presents itself not only as a landscape option, but also as urban resilience, mitigating the risks that cities are increasingly exposed to.

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