36 Best Management Practices for Manaus-Amazon Urban Afforestation

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Abstract

In 2010, the Brazilian Institute of Geography and Statistics published a survey on urban afforestation in Brazil and Manaus city occupied the 4493rd place among the 5565 municipalities analyzed. Concerning the cities with more than 1 million habitants, Manaus was in the penultimate place, a frustrating result, since the city is the Amazon' capital, surrounded by the largest rainforest in the World. On the other hand, the cities with the best performances were Goiânia, Campinas, Belo Horizonte, Porto Alegre, and Curitiba. Given this context, the research aims to investigate the urban afforestation's best management practices to propose suggestions for Manaus' public managers. The data collection and analysis are based in the study "Urbanistic Characteristics of the Surroundings of the Domiciles", besides obtaining information and documents from articles and websites of the governments and partners of the best city investigated. After the intersection of information, 36 good urban management practices were cataloged and proposed to Manaus' public managers.

Keywords: Best Management Practices (BMP); Urban Afforestation; Green cities.

1. Introduction

1.1 General Context

The state of Amazonas is located in the northern region of Brazil, is the largest state in the country in extension and is known for having the largest rainforest in the world, with a huge diversity of fauna and flora, as well as the largest river basin on the planet.

The state's economy is based mainly on industry and extractivism, which contributes to having the 15th largest GDP in Brazil (IBGE, 2018). Its capital is Manaus, the most populous metropolis of the Amazon with more than 2.1 million inhabitants and holder of the 8th largest GDP of the country (IBGE, 2017).

Every ten years, the Brazilian Institute of Geography and Statistics (IBGE) conducts the demographic census throughout the country, aiming to identify the characteristics of the population and, through these data, reveal the reality of the Brazilian.

In 2010, one of the points of the survey was the urban afforestation of cities, which reveals the percentage of trees around houses. To make the calculations, the IBGE (2010) collection methodology for afforestation data is to identify whether on a corner or its front of or in the median strip, if there was afforestation, ie at least one tree along the sidewalk or in a median strip that divided lanes from the same

street, even if only in part. Also, afforestation is when existing in unpaved streets or without a sidewalk. It is noteworthy that the IBGE did not count the trees within homes or private areas.

Based on this concept, IBGE reached the following conclusions:

First) In Brazil, one-third of urban households do not have a single tree around them. The lack of green areas is more pronounced in the poor houses since that 43.2% of them do not have trees in the surroundings are households with monthly per capita income of up to a quarter of the minimum wage. The rate is almost halved (21.5%) in households with an income of more than two minimum wages per person;

Second) The best rate of afforestation is in small municipalities (up to 20,000 inhabitants), where 29.4% of households do not have trees planted around them. The worst performers are medium-sized cities with a population of 100,000 to 200,000, with 34.6% of the tree-free homes in the surrounding area;

Third) Regarding the distribution of the surrounding characteristics related to the environment and people's quality of life, it was found that in the North region (Figure 1) were located municipalities with the lowest incidence of afforestation of roads (IBGE, 2010 p. 49);
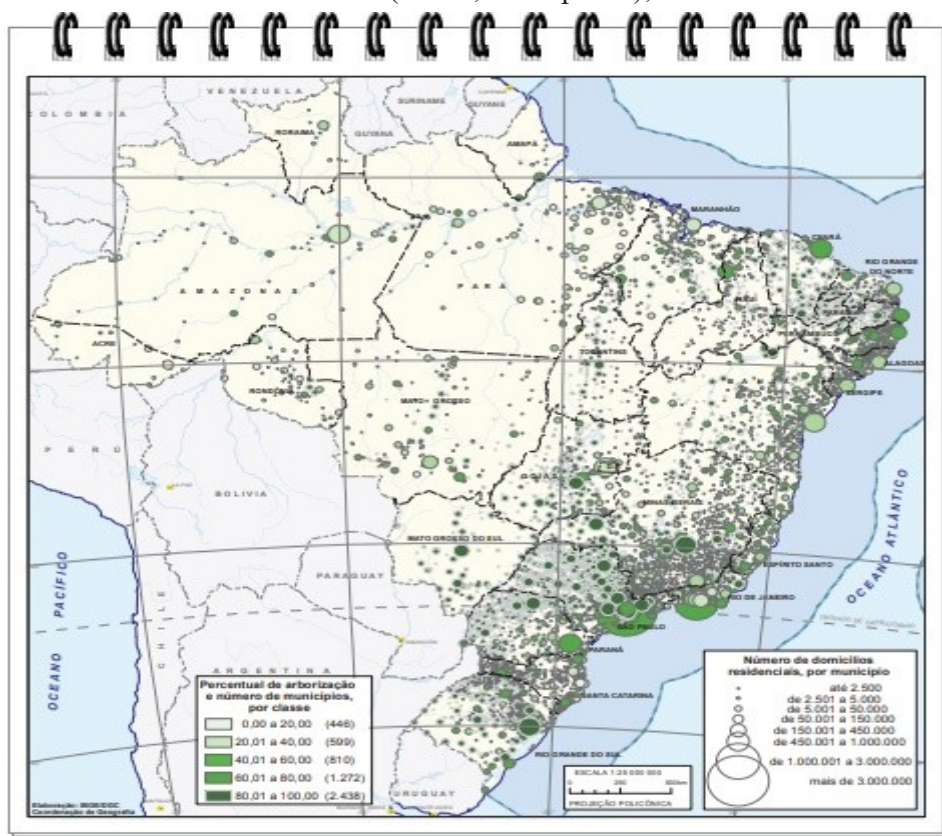

Figure 1: Permanent private households in urban areas with afforestation in 2010

Source: IBGE (2010)

Note: The result refers to the percentage of houses located on the corner with trees or to its front afforestation.

Fourth) The proportion of households with afforestation on the corner ranged from 89.5% in Goiânia to 22.4% in Belém city. Most of the best conditions were in the municipalities of the South and Southeast, except Goiânia, as mentioned above. There was a predominance of municipalities in the North and Northeast Regions with smaller proportions of houses on green areas, including Brasilia to this group,

which had only 37.2% of afforestation in the surroundings;

Fifth) Among the 15 cities with more than one million inhabitants (Table 1), the five most forested cities were: first) Goiânia (89.5%); second) Campinas (88.4%); third) Belo Horizonte (83%); fourth) Porto Alegre (82.9%); fifth) Curitiba (76.4%). On the other hand, the five cities with the worst rates were: 15th) Belém (22.4%); 14th) Manaus (25.1%); 13th) São Luis (32.7%); 12th) Brasília (37.2%) and 11th) Salvador (40%);

Sixth) In addition to the penultimate place among the 15 cities with more than 1 million inhabitants, Manaus occupied 4493rd place among the 5,565 municipalities listed.

Table 1: Percentage of permanent private houses by surroundings characteristics

Municipios com mais de 1 000 000 hab.	Percentual de domicílios particulares permanentes (%)	Municipios com mais de 1 000 000 hab.	Percentual de domicílios particulares permanentes (%)	Municipios com mais de 1 000 000 hab.	Percentual de domicílios particulares permanentes (%)	Municipios com mais de 1 000 000 hab.	Percentual de domicílios particulares permanentes (%)
Arborização		**Bueiro/boca de lobo**		**Esgoto a céu aberto**		**Lixo acumulado nos logradouros.**	
Brasil	**68,0**	**Brasil**	**41,5**	**Brasil**	**11,0**	**Brasil**	**5,0**
Goiânia	89,5	Rio de Janeiro	84,6	Belém	44,5	Belém	10,4
Campinas	88,4	Curitiba	84,3	São Luís	33,9	Fortaleza	7,7
Belo Horizonte	83,0	Porto Alegre	77,8	Manaus	20,2	São Luís	6,3
Porto Alegre	82,9	Brasilia	66,5	Fortaleza	19,3	Manaus	6,2
Curitiba	76,4	Campinas	58,6	Recife	16,7	Porto Alegre	6,0
São Paulo	75,4	Recife	54,3	Campinas	5,3	Curitiba	5,7
Fortaleza	75,2	Belém	53,2	Porto Alegre	5,2	Recife	5,6
Guarulhos	72,4	Goiânia	53,1	Rio de Janeiro	5,1	Salvador	4,8
Rio de Janeiro	72,2	São Paulo	52,0	Salvador	4,9	Guarulhos	4,7
Recife	60,8	Manaus	46,3	São Paulo	3,9	Rio de Janeiro	4,5
Salvador	40,0	Belo Horizonte	45,3	Guarulhos	3,8	São Paulo	4,1
Brasilia	37,2	Salvador	44,2	Brasilia	3,8	Brasilia	4,0
São Luis	32,7	Guarulhos	37,4	Curitiba	2,6	Campinas	3,6
Manaus	25,1	São Luís	17,1	Belo Horizonte	1,4	Belo Horizonte	2,8
Belém	22,4	Fortaleza	16,5	Goiânia	0,5	Goiânia	2,6

Fonte: IBGE (2010)

1.2 Problem and main question

Although Araújo (2015) considered that IBGE data may be oversized, recommending caution to those who wish to carry out studies on afforestation. But, the IBGE's large survey points to the need for reflection on the role of public power and organized civil society in the improvement of urban afforestation, as the World Health Organization (WHO) recommends 12 m² of green area per inhabitant, with 36 m² being the ideal value, about three trees per inhabitant.

This reality is due to the disordered growth of city with ineffective actions of the public power about urban afforestation, which is a contradiction since Manaus is a city that has the eighth GDP of Brazil and is located in the largest tropical forest of the planet. Also, it is noteworthy that in 2016, the Manaus City

Hall updated the Urban Afforestation Master Plan (PDAU) with guidelines focused on urban afforestation as a principle of sustainable development (SEMMAS, 2016), however, despite efforts, the result is very far from expected, especially if Manaus is compared with other cities in Brazil and the world, considered a reference in urban afforestation.

So, the main question of the research is "What are the best urban afforestation management practices developed by Goiânia, Campinas, Belo Horizonte, Porto Alegre and Curitiba cities that could be adapted and implemented by Manaus public managers?

1.3 Main aim and importance

Given that there are few update studies involving public policies directed at the theme, this article aims to investigate the best management practices of urban afforestation adopted by the public administration of the five cities with more than one million inhabitants in Brazil, holders of the best urban afforestation index, to propose suggestions for improvements to the Manaus government.

For academia, the research is relevant because of the reflection of the theme and the pointing of new research. For city managers, the research is relevant since it points out the best practices of urban afforestation management, which can be adopted with adaptation to local reality. Moreover, for society, the research is relevant, since it encourages citizen participation in the process of improving the quality of life in their city.

2. Theoretical Referential

2.1 Challenges to Brazilians

The disordered growth of cities leads to drastic changes in their landscape, where tree spaces are replaced by houses, buildings and other urban facilities, causing various problems in preserving urban biodiversity and the quality of life of the population, especially with regard to increased pollution of the environment.

A report published by Larsen (2015) affirms that 49,000 people die each year because of air pollution in Brazil. About 25,000 of the deaths are from outdoor ambient air pollution mainly in urban areas, and 24,000 are from air pollution caused by cooking with wood and other solid fuels.

According to the Brazilian Ministry of Health (BRAZIL, 2019 p.10, and p. 319), the number of deaths classified as resulting from air pollution has increased 14% in 10 years with 38,782 deaths in 2006 and 44,228 in 2016. Among the Factors associated with Chronic Noncommunicable Diseases (NCDs), outdoor air pollution is considered an important health determinant and a major environmental risk factor for human health. It is estimated that 4.2 million premature deaths are attributed annually to ambient air pollution worldwide. Of this total, 91% occur in low and middle-income countries in the Pacific and Southeast Asia.

A survey by Le Quéré et al. (2018) estimated that between 1751 and 2016, Brazil accumulated a total of 13.88 billion tons of carbon dioxide (CO_2), the main greenhouse gas (GHG) in the atmosphere. Ritchie and Roser (2019) presented another worrying study, which shows that Brazil is the seventh world economy in greenhouse gas emissions, in a growing trend from the mid-twentieth century.

For the Global Carbon Atlas, between 1998 and 2018, Brazil was the 14th most emitting (CO_2) country in

the world, equivalent to 457 megatons over the last 20 years (Figure 2). In Latin America, Brazil was the 2nd country that most polluted behind Mexico. It is noteworthy that in 2015, during the Paris Agreement, Brazil guaranteed to reduce its emissions by 37% until 2025 and by 43% until 2030, with 2005 as the base year for comparison purposes.
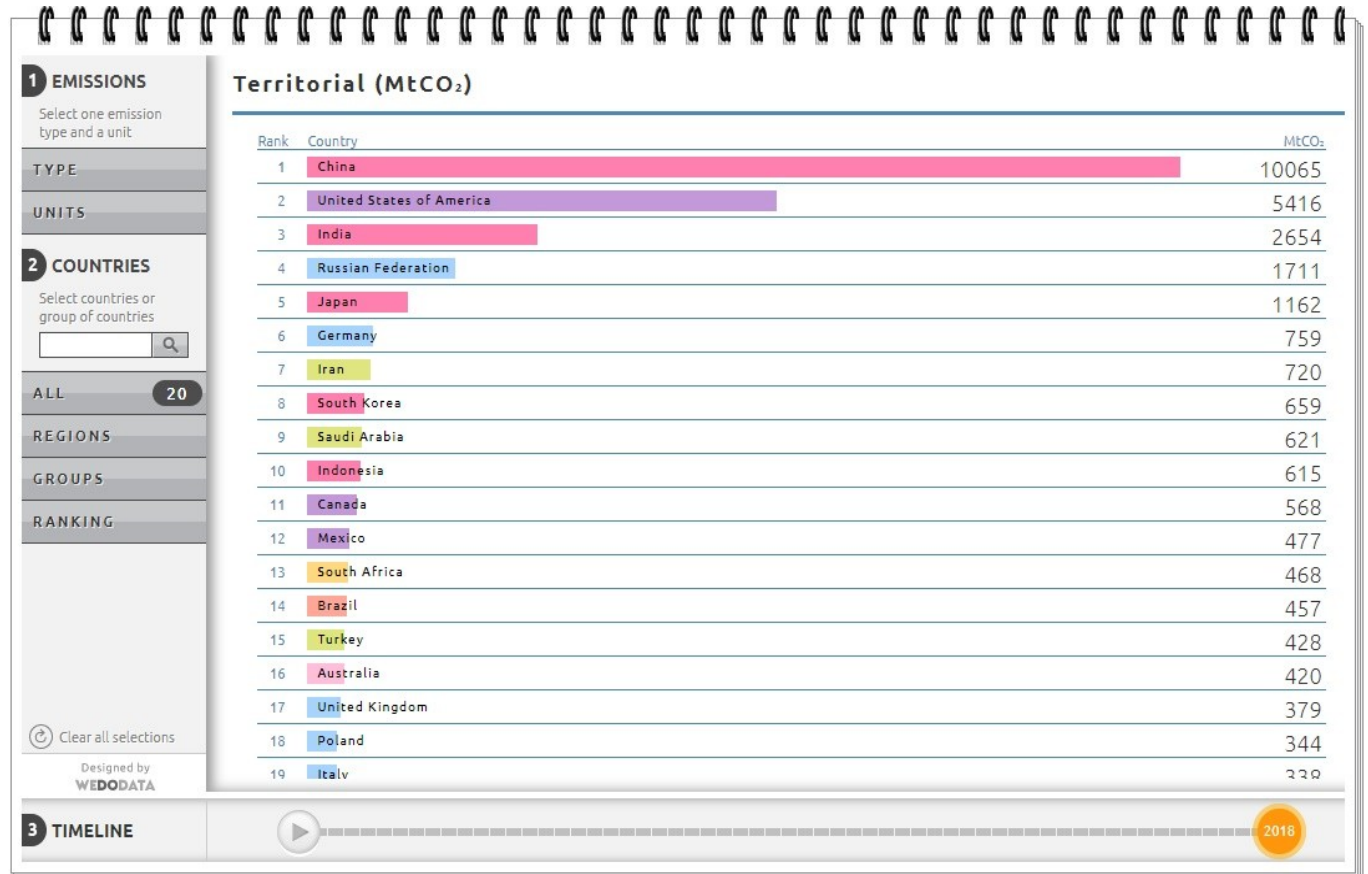

Figure 2: List of the 15 countries that emitted the most CO_2 in the world between 1998 and 2018
Source: Global Carbon Atlas <http://www.globalcarbonatlas.org/en/CO2-emissions>

2.2 Importance of urban afforestation

Given this scenario, trees are important to contribute to overcoming the problems mentioned. According to Nowak et al (2013), trees become potential elements to compensate GHG emissions as they reduce the concentrations of these gases in the atmosphere.

A study recently published by Reis et al (2019) involving carbon stocks and carbon dioxide in street trees in Brazilian cities, stressed the importance of street trees in mitigating climate change due to their biomass production, by fixing the Carbon and CO_2 removal from the atmosphere.

A survey by Madureira et al (2015) in Paris, Angers, Lisbon and Porto found the importance of urban green spaces for personal health and well-being. Contact with nature in urban areas helps to reduce air temperature and noise, as well as increase biodiversity, also contributing to the city's image.

According to Oldfield et al (2014), trees provide multiple benefits in cities, including reduction of urban temperatures, improved air quality, mitigation of storm-water run-off, and provision of wildlife habitat.

For Milano (1992), urban afforestation is the set of public and private lands with predominantly arboreal or natural vegetation that a city has and includes street/avenue trees, public parks, and other green areas.

For Nowak et al. (2002) urban forest refers to all publicly and privately owned trees within an urban area, including individual trees along streets and in backyards, as well as areas of remaining forest.

The methods of urban afforestation come from the earliest civilizations. However, one of the models is derived from the 18th century Paris revitalization plan (TERRA, 2000) and is present in many urban centers around the world.

Some associate urban afforestation with the aesthetic and landscape factor. However, the practice also has as its main functions: providing shade and softening the temperature, purifying the air, attracting birds, reducing noise pollution, reducing the impact of rainfall, contributing to water balance and enhancing the local quality of life (MILANO and DALCIN, 2000).

According to Nowak et al. (2010), trees are a valuable asset to the urban community. The urban forest in the USA was estimated to have 3.8 billion trees with a structural price near $ 2.4 trillion. Also, Nowak et al. (2010) presented thirty scientific studies about the ten benefits that come from urban forest services:

1) local climate and energy use (AKBARI et al., 1988, 1992; DONOVAN AND BUTRY 2009);

2) Air quality (NOWAK et al., 2006);

3) Climate change (NOWAK AND CRANE, 2002);

4) Water flow and quality (SANDERS, 1986);

5) Noise abatement (ANDERSON et al., 1984; COOK, 1978);

6) Wildlife and biodiversity (HOWENSTINE, 1993; SHAW et al., 1985; VANDRUFF et al., 1995)

7) Soil quality (WESTPHAL and ISEBRANDS, 2001);

8) Real state and business (ANDERSON and CORDELL, 1988; CORRILL et al., 1978; DONOVAN and BUTRY, 2008; DWYER et al., 1992; WOLF, 2003, 2004; WOLF 1998);

9) Individual well-being and public health (DWYER et al., 1991; TAYLOR et al., 2001A, 2001B; ULRICH 1984; HEISLER et al. 1995);

10) Community well-being (KUO and SULLIVAN, 2001A, 2001B; SOMMER et al. 1994A, 1994B; WESTPHAL 1999, 2003).

One point to consider is that the wooded spaces are being incorporated into the housing market, because the higher the neighborhoods' greening rate, the more value is added to the property. Properties located in the greenest regions have the most expensive square meter and can be sold for up to 10% higher than in other regions (CORRÊA, 2018).

It is also relevant to the economic issue because a single tree exudes 400 liters per day, which significantly increases air humidity by matching the operation of five (2500 kcal/h each) air conditioners running for 20 hs (ALMEIDA, 2009).

Urban afforestation provides benefits to the population such as shading, CO_2 retention, ornamentation; improvement of the urban climate by reducing the temperature and releasing moisture into the air; Greater ecological balance, as trees provide shelter and food for other living things; Mitigation of noise pollution; Flood prevention; Assists water infiltration in the soil; Reduces surface runoff of rainwater. (SANTANA, 2010).

Gains can also be assessed in the health of people living in forested areas, as it provides humans with a

reduction in blood pressure in stressful events through the singing of birds and other living things that make the tree element their habitat (CAPPS, 2010).

Plus, it is important to reflect on the challenges of urban reforestation. Nowak et al (2010) also presented six threats to urban forests such as invasive species, fire, air pollution, lack of management capacity, and development pressures, which may be reduced by long-term urban forest plans to be implemented with good management practices.

For example, to Oldfield et al. (2013), urban afforestation efforts have traditionally relied on street-tree plantings, but more recently cities such as Auckland, London, Los Angeles, and New York have implemented large-scale, tree-planting campaigns to establish contiguous stands of urban forest composed predominantly of native species.

2.3 Best Management Practices (BMP)

According to the Cambridge Dictionary, management is the activity of being in charge of a company, organization, department, or team of employees. Also, it defines as a group of people who control a company or organization.

To Drucker (1954), considered as the father of administration, management is a multipurpose organ that manages a business and manages manager and manages workers and work. The author stressed 3 jobs of management: (a) manage the business; (b) manage the manager; (c) manage the workers and work.

The term management practice is viewed to some authors as an entity of analytical instruments used to support the managers at work during the implementation of the selected management concept (DESSLER, 2004; SUTHERLAND and CANWELL, 2004; VAN ASSEN et al., 2009). Others consider management practices as tools that are defined as a set of concepts, processes, and exercises (RIGBY, 2001).

According to Encyclopedia.com, Best Management Practices (BMP) are methods that have been determined to be the most effective and practical means of preventing or reducing the non-profit source of pollution to help achieve water goals.

For this article, Best Management Practices (BMP) is defined as those effective management instruments able to achieve a goal creatively and sustainably. The instrument could be a system, a policy, a law, a methodology, a method/technique, or a process.

The term is well used in organizations that deal not only with water, but with land, forest, and other environmental issues. For example:

a) To the North Carolina Forest Service <bit.ly/2tIKMrR> the BMP means practice or combination of practices, that is determined to be an effective and practicable means of preventing or reducing the amount of pollution generated by nonpoint sources to a level compatible with water quality goals;

b) To Nelson Institute for Environmental Studies, from University of Wisconsin-Madison <bit.ly/2tC5YQ4>, the BMP are management practices that improve the quality of the land or water;

c) To the Ministry of Ontario's Agriculture, Food and Rural Affairs <bit.ly/34OO6ym>, BMP is a practical, affordable approach to conserving a farm's soil and water resources without sacrificing productivity;

d) The OCDE has several guidelines with BMP, for example, in this link <bit.ly/2EEv1V4> the OCDE

presents several BMP for pesticides;

e) The Minnesota Department of Natural Resources has several BMP for Urban forestry <bit.ly/36Vrf5N>. Tree Canada has an interesting Compendium of BMP for Canadian Urban Forest developed by Bardekian (2018);

f) The United States (1993) developed the complete Guidance Manual for Developing Best Management Practices for pollution prevention (Metal finishing, organic chemicals, plastics, and synthetic fibers, textile manufacturing, pesticides, pharmaceutical, petroleum refining, inorganic chemicals, etc.).

Although this Guidance does not deal with urban forest issues, it has standardized elements that could be useful for a baseline a BMP Plan, as shown in Figure 3;

g) The Society of Municipal Arborists <https://www.urban-forestry.com/about-sma > is another good source to those interesting to learn about municipal urban forest BMP.
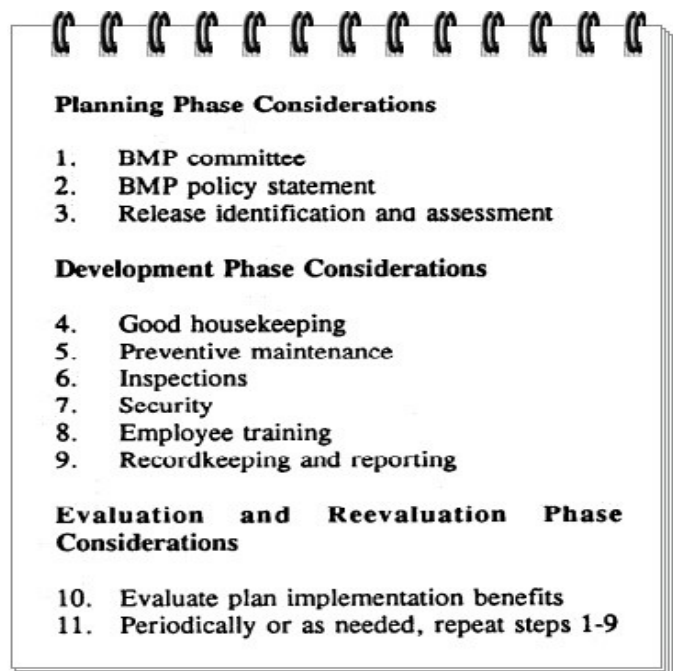
Planning Phase Considerations

1. BMP committee
2. BMP policy statement
3. Release identification and assessment

Development Phase Considerations

4. Good housekeeping
5. Preventive maintenance
6. Inspections
7. Security
8. Employee training
9. Recordkeeping and reporting

Evaluation and Reevaluation Phase Considerations

10. Evaluate plan implementation benefits
11. Periodically or as needed, repeat steps 1-9

Figure 3: Suggested Elements of a Baseline BMP Plan
Source: USA (1993)

2.4 The urban afforestation in Manaus

In 2019, Manaus completed 350 years; the city is the capital of the state of Amazonas. According to IBGE <bit.ly/2u4MZxY>, the city has an estimated population of 2,182,763 of inhabitants distributed along its 11,401 Km². The city has the Manaus Industrial Pole with more than 500 companies that in 2018 employed about 86,062 employees and earned close to $93 billion.

Although Manaus has a per capita GDP of R$ 34,362.71 (2017) and is the capital of Amazon state, surrounding by the biggest tropical forest, only 25.1% of urban households are afforested in their surroundings (IBGE, 2010).

Despite being considered one of the 8 richest cities in Brazil, the city has only 22% of urban wooded area, according to another survey results published on 10/24/16 by Journal G1 (2016), from an interview with Professor Dr. Marcos Castro, from the Department of Geography of Federal University of Amazonas (UFAM). According to the interview:

1°) The survey took place in 2013, with data collection by satellite images, considering all the vegetation cover of the city, including areas of high concentration of trees. These include the UFAM campus, the National Amazon Research Institute (INPA) area, Mindu Park and military areas;

2°) Only 22% of the 11,500 km² of the urban territorial area of Manaus has trees, that is, the wooded area of the city is 2300 km²;

3°) The reduction in vegetation cover is due to irregular occupations called invasions. There was also a decrease in urban plant fragments when compared to the 1992 images;

4º) Manaus is situated 3.6 degrees from the equator, its position makes the sun's rays hit the city most strongly. The ideal urban tree index in Manaus would be between 35% and 40%. This would require an urbanism policy linked to the systematic afforestation of the city.

The problem of the lack of urban afforestation in Manaus is old, to give an example, a documentary survey with the oldest newspaper of the city, the Jornal do Commercio do Amazonas (Figure 4), points out that a story published on October 30, 1960, already drew the attention of the rulers about the trees, pointing out that several municipal administrations have put the city's afforestation in the second plan.
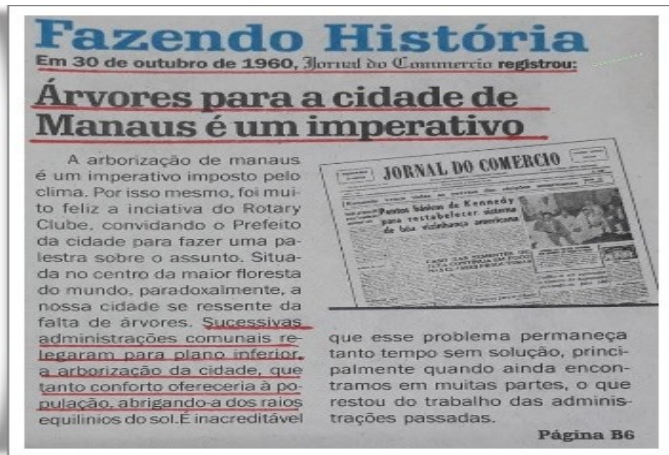

Figure 4: Article about Manaus urban forestation problem
Source: Jornal do Commercio do Amazonas (1960)

Another interesting research was conducted by Neto et al (2016) in 2014, with the application of a questionnaire to 647 residents of the city of Manaus (Table 2), when asked about the afforestation of Manaus as a whole, 74% of respondents considered the occupation of green spaces in public places bad or very bad and only 6% said they were satisfied or very satisfied. According to Neto et al (2016), the North (Norte) and East (Leste) zones of Manaus were the ones with the worst evaluations and despite the efforts of the municipal government to carry out afforestation in various parts of the city, the population has not yet realized the investments applied.

Table 2: Respondents' perception of afforestation in Manaus as a whole (2014)

ZONA	QUALIDADE DA ÁRBORIZAÇÃO (%)				
	Muito Bom	Bom	Regular	Ruim	Muito Ruim
Norte	5	10	28	10	47
Sul/Centro-Sul	1	13	29	25	32
Leste	0	3	9	27	61
Oeste/Centro-Oeste	7	10	33	31	19
Manaus	3	3	20	32	42
Média (%)	3,2	7,8	23,8	25	40,2

Source: Neto et al (2016 p. 167)

In Manaus, there is the Municipal Law 605, of July 24, 2001, and Resolution 01 of January 3, 2012, established the Manaus Urban Afforestation Master Plan (PDAU). As already mentioned, in 2016, the City of Manaus updated (Resolution 087 of December 1, 2016) the PDAU (Figure 6) with 49 pages containing guidelines focused on urban afforestation as a principle of sustainable development (SEMMAS, 2016).

According to the Municipal Secretariat of Environment and Sustainability of the Manaus City Hall <bit.ly/39qda2h>, there is the Arboriza Manaus project to plant 10,000 seedlings annually in at least sixty public places, with tree maintenance actions.

According to Manaus City Hall, SEMMAS manages 12 protected areas in the city: 10 Conservation Units and 2 Ecological Corridors, which occupy 4.75% of the area of Manaus.

The protected areas are Sauim Castanheiras Ecological Reserve (95 ha), Mindú Municipal Park (40.8 ha), Source of the Mindú Municipal Park (16.2 ha), Tarumã/Ponta Negra Environmental Protection Area (22,698.8) ha), Tupé Sustainable Development Reserve (11,973 ha), Bindá Linear Park Environmental Protection Area (5.8 ha), Gigante Linear Park PPA (155.1 ha), Ponta Negra Park PPA (39.8 ha), Adolpho Duque PPA (18,240.8 ha), PPA Manaós Forest (759.15 ha), Urban Ecological Corridor of Mindú Stream (195.27 ha) and Urban Ecological Corridor of Tarumã Waterfall (289.3 ha).

There are also Private Reserves of Natural Heritage (RPPN), established by Law 886 of 10/14/2005. Seven RPPN's were created, protecting an area equivalent to 240.89 hectares: Honda Reserve, Buritis Reserve, Norikatsu Myamoto Reserve, Águas do Gigante Reserve, Bons Amigos Reserve, Nazareth das Lages Reserve, and Socrates Bonfim Reserve.

Municipal RPPN owners, through Municipal Law No. 1091 of 12/29/2006, may apply to the city for exemption from Property Tax (IPTU), as well as request resources from the Municipal Environment Fund for environmental activities, upon presentation and approval of projects by SEMMAS.

However, despite efforts, those who walk around the streets of Manaus perceive a lot of urban afforestation problems, specially concerning with the maintenance process, such as several dead trees without replacement, rickety trees because of lack of adequate water and fertilizer, trees with weeds, public construction and construction site without urban tree planting project, dead tree stumps without replacing new trees. Figure 5 and 6 show some of the problems mentioned above.

Figure 5: Several dead trees identified in december/2019 on the streets and squares of Manaus

Source: Author

Figure 6: Empty spaces, trees with weeds, dead tree stumps without replacing new trees in Manaus

Source: Author

Note: Photos were taken after 6 hours driving and walking in Manaus during the ending of december/19. Some of streets are Avenida Bolevar Álvaro Maia, Avenida Djalma Batista, Av. Humberto Calderado, Av. Darcy Vargas, R. Belém, R. Castelo Branco, V8, R. Eduardo Ribeiro, R. Henrique Martins, Praça de Petrópolis, etc.

3. Methodology

Regarding the nature, the research is applied, because its results and recommendations can be applied with adaptation in the management of the city of Manaus. The research is descriptive, with a qualitative approach, based on bibliographic and documentary research, involving the study of articles, reports, manuals and other technical documents related to the subject. Basically, the research has four steps:

Step 1) Sample definition

The five cities with more than one million inhabitants with the best urban afforestation index were chosen, according to the document "Urban Characteristics of the Surroundings of the Domiciles" published by IBGE (2010), whose best cities are Goiânia (89.5%); Campinas (88.4%); Belo Horizonte (83%); Porto Alegre (82.9%); and Curitiba (76.4%).

Step 2) Study of the main laws, policies, actions, projects and government partnerships

It will be surveyed documents available on the websites of the prefectures of the cities investigated, as well as reading related articles on the subject. The BPM adopted by the municipalities managing these metropolises will be identified, together with the partners, referenced in each Urban Afforestation Master Plan (PDAU), to reference this work. Newspaper or magazine articles will also be identified to complement the research.

Step 3) BMP Cataloging

Cataloging will focus on the Best Management Practices (BMP) adopted among the cities investigated.

Step 4) Preparation of BMP proposals for Manaus City Hall

In the end, proposals for the best urban afforestation practices will be made to the managers of Manaus.

4. Results

The discussion will be made by city until the data intersect between them.

4.1 Goiânia (GO)

The city of Goiânia turned 86 years old in 2019, is the capital of Goiás, state of the Midwest region of Brazil.

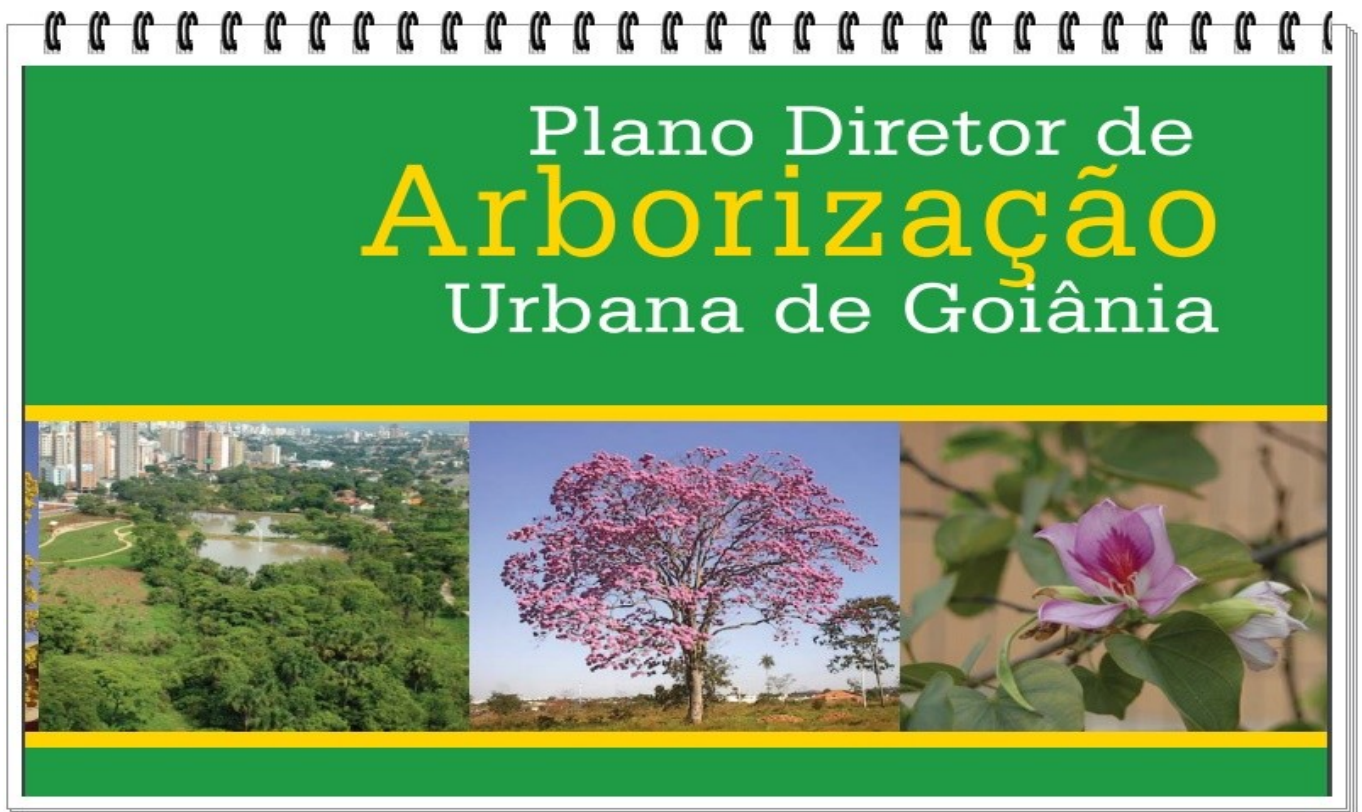Figure 7: Goiânia City Basic Information

Figure 8: Goiânia's PDAU
Source: Municipal Environment Agency

According to the IBGE <bit.ly/2MBLcqz>, Goiânia has 1,516,113 inhabitants spread over its 728,841 Km^2 (Figure 7), with a GDP per capita of R $ 33,437.67. It is the 15th city that most contributes to the Brazilian GDP (IBGE, 2016) and was considered the city with more than one million inhabitants with more forested urban households (89.5%) in its surroundings (IBGE, 2010).

Goiânia's PDAU (2008) is one of the most complete (Figure 8) when compared to other cities, has 134 pages, is the responsibility of the Municipal Environment Agency (AMMA) and has the declared sponsorship of VIVO company.

In analyzing the PDAU and other articles on urban afforestation in Goiânia over time, the following good management practices are observed:

4.1.1) Historical rescue of the urbanization of the city

Surveying old city photos and testimonials from residents was instrumental in rescuing past efforts to improve the city's urban afforestation;

4.1.2) Formalization of partnerships through Agreement 097/97

Held between Goiânia City Hall, AMMA and Goiânia Urbanization Company (COMURG), Goiás Energy Centers SA (CELG), Goiás Sanitation SA (SANEAGO), Federal University of Goiás (UFG), Catholic University of Goiás (UCG), and the Public Prosecution Service of the State of Goiás. Later, the cellular phone company Vivo also joined the effort and this agreement contributed to the registration and mapping of the Urban Arborization;

Diagnosis of trees

Through the registration of several neighborhoods, estimating in 2007 more than 950 thousand trees of 328 different species on public roads. The survey served to carry out actions in various areas of the city. For example, at that time, in 70 sectors (11.16% of the city's neighborhoods) 178,230 entries were made and Chart 1 shows the description of these points with 133,061 trees, 6,295 stump removals, and 38,874 new plantings;

DADOS	QUANTIDADES	PERCENTUAL
Pontos cadastrados	178.230	100
Árvores	131.061	74,65
Remoções	7.079	5,32
Remoção de Tocos	6.295	3,53
Plantios	38.874	21,81

Chart 1: Description of 178230 points registered

Source: PDAU (2008)

Another interesting fact is that the Urbanization Company (Comurg) is the municipal agency responsible for the collection of trunks and branches from public roads and reuses all matter. The thinnest branches are collected, crushed and sent to the landfill where they enter as a raw material in the composting process. The thicker branches with commercial value are stored and sold as firewood. The denser wood trunks are used to make benches, chairs, tables, and pergolas that are installed in the Company's units, as well as in municipal agencies and public spaces. Moreover, the trunks with landscaping conditions are used in the natural, composing arrangements or even for making flower boxes, troughs, fences (GOIÁS DIARY, 2018).

4.1.4) Identification and protection of preserved areas

From 2005 to 2007, the Goiânia City Hall sought to identify and protect preserved areas in urban areas, resulting in an increase from 80 to 187 park and woodland areas, which together totaled 1,657 hectares of urban green areas (PDAU, 2008).

From 2005 to 2019, the number of parks deployed jumped from six to 35, all with elaborated fact sheets available to society. According to the PDAU (2008), Goiânia had an index of 0.79 trees per inhabitant, with more than 94 square meters of green areas per inhabitant, an index almost 8 times higher than that recommended by the United Nations, which is 12 m²/inhabitant.

4.1.5) Plante Vida Program

The Plante Vida Program <bit.ly/2tfsWwe> was launched on the environment day (05/06) of 2005 to distribute free seedlings to the encouraging voluntary planting on sidewalks of public roads, parks, squares, yards, farms, etc., with the proper guidance of AMMA technicians.

In 4 years it has distributed 1,200,000 seedlings in neighborhood work, green work, inaugurations, technical-scientific events, etc. Because of this, the Plante Vida Program is considered one of the largest voluntary planting programs in the world, whose success and innovative character led the executive director of the United Nations Environment Programme (UNEP) to recommend it as a model of action to other cities (AMMA, 2008).

Lastly, environmental education activities are carried out with the population through lectures, workshops, and the Ecomobile, a bus specially equipped for environmental education activities, which has already served more than 50,000 people. The Agency has the Green Room, which has a collection of over 800 books on environmental issues, available for public consultation. From its inception until November 2009, there were 5,151 consultations. Another highlight is the Environmental Village, in Areião Park, which served almost 20,000 students in 2008 (AMMA, 2008).

4.1.6) Landscape planning with indication of species

The PDAU (2008) also has a landscape planning of 16 areas of the city of Goiânia, all inserted in the 70 inventoried sectors. The Landscape Planning indicates the tree species to be planted in the places already diagnosed in the inventory as new planting points, considering the characteristics of each location: the existence of aerial wiring, street and sidewalk width, underground pipes, urban equipment, etc. At the time, it was recommended to plant 24,415 trees of 151 species, giving priority to the native of the Cerrado and fruit species focused on bird food and exotic with good adaptation to the climate and soil of the region. Chart 2 shows an example of indicating trees for the airport sector streets and avenues.

AV. DR. ISMERINO SOARES CARVALHO		LARGURA: 11,5 M		CALÇADA: 7 M
QUADRA	FIAÇÃO	ODADE.	INDICAÇÃO	OBS.
-	BT	5	*Myroxylon peruiferum* L.f. (Bálsamo)	Em frente a Q. 4 A
4 A	AT/BT	4	*Tabebuia chrysotricha* (Mart. ex DC.) Standl. (Ipê-tabaco)	
5 A	AT/BT	4	*Tabebuia chrysotricha* (Mart. ex DC.) Standl. (Ipê-tabaco)	
6 A	AT/BT	5	*Tabebuia chrysotricha* (Mart. ex DC.) Standl. (Ipê-tabaco)	
7 A	AT/BT	4	*Tabebuia chrysotricha* (Mart. ex DC.) Standl. (Ipê-tabaco)	
8 A	AT/BT	3	*Lagerstroemia speciosa* Pers. (Escumilha-africana)	
9 A	AT/BT	5	*Lagerstroemia speciosa* Pers. (Escumilha-africana)	
10 A	AT/BT	4	*Lagerstroemia speciosa* Pers. (Escumilha-africana)	
11 A	AT/BT	4	*Lagerstroemia speciosa* Pers. (Escumilha-africana)	
12 A	AT/BT	8	*Lagerstroemia speciosa* Pers. (Escumilha-africana)	
13 A	AT/BT	4	*Lagerstroemia speciosa* Pers. (Escumilha-africana)	
14 A	AT/BT	4	*Lagerstroemia speciosa* Pers. (Escumilha-africana)	
15 A	BT	5	*Myroxylon peruiferum* L.f. (Bálsamo)	
16 A	BT	7	*Myroxylon peruiferum* L.f. (Bálsamo)	
17 A	BT	7	*Platypodium elegans* Vog. (Jacarandá-canzil)	Plantar meio calçada
18 A	BT	4	*Platypodium elegans* Vog. (Jacarandá-canzil)	Plantar meio calçada
19 A	BT	1	*Erythrina crista-galli* L. (Mulungu-de-jardim)	
20 A	SF	6	*Myroxylon peruiferum* L.f. (Bálsamo)	

Chart 2: Suggested tree species for Dr. Ismerino Soares Avenue in the city of Goiânia
Source: PDAU (2008)

4.1.7) Planning with general guidelines

PDAU (2008) has similar technical guidelines as a manual with important guidelines for planning and implementing programs during the management of afforestation in the city. Among the programs mentioned are: creation of an interdisciplinary working group; covenants; qualification of the workforce to perform afforestation services; environmental education; tree registration; planting; production of native and exotic seedlings; maintenance; gradual replacement of trees such as Monguba due to its difficulty in adapting to the climatic conditions of the city, as well as its fragility to the pest; voluntary planting; analysis of municipal legislation, etc.

There is evidence that the effort made in Goiânia is paying off. A survey by Weirich et al (2015) investigated the urban afforestation of two avenues in Goiânia and concluded that urban afforestation contributed to improving the microclimatic conditions of urban environments (temperature reduction and relative humidity increase), positively influencing the human welfare.

4.1.8) Main Laws

Law 7009 of October 23, 1991 that provides for the planting, extraction, pruning, replacement of trees;

Normative Instruction 13 of October 3, 2006, which deals with the replacement of trees of the species Fícus Benjamina, located on the public roads of Goiânia;

Normative Instruction 22 of June 12, 2007, with rules for Park visitation and Conservation Units;

Normative Instruction 27 of August 18, 2008, with guidelines and procedures for applying environmental compensation to projects considered to have a significant environmental impact;

Normative Instruction 37 of November 21, 2011, which instituted the Goiânia PDAU.

4.2 Campinas (CAMP)

The city of Campinas turned 245 years old in 2019, is a city of São Paulo located in southeastern Brazil.
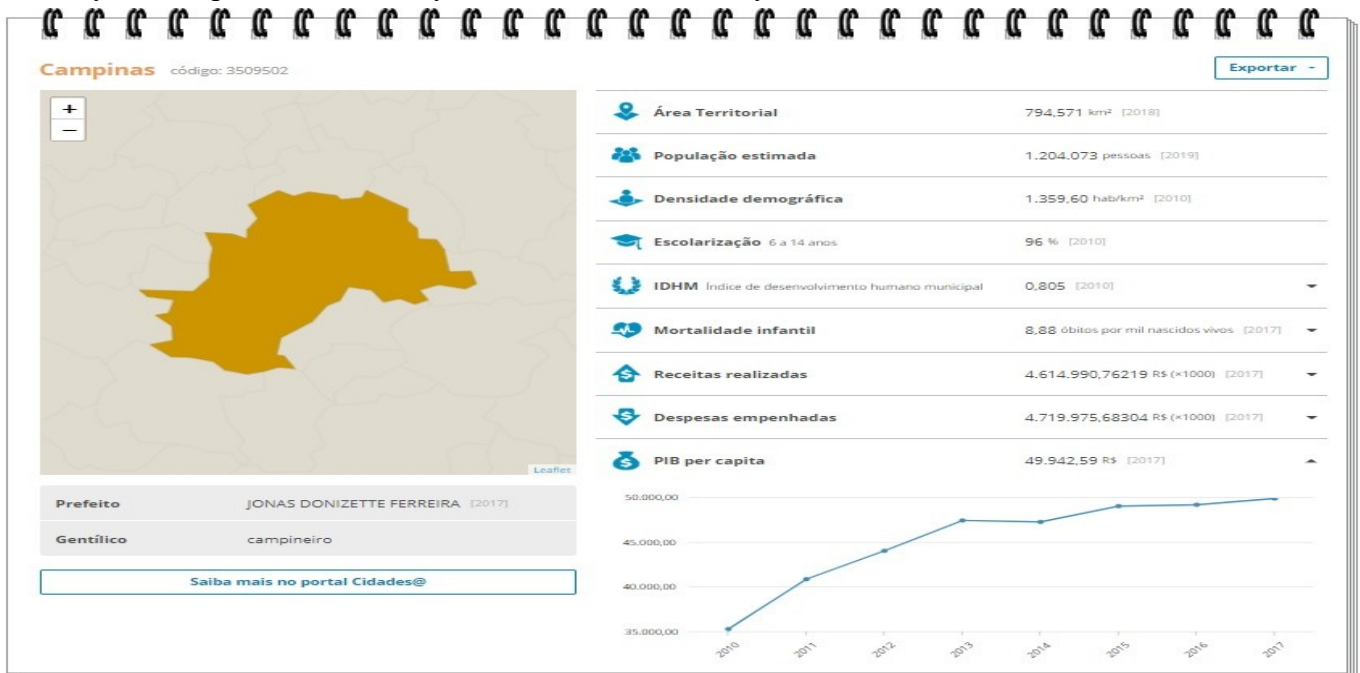

Figure 9: Campinas Basic Information

According to IBGE <bit.ly/39s1ZpG>, Campinas has 1,204,073 inhabitants spread over its 794,571 Km^2 (Figure 9), with a GDP per capita of R $ 49,942.59. It is the 11th city that most contributes to the Brazilian GDP (IBGE, 2016) and was considered the second-best city with more than one million inhabitants with more forested urban residences (88.4%) in its surroundings (IBGE, 2010).

The City of Campinas does not have a PDAU, instead, there is a 36-page Campinas Urban Afforestation Guide (GAUC, 2007), which is the responsibility of the Department of Parks and Gardens of the Municipal Infrastructure Secretariat of the Campinas City Hall. It was instituted by Decree 15986 of September 19, 2007, <bit.ly/36cb0RF>. In analyzing GAUC (2007) and other articles on urban afforestation planting in Campinas over time, the following good management practices are observed:

4.2.1) History of Campinas urbanization afforestation

Survey of facts dated since 1907 with afforestation recorded in several streets of the city, including problems of depredation, conservation record of gardens and trees, creation of ornamental plant vivarium, and seedlings for afforestation and participation of people in this process. It is noteworthy that in 1937, the City Council, through Law 524 of 09/01/37, the exemption of 5 years in the payment of taxes for those who built street tree protectors and public places, shelters of parades of vehicles. The record also points to the organization of flower and tree vivarium and the creation of a series of laws involving urban afforestation issues.

4.2.2) Legislation

Figure 10 presents five laws and a decree that legally support the process of urban afforestation in Campinas.

Figure 10: Campinas Major Laws for Urban Afforestation
Source: Campinas City Hall

Law 8744 of January 16, 1996, states that certain tree species are immune from logging because of their rarity, beauty, or seed carriers, such as two Pink Jequitibás (Cariniana legalis and Lecythidaceae) located at Avenida Anchieta, No. 200; ninety-six Imperial Palms (Roystonea oleracea-Palmae) located on Carlos Gomes Square and along Sister Serafina Avenue; and a Cedar (Cedrela fissilis - Meliaceae) located on November 15 Square;

Law 9184 of December 23, 1996, allows the execution of pruning and logging services by residents or property owners;

Law 9970 of December 29, 1998, requires service providers to immediately pick up pruned tree branches due to maintenance on their power grids;

Law 11,111/01 in its article 4, item V; and Decree 16,974/10 which became known as the Law of the Bank of Green Areas that gives exemption of 15% to 100% of the property tax;

Law No. 11.571 of June 17, 2003, governs the planting, replanting, pruning, suppression and proper and planned use of urban afforestation, etc.;

Law 12,325 of July 25, 2005, which states that 30% of the seedlings planted in public areas of the city must be fruitful.

4.2.3) Formalization of Partnerships

There is an agreement of the Campinas City Hall with the Society of Water Supply and Sanitation (SANASA), Association of Parents and Friends of the Exceptional (APAE) and Pontifical Catholic University of Campinas for students of APAE and inmates of penitentiary system at Engineer Otávio Tisselli Filho Municipal Vivarium, aiming at the cultivation of flowers, ornamental plants and tree seedlings planted in the city's squares and median strips.

On June 5, 2013, a technical cooperation agreement between Campinas City Hall and Embrapa Satellite Monitoring was signed and allowed the creation of WebGIS Trees <http://mapas.cnpm.embrapa.br/arvores_campinas/>.

WebGIS is a portal containing a database of urban tree planting in Campinas, where any citizen can interactively access maps, statistics and other information from surveys conducted with high-resolution satellite imagery.

The citizen can also access the Bank of Green Areas plantations and the trees considered immune to the court. This partnership was relevant as it made information more accessible, reduced survey costs and provided more agility in obtaining information for decision-making.

It is worth remembering that before the partnership, Embrapa was already conducting studies on the quantification of urban afforestation of Campinas' road. A technical statement published by Alvarez and Gallo (2012) reveals that in 2012 the total number of trees found on the Campinas roadside was 120,730 trees, excluding the seedlings.

Table 3 and Figure 11 show, respectively, the most wooded sites in Campinas, highlighting the University City with 48.97 Trees per Km, 0.60 trees per inhabitant and 2 inhabitants per tree.

According to estimates by the Secretary of Public Services, Ernesto Paulela, who is responsible for managing the urban afforestation policies, the city of Campinas has approximately six thousand adult fruit trees, planted on the streets or in public spaces. The spread of this type of cultivation gained momentum in late 1991 when then-mayor Jacob Bittar addressed the issue by law. The legislation stated

that the Administration had an obligation to include fruit trees in the afforestation programs to be adopted thereafter. And that was how tens of thousands of these trees were spreading through the city (CORREIO, 2019).

Table 3: Number of trees per Km and inhabitant in basic territorial units of Campinas

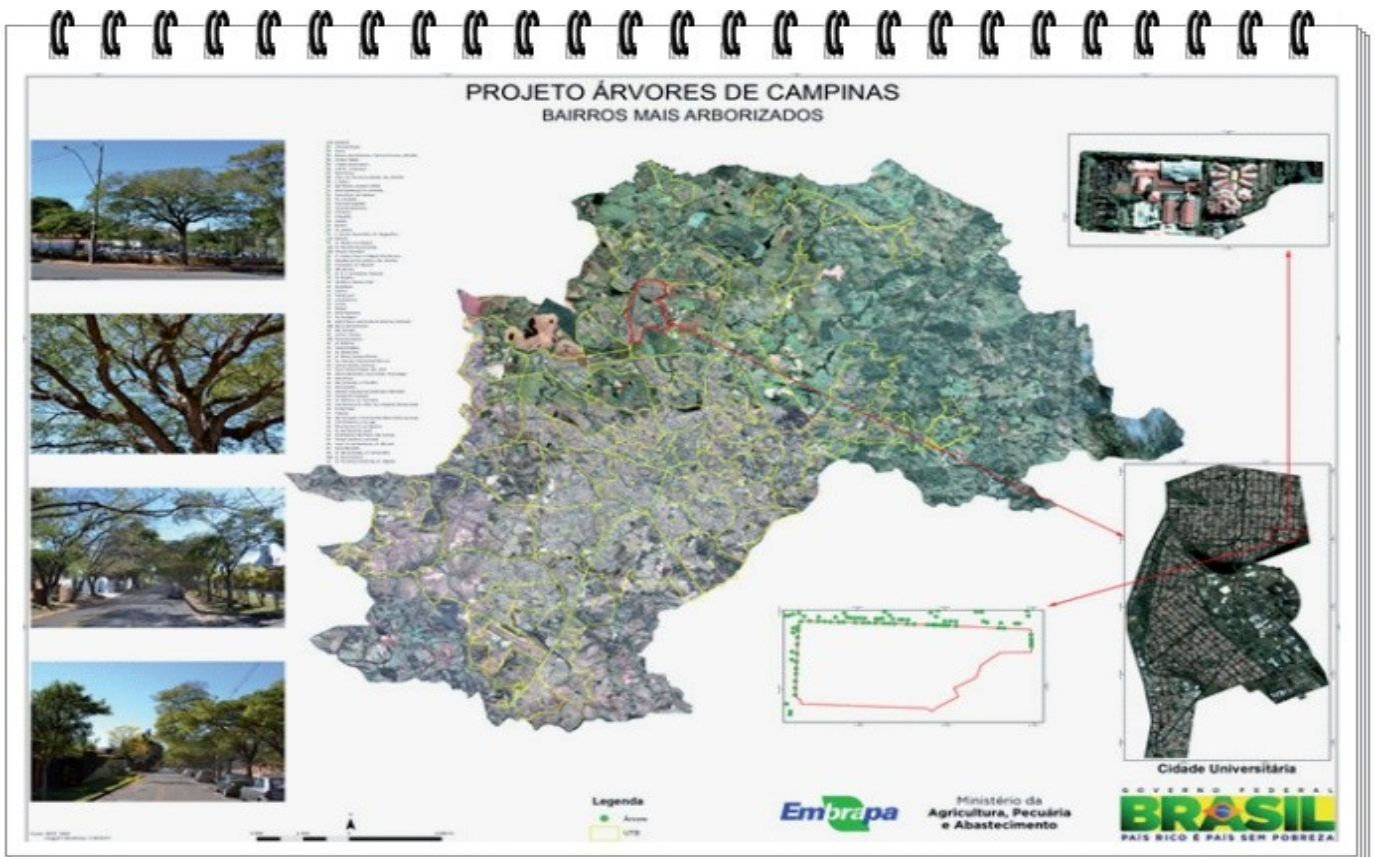| Mais arborizadas			
UTB	Arv./km	Arv./hab.	hab./arv.
Cidade Universitária	48,9762	0,6093	2
Centro / Barão	48,4915	0,3204	3
Joaquim Egídio	44,0888	0,5075	2
Real Parque	43,2769	0,2508	4
Vila Brandina	42,3422	0,2960	3
Pq. das Universidades, Sta. Cândida	41,9769	0,6076	2
Nova Campinas	39,7974	0,3865	3
Chapadão	34,7289	0,2173	5
Flamboyant	34,4164	0,1716	6

Source: Alvarez and Gallo (2012 p. 4)

Figure 11: Square of the leafiest neighborhood (University City) in 2012
Source: Alvarez e Gallo (2012 p. 4)

There are also examples of a partnership formed from the signing of the Environmental Commitment Terms (TCA), where a company is responsible for planting and maintaining trees for a certain term, and then passing the responsibility to the Parks and Gardens Department of Campinas City Hall.

To illustrate, there are three Environmental Commitment Terms signed with Construtora MRV, responsible for two constructions in the amount of R $ 338,341.83. Based on these Terms, MRV has already installed 99 trees in large pots along Francisco Glicério Avenue. The pots are graffiti by the plastic artist Alexandre Filiagi and also contain QR Codes for the citizen to get information about the species of tree planted, the graffiti animal and also to have a georeferenced view of the trees planted in the avenue. The digital identification process and use of the Environmental Commitment Terms are easily found at this link <https://ambientecampinas.wixsite.com/qrcode/o-processo>, through which it is also possible to locate projects carried out with QR-Code technologies.

Another partnership that was recently formed between the Campinas City Hall and USP's Luiz de Queiroz College of Agriculture will allow the beginning of a 2020 census of trees to identify the address of each tree and its characteristics.

4.2.4) Green Municipality Plan (Plano Municipal Verde) and Conservation Units

The Green Municipality Plan is a strategic instrument that has defined programs and actions for 10 years, to implement and consolidate the System of Green Areas and Conservation Units.

This plan has the following specific objectives:

a) Quantify Green Areas by category (Parks, Squares, Conservation Units, etc.);

b) Analyze the distribution of the green areas of the municipality;

c) Identify the social and environmental problems that hinder the implementation of the SAV-UC (Green Areas System and Conservation Unit);

d) To propose specific guidelines for the conservation of Cerrado and Atlantic Forest Phyto physiognomies;

e) Identify the legal and administrative instruments for the management of Green Areas;

f) To instruct the collective competence on the management of the Green Areas (establishment of procedures);

g) Align proposals with the revision of the Campinas Master Plan;

h) Monitor the reduction or expansion of Green Areas;

i) Map sources of resources to implement programs and actions.

In this link <bit.ly/2QaPFCP>, it is possible to access the actions already taken over time since 2015, including diagnosis, prognosis, programs, subprograms, goals, and actions within the Articulating Axis, such as promotion of laser activities, sports, and culture in green areas, enhancement of safety in green areas, control of fires, management of invasive alien plant species, heritage management natural areas, implementation of ecological corridors, restoration of degraded areas, etc.

Chart 3 presents some numbers of the Green Municipal Plan: six participatory workshops, a public consultation during the diagnosis phase, 1590 hectares of recovered permanence preservation areas, etc.

- ✓ 06 Oficinas Participativas (cinco espalhadas pelo território de Campinas, uma oficina com o setor rural e instituições técnicas e de pesquisa)
- ✓ 02 Oficinas com o Comdema (em parceria com a SOS Mata Atlântica)
- ✓ 01 Consulta Pública da Fase de Diagnóstico
- ✓ 241 Questionários online preenchidos
- ✓ 03 Programas, 19 Subprogramas
- ✓ Proposição de 49 trechos de Parques Lineares, que abrangerão 940 ha
- ✓ Proposição de 1.677 ha de áreas protegidas
- ✓ 280 km de Linha de Conectividade para implantação de corredores ecológicos
- ✓ 1.590 ha de Áreas de Preservação Permanente recuperadas
- ✓ 2.650.530 mudas[2]
- ✓ 6 núcleos de conectividade prioritários
- ✓ 10 anos para implantação
- ✓ Índice de Área Verde Social atual: 6,2 m²/hab
- ✓ Índice de Área Verde Social 2020 (m²/hab): 9,0 m²/hab[3]
- ✓ Índice de Área Verde Social 2025 (m²/hab): 12,8m²/hab[4]
- ✓ Índice de Área Verde: 87 m²/hab, que será mantido com a implantação do Sistema de Áreas Verdes e Unidades de Conservação até 2025
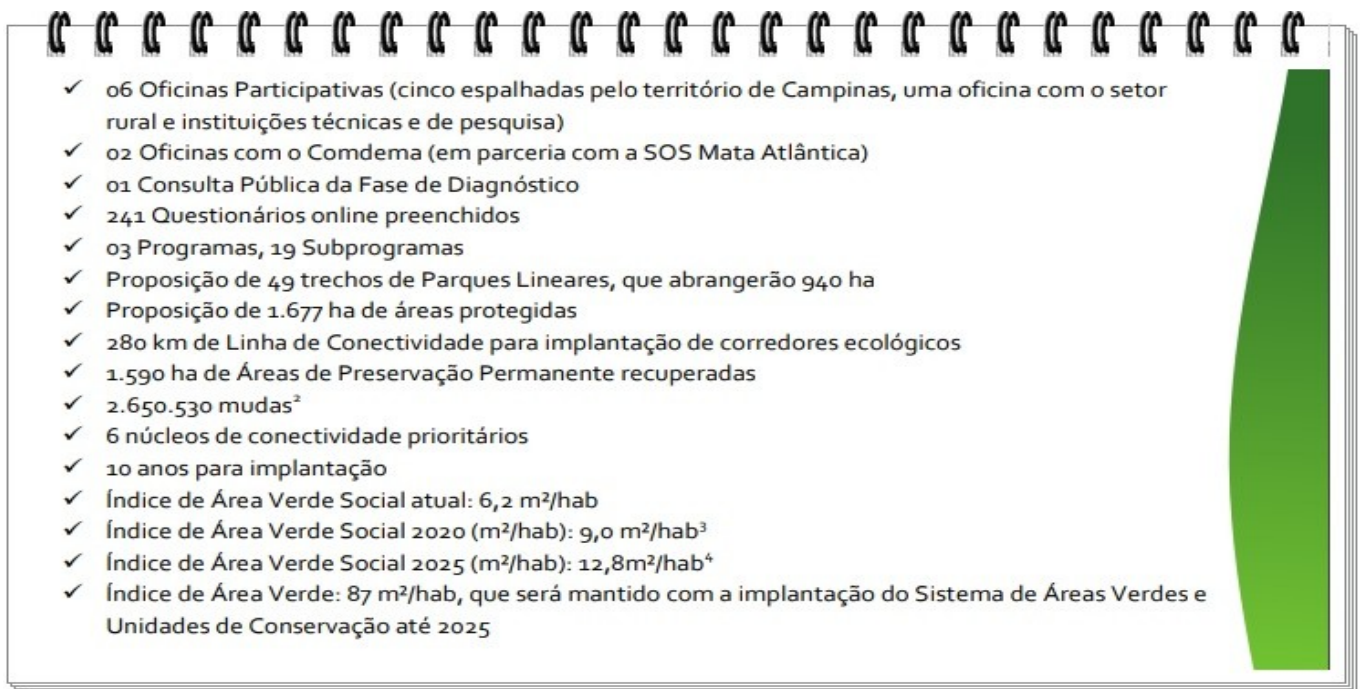
Chart 3: Campinas Green Municipal Plan Numbers
Source: Campinas City Hall

4.2.5) Bank of Green Areas and IPTU (Property Tax) Exemption

According to the Campinas City Hall, the Bank of Green Areas is a set of specially protected spaces, such as the ecological macro corridors, green axes, parks, green ways, conservation units, preservation and permanent protection areas, legal reserve areas, and remnant areas. native vegetation, among others. The owner can register his property in the Bank of Green Areas and obtain an exemption of 15% to 100% on Urban Property Tax (IPTU) provided that the property is following the terms of Law 11.111/01 in its article 4, item V; and Decree 16,974/10.

In 2018, the city was awarded first place by the Green Municipality Program, resulting from the actions of planting 140 hectares of Permanent Preservation Areas (PPAs) and one million trees planted between 2013 and 2018.

The Engineer Otávio Tisselli Filho Municipal Vivarium, located in Xangrilá Park, eastern Campinas, produces about 80,000 seedlings per month. The site can produce 1.8 million tree species such as ipês, magnolias, palm trees, fig-trees and ornamental plants (azaleas, raffia palm trees, among others) per year. The seedlings are reproduced in greenhouses donated by the highway concessionaire Rota das Bandeiras, which were installed in the masonry structures renovated by the City Hall.

4.2.6) Planning and implementation of urban afforestation with indication of species

As of page 25 of GAUC (2007), there are numerous technical guidelines for planning and implementing urban afforestation in Campinas. From page 51 there are recommendations on the products that can be used for phytosanitary control, as well as the most suitable species for urban afforestation.

4.3 Belo Horizonte (BH)

The city of Belo Horizonte turned 122 in 2019, is the capital of the state of Minas Gerais, located in southeastern Brazil (Figure 12).

Figure 12: Basic information of Belo Horizonte

Source: IBGE

According to IBGE <bit.ly/2QDu2tY>, Belo Horizonte has 2,512,070 inhabitants spread over its 331,401 Km² (Figure 12), with a per capita GDP of R $ 35,245.02. It is the fourth city contributing to the Brazilian GDP (IBGE, 2016) and was considered the third best city with more than one million inhabitants with more forested urban residences (83.0%) in its surroundings (IBGE, 2010).

Also, in 2014, the city of Belo Horizonte was considered one of the ten greenest cities in Latin America and the Caribbean, according to a report by the United Nations Food and Agriculture Organization (FAO) available at <bit.ly/2ZDHu4M>.

4.3.1) PDAU, Partnerships, Inventory & Manual

It was not possible to identify the PDAU of Belo Horizonte City Hall, but a Manual of Urban Afforestation belonging to CEMIG that will be explained later.

In 2009, the City Hall of BH initiated a partnership with Minas Gerais Energy Company (CEMIG), through the Special Program for Integrated Management of Trees and Networks (PREMIAR), with actions related to the management of afforestation with the power grid in the capital.

According to Castanheiras and Reis (2017), in 2011 BH Municipal Secretariat of Environment (SMABH) formed a partnership with CEMIG to implement a tree inventory project in Belo Horizonte, to establish the best monitoring mechanisms and control of the city's afforestation. The Federal University of Lavras (UFLA) won the bidding and the project became known as Belo Horizonte Tree Inventory Information System (SIIA-BH) and was developed with three stages: development of SIIA-BH; Work planning and logistics; collecting and updating trees, as shown in Figure 13.
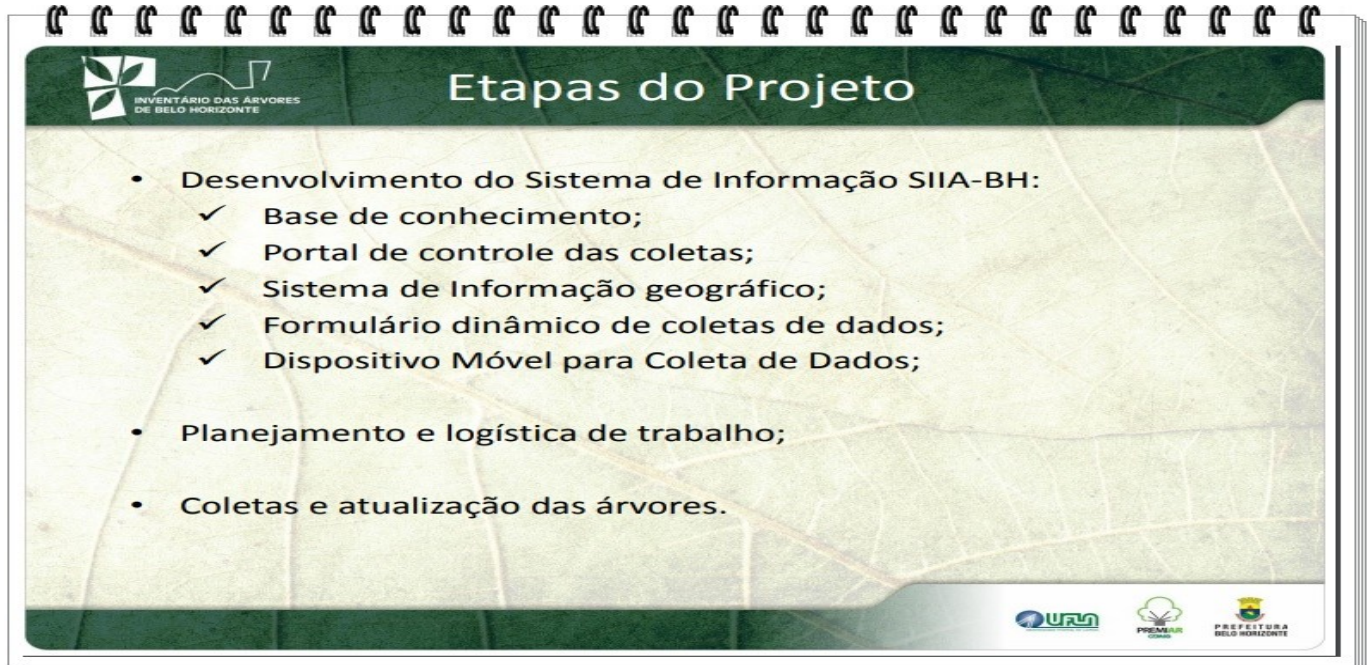

Figure 13: Project SIIA-BH Steps
Source: Gontijo (?)

By 2018, SIIA-BH had already cataloged 300,000 species, with more than 32086 fruit trees divided into 566 species. Of the more than 30,000 fruit trees, the most important are guava, octave, mango, lemon, pitanga, pomegranate, jaboticaba, mulberry, coconut, and acerola trees.

According to an article in the Minas Gerais State Journal (2018), the ten most cataloged trees were: the Sipiruna with 18,946 trees; the Myrtle with 18,585 trees; Purple Glory Tree with 10502 units; Pink Ipe with 9665 units; Resendá with 6321 units; the Pata de Vaca with 6263 trees; Ipê-tabaco with 6034 trees; Magnolia with 5599 trees; the African Scumilla with 5388 units and the Yellow Ipe with 2807 trees cataloged in 2018.

Given CEMIG's social and environmental responsibility and the increasing environmental appeal of the inhabitants of several municipalities where the concessionaire works, various methods have been developed to facilitate the compatibility of electricity networks with urban trees, such as the seed laboratory, Seedling Production, Urban Afforestation Manual, Technical Cooperation Agreement (SILVA, 2016).

Regarding the Urban Afforestation Manual (CEMIG, 2011), it was organized into themes that address biological, ecological and economic aspects of afforestation, as well as technical aspects of an energy distribution system, and the presentation of compatibility alternatives between two components, the coexistence between trees and electricity networks.

Another partnership was made between the Municipal Secretariat of Environment of the City of BH with COPASA and the Residents Association of Farm of the Serra, in Paquetá neighborhood, aiming at the implementation of a pilot project called Montes Verdes aiming at the recovery of degraded areas.

A partnership was also identified between the municipal secretariats of environment and education with the Municipal Parks and Zoobotany Foundation to help implement the Plantar BH Program which aims to provide environmental education in schools and the planting of trees in different parks. A Technical Cooperation Agreement with the Chico Mendes Institute was signed in 2018 to plant at least 20 seedlings by the end of the term, scheduled for March 2020 (BELO HORIZONTE PREFECTURE, 2018).

4.3.2) Legislation and Source Catalog

Normative Deliberation No. 5 of May 5, 1989 deals with the planting and pruning of trees;

Normative Deliberation No. 9 of July 8, 1989 deals with planting trees in public places;

Normative Deliberation No. 12 of November 11, 1992 deals with rules for the implantation of parks;

Municipal Law nº 6.314 / 93 that deals with norms for the Ecological Private Reserves;

Law 8616, of July 14, 2003, contains the code of postures of the Municipality of BH, whose Chapter II deals with afforestation;

Normative Resolution No. 68 of April 14, 2010 deals with the obligation to record falls of trees and branches in public places;

Normative Deliberation No. 71 of February 29, 2012, temporarily modifies minimum tree seedling pattern for planting in public places;

Law 10.879 of November 27, 2015, establishing the Municipal System of Protected Areas of Belo Horizonte.

There are other normative deliberations listed at <bit.ly/39kpEsh>, and it is worth mentioning the existence of a Source Catalog with information on afforestation. In Belo Horizonte's municipal legislation (BELO HORIZONTE, 2015), the document is the result of the survey of data on urban afforestation in the Municipal, State and Federal Legislation Collection referring to the Municipality between 1891 and 1986.

4.3.3) Green Areas

According to the Belo Horizonte City Hall (2017), the city has about 14 million m² of green areas distributed in 75 parks, 750 squares and gardens, in addition to 210 other public spaces.

A study (Table 4) conducted by Fernandes and Caldeira (2016) in 104 green areas considered institutionalized revealed that 64 were classified as conservation areas and 23 areas intended exclusively for recreation, considered municipal parks by the FPM/PBH, designation contested by author because these places do not have natural attractions or relevant vegetation cover, being used as public squares. Fernandes and Caldeira (2016) identified the number of green areas, the location and who were responsible for the management, with the City Hall of BH (PBH) maintaining significant green areas preserved in the land currently occupied by the Zoobotanical Foundation in the Pampulha region.

Table 4: Management of Institutionalized Green Areas of Belo Horizonte/MG (2013)

GESTÃO	TIPO	QUANTIDADE	PROPRIEDADE / LOCALIZAÇÃO (REGIONAL ADMINISTRATIVA)
Municipal	Parques	80	PBH
	Fund. Zoobotânica	1	PBH/ Pampulha
Estadual	Parques	3	Serra Verde, Serra do Rola Moça e
	Estação Ecológica	1	Cercadinho / Centro-sul
	Hospital	1	Hospital Julia Kubitscheck / Barreiro
Federal	Universidade	1	*campus* UFMG / Pampulha
	Horto Florestal	1	UFMG / Leste
Particular	RPPN	1	Minas Tênis Clube / Leste
	RPE	9	
	Hospital	1	Hospital da Baleia / Leste
	Universidade	1	PUC-Minas - Igreja Católica / Nordeste
	Mosteiro	1	Igreja Católica / Centro-sul
	Reserva Florestal	1	Vallourec Tubos do Brasil / Barreiro
	Clube recreativo	2	Clube Topázio e SESC / Venda Nova
Total		104	

Source: Fernandes and Caldeira (2016 p. 11)

According to Fernandes and Caldeira (2016 p. 11), among the green areas located on private property, highlighted the twenty hectares of vegetation contained in the Forest Reserve of the Siderurgic Company Vallourec Tubos do Brasil, located in the Barreiro Administrative Region, and thirteen hectares of the Private Reserve of Natural Heritage (RPPN) of Minas Tennis Club located in the far east of the municipality (Table 4). The smaller spaces are Ecological Private Reserves (RPEs created by Municipal Law No. 6,314 / 93), which together total nine and have approximately twenty-two hectares.

Besides, Fernandes and Caldeira (2016) calculated that the area of Environmental Preservation Zones (ZPAMs) represented about 11.89% of the total area of the city of Belo Horizonte. The study also pointed out areas considered as ZPAM that are not institutionalized green areas and that correspond to 14.15 km² or 4.27% of the city of Belo Horizonte, recommending them with potential to be destined to the creation of parks aimed at recreation and conservation, especially in the extreme northeastern portion of the North and Northeast Administrative Regions.

4.3.4) Programs, Projects and Ecological Private Reserve (RPE)

Belo Horizonte has a long history of afforestation, with measures ranging from combating crimes against afforestation (theft of seedlings and cages that protected plants) in 1917 (BARRETOS, 1936) to more recent programs (Green BH Programs, Monte Verde Project, etc.) to encourage tree planting and recovery of degraded areas.

In an article published on October 31, 2013, by the Estado de Minas Gerais newspaper (2013), the Green BH Program began in 2011 intending to plant 54,000 trees by 2013. At the time, the newspaper reported that the program had an investment R$ 17 million from the City of Belo Horizonte.

The Montes Verdes Project is a program created in 2016, aimed at restoring the vegetation of degraded areas, replanting 8 thousand trees in the Serra of Engenho Nogueira, Fernando Sabino Park, and Pampulha.

An Ecological Private Reserve (RPE) is a specifically protected area modality created and regulated by Municipal Laws 6,314 and 6,491, both of 1993, to stimulate the preservation of privately owned areas of great environmental relevance.

The RPEs are requested by the property owners from the Executive to transform their property in this type of reserve, for a minimum of 20 years, all or only part of the properties, with proportional exemption from property tax, once identified the environmental and ecological values, as established by said laws.

By October 2, 2019, Belo Horizonte already had 12 Ecological Private Reserves totaling 363,100.02 square meters, as can be viewed on the Belo Horizonte City Hall website <bit.ly/2QAPkbD>.

Other projects that deserve highlighting are those that are part of CEMIG's PREMIAR, which can be viewed at this link <bit.ly/36gQDmI>.

4.4 Porto Alegre (POA)

The city of Porto Alegre turned 247 years old in 2019, is the capital of Rio Grande do Sul, located in southern Brazil (Figure 14).

Figure 14: Porto Alegre Basic Information
Source: IBGE

According to IBGE <https://www.ibge.gov.br/cidades-e-estados/rs/porto-alegre.html>, Porto Alegre has 1,483,771 inhabitants spread over its 495390 Km² (Figure 14), with a per capita GDP of R$ 49,740.90. It

is the 7th largest city contributing to the Brazilian GDP (IBGE, 2016) and was considered the fourth-best city with more than one million inhabitants with more forested urban residences (82.9%) in its surroundings (IBGE, 2010).

4.4.1) Major laws <bit.ly/2QvFXtv>

Porto Alegre City Hall has one of the most organized and efficient law search systems in the city, where the user can choose to find them by themes, chronological index, etc.

Law no. 5080, of January 4, 1982. Authorizes the Municipality to receive the donation of metallic tree protectors, and allows donors to insert advertising on them. Official Diary of the State of Rio Grande do Sul, Porto Alegre, 01/13/1982;

Complementary Law no. 89, of November 25, 1983. Deals with the planting of fruit trees on public roads and public places in the city of Porto Alegre. Official Diary of the State of Rio Grande do Sul, Porto Alegre, 11/29/1983;

Law No. 7543, of December 6, 1994, which determines the planting of fruit trees in schools;

Complementary Law 434/1999 that provides for urban development in the city of Porto Alegre, establishing the Environmental PDAU;

Instruction nº 17/06, December 22, 2006. [Creates the "Adopt a Tree" Program]. Official Diary of Porto Alegre, Porto Alegre, 01/31/2007;

COMAM Resolution 05 of September 28, 2006 that has the Porto Alegre PDAU;

Municipal Law 11.292 of June 5, 2012, defines the areas of special use the public places considered Green Tunnels.

Supplementary Law 757 of January 14, 2015 establishing rules for the suppression, transplantation or pruning of plant species in the municipality.

4.4.2) PDAU

Porto Alegre was one of the first municipalities in Brazil to have a PDAU.

According to the Porto Alegre City Hall, the PDAU is the set of methods and measures adopted for the preservation, management, and expansion of trees in cities, according to the technical demands and expressions of interest of local communities.

The last edition was revised in 2006 and there is a 2007 booklet (Figure 15) containing the city's urban afforestation history and PDAU components: Objectives, Definitions, Guidelines, Population Participation in the Afforestation Deal, Instruments (Seedling Production) and Planting, Management and Conservation, Pruning, Management Plan, Transplant, Vegetation in Private Areas, Attachments, References and Contact Phones.
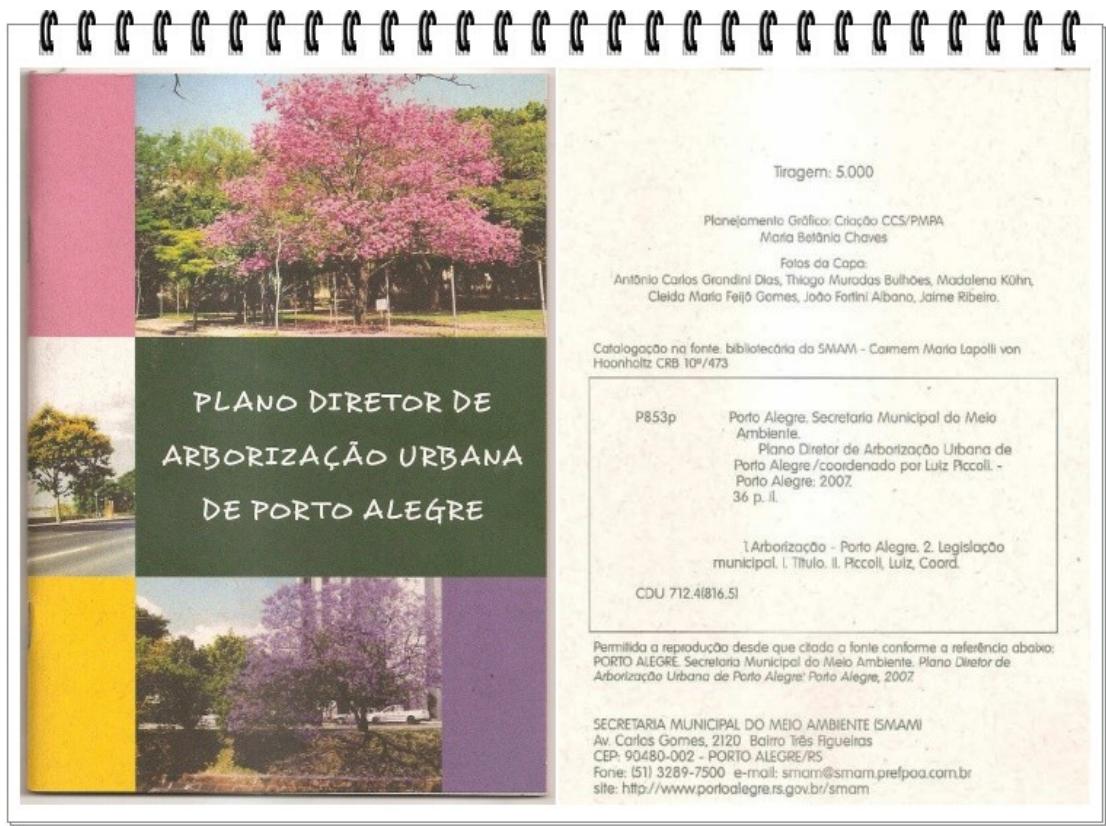
Figure 15: Porto Alegre's PDAU

Source: Municipal Secretariat of the Environment of Porto Alegre City Hall (2007)

4.4.3) Partnerships, Actions and Projects

A survey was done in documents and websites of Porto Alegre City Hall indicate about five projects carried out in recent years.

Project 1) Tree Analysis at Risk in partnership with IPT technicians contributing to the development of the technical report (150 large trees) and training with 40 theoretical and practical hours, where technicians learned to handle internal tree condition analysis equipment;

Project 2) Green tunnels are streets with preserved vegetation and protected by municipal decree, are 51 streets, besides the square Mauricio Cardoso.

Figure 16 shows one of the first green tunnels created by the union of the population in 2005 to prevent the construction of parking, located at São Gonçalo de Carvalho Street.
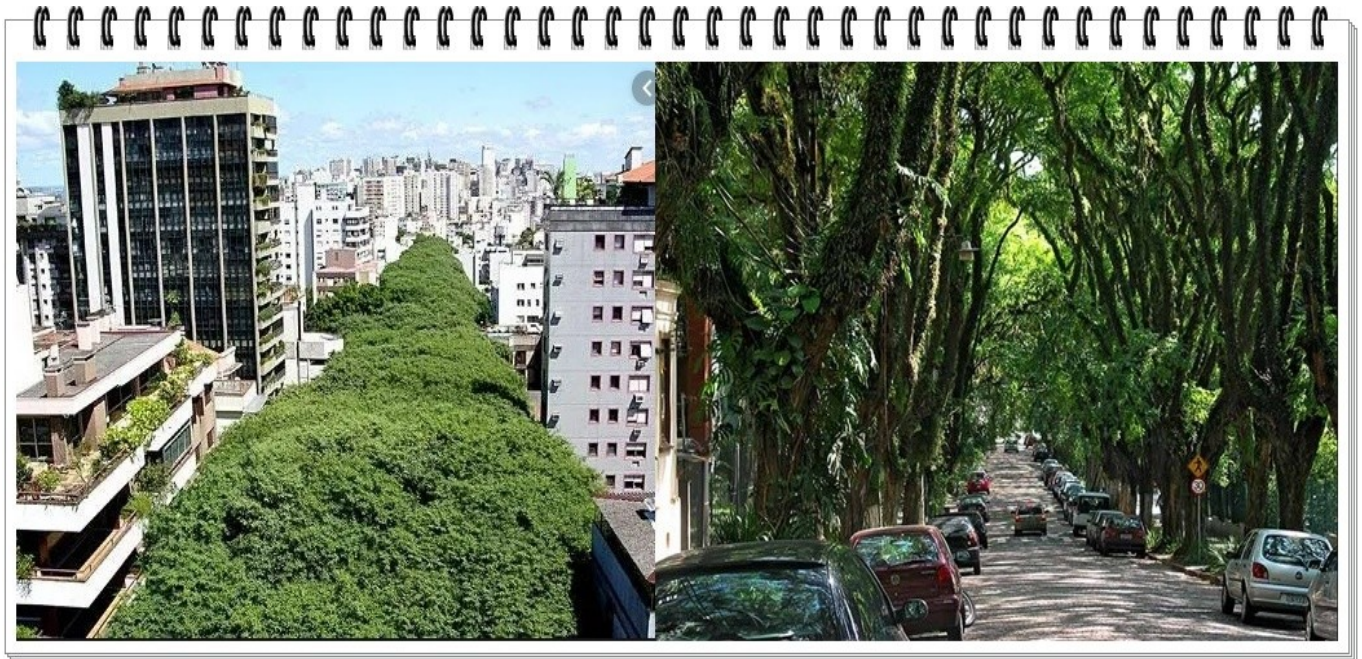
Figure 16: First Green Tunnel located at São Gonçalo de Carvalho St, Floresta neighborhood
Source: Porto Alegre City Hall and Ricardo Stricher

As a tourist spot, the street has two signs: one with the street name and the one that identifies the local trees. The following tree specimens are found on the road: tipa, chuva-de-ouro, cerejeira-do-mato, jacarandá, Chal-chal, pitangueira, paineira, ligustro e uva-do-japão.

Gonçalo also has a group of permanent caregivers, thanks to the organization of the local community, as can be viewed at <http://goncalodecarvalho.blogspot.com/>

Project 3) Inventory of Cut Immune Trees

From 2009, the inventory began to re-evaluate the phytosanitary state of cut-off trees. The study was closed in 2014 and allowed the identification of 664 trees that were felled and georeferenced.

Project 4) 60-year-old municipal vivarium with an area of 200 hectares

Program 5) Adopt a square created in 1986 that allows any civil entity to take responsibility for urbanizing and maintaining public green areas of the municipality. Remember that in 2013 there were about 608 well-distributed squares in the city (OLIVEIRA; DIAS, 2013). In the link below, it is possible to access the list of squares adopted by dozens of partners that have joined the program <bit.ly/369l265>.

4.4.4) Conservation Units and Green Areas

The Conservation Units administered by the municipality of Porto Alegre are: Saint Hilaire Municipal Natural Park (1148 ha), Morro do Osso Natural Park (220 ha), Lami Biological Reserve (204 ha) and the São Pedro Wildlife Refuge, all have a Management Plan with norms and restrictions of visitation.

There are about 1.3 million trees on public roads, considering only the municipal green areas (608 squares, 9 parks, 3 conservation units, and 354 complimentary green spaces), Porto Alegre has 14.78 m² of green area per inhabitant. If it includes state and federal green areas, the index rises to 49 m².

Among the environmental education activities, there are walks in the ecological trails of conservation units, educational plantations, environmental lectures in schools and universities, storytelling, etc.

4.5 Curitiba (CUR)

The city of Curitiba turned 326 in 2019, is the capital of Paraná, located in southern Brazil. According to the IBGE <bit.ly/2SDxJlO>, Curitiba has 1,933,105 inhabitants spread over its 435,036 Km^2 (Figure 17), with a GDP per capita of R $ 44,384.92.

Figure 17: Curitiba Basic Information

Source: IBGE

It is the 5th largest city contributing to the Brazilian GDP (IBGE, 2016) and was considered the fifth-best city with more than one million inhabitants with more forested urban residences (76.4%) in its surroundings (IBGE, 2010). However, according to the 2010 Census, 30.66% of the neighborhoods in the state capital have less green area per person than recommended by the World Health Organization (WHO), which is 12 m² person (MENEZES, 2016).

4.5.1) Legislation

Through an agreement signed with the then Brazilian Institute of Forest Development (IBDF), currently IBAMA; Curitiba has the authority to legislate on its green areas. These are some decrees and laws of this county:

Law 4557/73 which provides for the protection and conservation of tree-sized vegetation, specifying the limitations regarding tree felling;

Law 4857/74 that grants incentives for the preservation and protection of forested areas;

Decree 667/74 Establishing the Green Areas Commission;

Decree 226/78 which deals with the Urban Afforestation Plan;

Law 6819/86 that creates incentives for the preservation and formation of green areas and provides for the special green area sector;

Law 6840/86, which provides for the mandatory planting of tree seedlings in the building and subdivision areas of Curitiba;

Decree 403/87 declaring the trees considered to be of special protection to be immune from felling because of their location, rarity, beauty or seed holders;

Law 7230/88 requiring the planting of trees, shrubs, and undergrowth in undeveloped strips of valley bottoms;

Law 7651/91 on the obligation to plant trees on sidewalks for issuing the completion certificate;

Law 7,833 of December 19, 1991, provides for the policy of protection, conservation and restoration of the environment and other measures;

Law 7.833 of December 19, 1991, Art. 38 creates the Municipal Environment Council;

Decree Nº 391/1992 of June 25, 1992, establishes the Administration of the Municipal Environment Fund, which aims to concentrate sources of funds for the development of projects aimed at environmental protection and improvement of the population's quality of life;

Decree Nº 691 of 23 August 1995 Establishes the Internal Regulations of the Municipal Council of the Environment.

Law 9804 of January 3, 2000, creates the System of Conservation Units of the Municipality of Curitiba and establishes criteria and procedures for the implementation of new conservation units.

Law Nº 9806 of January 3, 2000, establishes the Curitiba City Forest Code for the protection, conservation, and monitoring of isolated trees and plant associations in the city of Curitiba.

Law Nº 11.266 of December 16, 2004, which provides for the adaptation of the Curitiba Master Plan to the city's bylaws - federal law Nº 10,257/01, for guidance and control of the municipality's integrated development.

Decree Nº 1819 of November 22, 2011 deals with the environmental licensing system in the city of Curitiba.

Law Nº 14,771, of December 17, 2015, which provides for the revision of the Curitiba master plan under the provisions of art. 40, § 3, of the city statute, to guide and control the integrated development of the municipality.

4.5.2) Partnerships with Actions/Projects or Programs

Project 1) Barreirinha Municipal Garden: founded in 1959, is a space of 125 m² and produces about 50 thousand seedlings per year, which are intended for planting on public roads, squares, and parks of Curitiba to providing seedlings for the program "Adopt a tree". The Garden currently houses about 142,000 trees in various stages of development;

Project 2) Adopt a Tree: the Municipal Secretariat of the Environment (SMMA), which, through the analysis of the technicians, suggests the most suitable species for the planting site, coordinates the project. Any person or company is allowed to apply at the Barreirinha Municipal Garden and it is possible to plant both in the backyards and on public roads. In this case, the resident calls phone 156 to request a tree and the technicians will review the request and determine which species will be most recommended for the region;

Project 3) Challenge 100 thousand seedlings Campaign

The City of Curitiba launched in September 2019 the platform <https://www.100milarvores.com.br/> so that the citizen knows the types of trees and their characteristics, as well as follow the progress of the campaign, being able to know the number of trees already planted, and visualize the regions that received the planting.

Figure 18: Number of trees planted during the Challenge 100,000 seedlings Campaign (Dec/2019)
Source: Curitiba City Hall <https://www.100milarvores.com.br/ >

In 3 months the Arvometer (Meter that counts the number of trees planted) already points to 33759 trees planted (Figure 18) and the campaign extends until September 2020. The partners of this initiative are Pedala Christian and Regional, Kids Innovation School, Company of Sanitation of Paraná (SANEPAR), Maria M. Piovisan Municipal School, CEI Issa Nacli, Sta Casa de Misericórdia Hospital of Curitiba, etc.

Project 4) Planted Seedling Review: after planting the trees on public roads, the seedlings are monitored. To ensure the safety of pedestrians and vehicles, the teams conduct a survey of lap protectors, fertilize the soil and observe the need to remove trees.

Project 5) Green Map: created in New York, the project is already present in 850 cities around the world. Among these is Curitiba, which since 2009 has been supported by the UFPR Department of Information Science and Management to continue the project. The purpose of the site is to enable city residents to signal the existence of green spaces for others to discover and interact through the map available at <http://www.opengreenmap.org/es/greenmap/mapa-verde-curitiba>.

Project 6) Environmental Education: the city establishes parallel environmental education programs such as the Bosque Escola and Sustainability Station (SMMA, 2016).

Project 7) Replacement of trees presenting fall hazards

According to the Municipal Secretariat of the Environment of the Curitiba City Hall, there are about 300,000 trees located on public roads in the city, of which 90,000 present some risk of falling. In 2017, this secretariat partnered with UFPR to survey to identify the number of trees at risk of falling, their location and situation to take action over time;

Project 8) Manual for Elaboration of the Municipal Plan of Urban Afforestation

In its 2nd edition, this Manual was developed by the Public Ministry of the State of Paraná in partnership with CRBio-07, the Parana Institute of Technical Assistance and Rural Extension (EMATER), CREA-PR, Paranaense Association of Forest Engineers (APEF), UNICENTRO Paraná, COPEL, UTPR, Federal University of Paraná (UFPR) and the Environmental Institute of Paraná.

According to the Paraná Public Ministry (MPPR, 2018), the purpose of this Manual (Chart 4) is to present subsidies to the Municipalities of the State of Paraná regarding the requirements, topics, and steps that must be contemplated in the Municipal Plan of Urban Afforestation.

ELEMENTOS INTERNOS	ELEMENTOS EXTERNOS	Capa		Obrigatório
		Contracapa		Obrigatório
	ELEMENTOS PRÉ-TEXTUAIS	Lista de figuras		Opcional
		Lista de tabelas e/ou quadros		Opcional
		Lista de abreviaturas e siglas		Opcional
		Lista de símbolos		Opcional
		Sumário		Obrigatório
	ELEMENTOS TEXTUAIS OU CONTEÚDO DO PLANO	Introdução	Histórico Importância Objetivo(s)	Obrigatório
		Caracterização do Município		Obrigatório
		Diagnóstico da Arborização Urbana do município	Levantamento Características Problemas	Obrigatório
		Planejamento da Arborização Urbana	Critérios - Espécies Critérios - Locais Espaçamento/distância Indicação dos locais	Obrigatório
		Implantação da Arborização Urbana	Características - mudas Produção de mudas Procedimentos - plantios Campanha/Conscientização	Obrigatório
		Manutenção da Arborização Urbana	Poda Remoção/substituição Outras práticas	Obrigatório
		Monitoramento da Arborização Urbana		Obrigatório
		Gestão da Arborização Urbana		Obrigatório
		Informações Finais		Obrigatório
	ELEMENTOS PÓS-TEXTUAIS	Referências		Obrigatório
		Anexos		Opcional

Chart 4: Structure of the Municipal Urban Afforestation Plan proposed by MPPR

Source: MPPR (2018)

The second edition has the following innovations: the inclusion of topics related to "Participatory Diagnosis - Survey of Population Perception" and "Analysis of Risk of Falling Urban Trees", both in the chapter "Diagnosing the Urban Afforestation of the Municipality"; the topic related to the "Environmental Awareness Campaign", in the first edition of the chapter "Implementation of Urban Afforestation", was transformed into a specific chapter; Chapters "Felling and Cutting Immune Trees", "Management of Urban Afforestation" and "Working Committee Criteria for Plan Analysis" were added; In the chapter "Final Information", the item "Recommendations after the elaboration of the municipal urban afforestation plan" was added. Besides, several issues are more detailed and have been complemented, aiming at facilitating the understanding by the professionals responsible for the elaboration of the Urban Afforestation Plans, as well as to improve the quality of these Plans.

This Manual has 67 pages and is a highly relevant document to help standardize the actions of various cities regarding municipal urban afforestation planning.

For example, Chart 4 presents the structure of a Municipal Urban Afforestation Plan, containing among the textual elements (content of the plan), the introduction, the history, importance, objectives,

characterization of the municipality, urban afforestation diagnosis (survey, characteristics, problems), afforestation planning (criteria, species, locations, spacing, location indication), urban afforestation implementation (seedling characteristics, seedling production, procedures, planting, awareness campaign), urban afforestation maintenance (Pruning, Removal, Replacement, other practices), monitoring, management, and final information.

4.5.3) PDAU and Diagnosis

After surveying the Curitiba City Hall website, it was not possible to locate the city's Urban Afforestation Master Plan or any other plan that could have any relationship with the local afforestation.

However, by researching some articles published by the Curitiba City Hall, it was possible to detect that the Curitiba Public Afforestation Plan started in 2006 with preventive actions to replace devitalized trees with native species and more suitable for the region.

This plan came from a diagnosis made in 2006 by the Municipal Secretariat of the Environment that analyzed the situation of each tree on the streets of 23 neighborhoods in the city. Between 2007 and 2012, 15580 native seedlings were planted and 5698 removals were made in the neighborhoods related to the Master plan.

4.5.4) Conservation Units and Flowchart for the Creation and Elaboration of the Management and Conservation Plan

In 2013, Curitiba had 64.5 m² of tree vegetation per inhabitant, distributed in 42 public municipal Conservation Units (21 parks, 17 forests, two Environmental Protection Areas, a Botanical Garden, and an Ecological Station), in addition to the Reserves. Private Reserves of the Municipal Natural Heritage (RPPNMs), which are private Conservation Units, and the numerous forest fragments located in public and private real estate.

The definition of the types of Conservation Units (UCs) in Curitiba is based on the Municipal Law Nº 9804 of 2000, which establishes the Municipal System of Conservation Units of Curitiba, the SMUC.

According to the Curitiba City Hall, the city already has 27 Private Reserves of the Municipal Natural Heritage in 2019, which are urban forests with 361 m² preserved.

Regarding the RPPNMs, the flowchart for the Creation and Elaboration of the Management and Conservation Plan (Figure 19) whose 1st edition was published in 2013 by the Curitiba City Hall (2013) in partnership with SPVS and the Boticário Group Foundation, available at <http://multimidia.curitiba.pr.gov.br/2014/00145487.pdf>.

This flowchart has basic information about what a Conservation Unit is, the reasons for setting up an RPPNM, the necessary documentation, a flowchart for setting it up, the step-by-step for developing a management and conservation plan, etc.
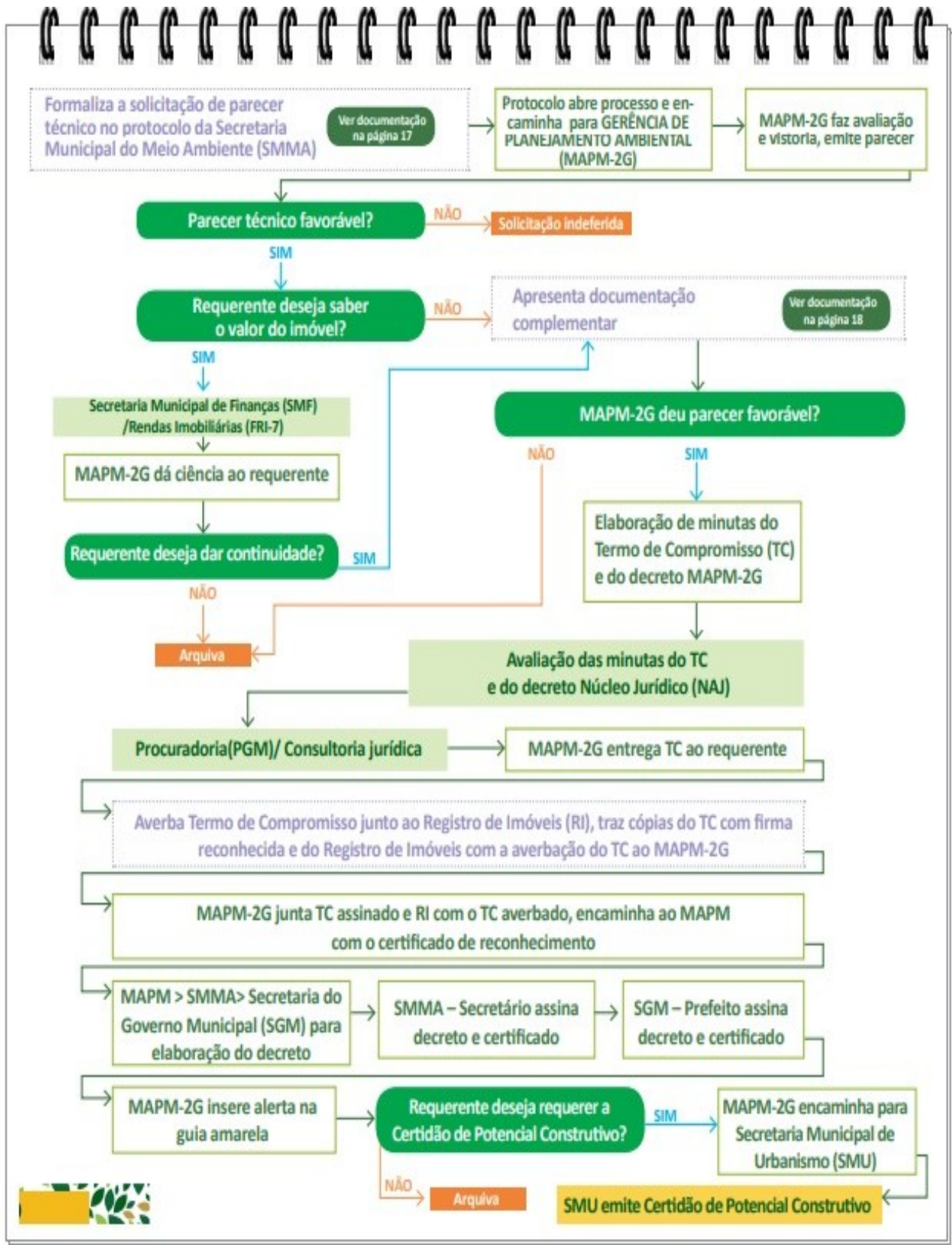
Figure 19: Flowchart for RPPNM Creation

Source: Curitiba City Hall (2013 p. 20)

4.6 Basic indicators and Best Management Practice of urban afforestation

Chart 5 presents the basic indicators of the six cities investigated. Regarding the indicators, there is great difficulty in finding organized and updated indicators involving afforestation in most of the cities analyzed. Only Curitiba presented documentation with programs, goals, actions and some more organized indicators on the subject.

Items	Manaus	Goiânia	Campinas	BH	POA	Curitiba
Age (2019)	350 y.o	86 years old	245 years old	122 y.o	247 years old	326 years old
Population (2019)	2,182,763	1,516,113	1,204,073	2,512,070	1,483,771	1,933,105
GDP Per capita (2017)	R$ 34,363	R$ 33,438	R$ 49,953	R$ 35,245	R$ 49,741	R$ 44,385
GDP (IBGE, 2017)	R$ 73 billions 8th	R$ 49 billions 14th	R$ 59 billions 11th	R$ 89 billions 4th	R$ 74 billions 7th	R$ 85 billions 5th
Area (2018)	11,401 Km^2	728.8 Km^2	724.6 Km^2	331.4 Km^2	495.4 Km^2	435 Km^2
Stimated Green Area	2,724 Km^2	651 Km^2	634 Km^2	274.1 Km^2	409.7 Km^2	331 Km^2
Roadside afforestation (IBGE, 2010)	23.9%	89.3%	87.5%	82.7%	82.7%	76.1%
Number of Trees Identified	?	More than 950,000 AMMA(2008)	More than 700,000 Correio (2019)	More than 300,000 PBH (2018)	More than 1,3 million PPOA (2012)	More than 320,000 PCUR(2019)
Tree Planting Goals	Arboriza Manaus Project. Goal: Plant 10,000 seedlings a year in at least 60 public places in Manaus	Plante a Vida Project. Goal: from 2005 to 2009, distributed 1.2 million seedlings to the population.	Green Municipal Plan. Goal: Between 2013 and 2018 distributed 1 million seedlings	PlantarBH Program Goal: By March 2020, plant 20,000 trees	?	100,000 Trees Project. Goal: Between Sep/19 and Sep/20 distribute 100,000 seedlings to the population.

Chart 5: Basic indicators identified in IBGE and in the websites of the prefectures investigated.

Source: Author.

Analyzing only the performance of the Manaus city, it can be seen that:

a) Manaus is the oldest city with 350 years of foundation, followed by Curitiba (326 years), Porto Alegre (247 years) and Campinas (245 years). As it is the oldest city, in terms of good municipal management

over time, it should be the best-managed city, since in the process of good management, there is the concern of managers to learn from mistakes and improve over time. 350 years would be enough time to prepare the city with good urbanization, to involve and educate the population as it has happened in the last 85 years of Goiânia;

b) Manaus is the second most populous city, behind to Belo Horizonte. In this sense, it is worth noting that Manaus for many years has been suffering environmental, economic and social problems resulting from the unplanned growth of the city;

c) Manaus in 2017 was considered the 8th city with the largest Gross Domestic Product in Brazil (GDP), losing to Belo Horizonte, Curitiba and Porto Alegre;

d) Manaus is the city with the largest area (11401 Km²), being 15.6 times larger than Goiânia, 15.73 times larger than Campinas, 34.4 times larger than Belo Horizonte, 23 times larger than Porto Alegre and 26.2 times bigger than Curitiba. Consequently, its estimated green area (2724 Km²) is larger than the other cities, which makes the process of planning, control, and improvement of urbanization actions a challenge that can only be overcome with long-term participatory planning involving universities, organized civil society, churches, research institutes, funders and schools, all accompanied by the application of information and communication technologies, to disseminate, mobilize society, diagnose, act, document and transparently account for resources and results of the projects executed;

e) The municipal management of Manaus has not made a diagnosis of its urban afforestation, at least no documents or studies on the subject were found, which is a serious problem that does not contribute to improving the quality of life of the population in the long term. When investigating projects, programs or actions to encourage tree planting, it is clear that the Arboriza Manaus Program, which has the goal of planting 10,000 seedlings annually, comes last when compared to other cities.

For the city of Manaus to truly be considered a city with good urban afforestation management, it is recommended to adopt several good practices presented in Table 5. In all, around 36 good urban afforestation management practices were identified, of which about 6 (17%) were easily identified on the Manaus City Hall website.

Managers responsible for Manaus' urban afforestation guidelines and programs need to make more partnerships, adopt communication and information technologies and urgently elaborate participatory planning with the Manauara population, especially with Universities, Schools, Research Institutes and organized civil society. Productive partnerships could be made with Embrapa, the National Amazon Research Institute (INPA) and the Federal University of Amazonas (UFAM), through the Inventory and Measurement Laboratory of Tropical Forests, known as the Carbon House, which was inaugurated in 2019 and built with resources from the Amazon Fund.

In addition, the managers responsible for Manaus' urban afforestation guidelines and programs need to review the PDAU and insert projects and goals into the city's long-term planning. To give an example, the Manaus 2030 Strategic Planning does not address the issue and has no clear targets or budget for the city's urban afforestation. Most of the population is unaware of the history of urban tree planting in Manaus, unaware of the laws and actions of public agencies on the subject, which is why another survey in the city may continue to repeat the perception that most considered the occupation of green spaces bad or very bad in public places in the city (NETO et al 2016).

Table 5 – Good urban afforestation practices among Manaus and 5 best cities in Brazil

Good practices identified	MAO	GO	CAMP	BH	POA	CUR
Effective monitoring of planted seedlings	-	-	X	-	-	X
Adoption of squares	X	X	X	X	X	X
Extensive partnership with Municipal Vivarium	-	-	X	-	-	-
Broad formation of partnerships in general	-	X	X	X	-	-
Afforestation of median strips	-	-	-	-	X	-
Outdoor car park afforestation	-	-	-	X	X	-
Green Areas and Conservation Units	X	X	X	X	X	X
Bank of Green Areas	-		X			
Tree planting incentive campaign with online or technical guidance	-	X	-		-	X
Compatibility of energy networks with urban trees	-	-	-	X	-	-
Explicit Control of Burns in UCs	-	-	X	-	-	-
Native seed bank creation	-	-		X	X	-
Creation of ecological corridors	X	X	X	X	X	X
Declaration of Population Participation in PDAU	-	-	-	-	X	-
Ease of finding actions taken over time	-	-	X	-	-	-
Ease of finding Laws and Decrees: Ex: Source Catalog, Website, Digital Library, etc.	-	-	X	X	X	-
Ease of Identifying PDAU or Guide	X	X	X	-	X	-
Flowchart for Creating Private Reserves of Heritage and care with Conservation Units	-	-	-			X
Fruit Tree Identification	-	-	X	X	-	-
Identification and Analysis of Falling Trees	-	X	X		X	
Inventory with tree quantitative, etc.		X	X	X	X	-
Inventory of cut immune trees	-	-	X	-	X	X
Exemption from payment of IPTU to residents who maintain Ecological Private Reserves	X	X	X	X	X	X
Manual for the elaboration of the Municipal Urban Afforestation Plan	-	-	-	-	-	X
Planning with general guidelines	-	X	-	-	-	-
Landscape planning with indication of species	-	X	X	-	-	-
100% reuse of fallen trees	-	X	-	-	-	-
Recovery of degraded areas	-	X	X	X	-	-
Historic Rescue of Urban Afforestation in the City	-	X	X	-	X	-
Basic Indicator System	-	-	X	-	-	-
Effective replacement of devitalized or inappropriate trees	-	X	X	-	X	X
Replacing trees with a risk of falling	-	X	-	-	X	X
Environmental Commitment Agreement for afforestation	X	X	X	-	X	X
City Hall Technicians Training	-	-	-	-	X	-
Green tunnels (streets with preserved vegetation and protected by decree)	-	-	-	-	X	-
Use of technologies in urban afforestation actions that allow the population to access information	-	-	X	-	-	X

Source: Author (2019)

5. Final considerations with suggestions to Manaus managers

The article investigated the best management practices of urban afforestation adopted by Goiânia, Campinas, Belo Horizonte, Porto Alegre, and Curitiba.

From the analysis of articles, websites and documents of the municipalities of these cities and its partners, around 36 good practices were identified, which can be adopted with adaptation by the public managers of Manaus with partners.

Following the line of Baker et al (2013), the growing concern with environmental issues makes urban afforestation used by government authorities as a useful tool to contain environmental damage. Thus, it is recommended that the Manaus City Hall promotes participatory management with organized civil society, universities and companies, to discuss the issue, allocate resources, integrate Information and Communication Technology with the these and other actions in its Urban Afforestation Master Plan so that citizens enjoy the revitalization of the landscaped visual aspect of urban areas, the reduction of air pollutant concentration and, consequently, the improvement of the quality of life.

Manaus and the best five cities should update their sites and make them more friendly and easy to get all the laws, documents, budget, projects, actions and indicators about urban afforestation issues.

Finally, further research should be done to:

a) review and identify methods and techniques of each best management practices showed in Table 5;

b) identify the annual budget of each city invested in urban afforestation;

c) investigate the best methods used to involve the population and make the process more transparent. Regarding with this, the book written by Silva (2018) presents some methods to make the diagnostic more participative from brazilian and international case of success;

d) investigate the population level of satisfaction with their city afforestation process;

e) identify the urban afforestation best management practices adopted by the most sustainable or green cities in the World.

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